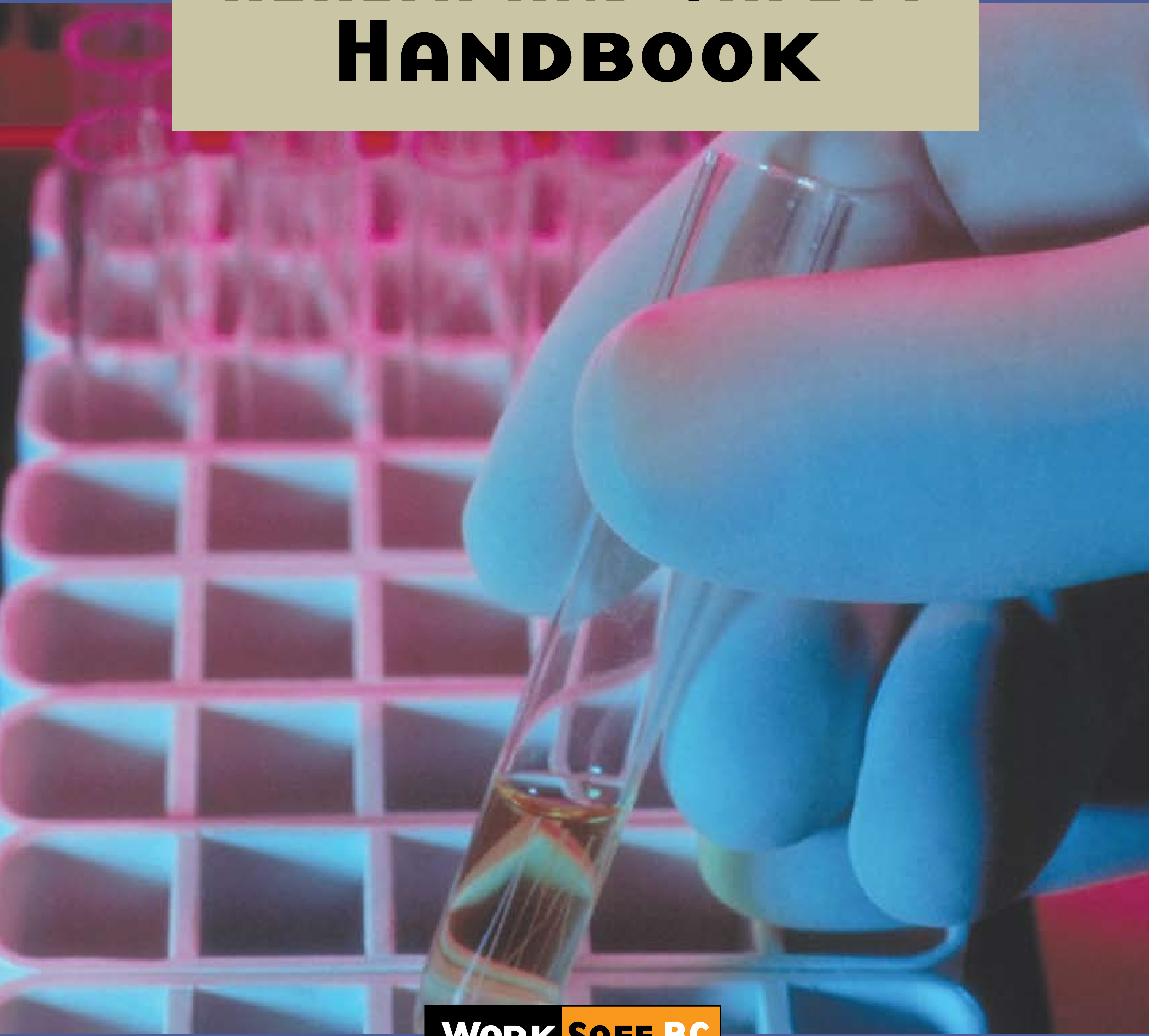
Laboratory Health and Safety Handbook



WorkSafe BC

WORKING TO MAKE A DIFFERENCE

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About WorkSafeBC

WorkSafeBC (the Workers' Compensation Board) is an independent provincial statutory agency governed by a Board of Directors. It is funded by insurance premiums paid by registered employers and by investment returns. In administering the *Workers Compensation Act,* WorkSafeBC remains separate and distinct from government; however, it is accountable to the public through government in its role of protecting and maintaining the overall well-being of the workers' compensation system.

WorkSafeBC was born out of a compromise between B.C.'s workers and employers in 1917 where workers gave up the right to sue their employers or fellow workers for injuries on the job in return for a no-fault insurance program fully paid for by employers. WorkSafeBC is committed to a safe and healthy workplace, and to providing return-to-work rehabilitation and legislated compensation benefits to workers injured as a result of their employment.

WorkSafeBC Prevention Information Line

The WorkSafeBC Prevention Information Line can answer your questions about workplace health and safety, worker and employer responsibilities, and reporting a workplace accident or incident. The Prevention Information Line accepts anonymous calls.

Phone 604 276-3100 in the Lower Mainland, or call 1 888 621-7233 (621-SAFE) toll-free in British Columbia.

To report after-hours and weekend accidents and emergencies, call 604 273-7711 in the Lower Mainland, or call 1 866 922-4357 (WCB-HELP) toll-free in British Columbia.

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WorkSafeBC publications

Many publications are available on the WorkSafeBC web site. The Occupational Health and Safety Regulation and associated policies and guidelines, as well as excerpts and summaries of the *Workers Compensation Act,* are also available on the web site: WorkSafeBC.com

Some publications are also available for purchase in print:

Phone:	604 232-9704
Toll-free phone:	1 866 319-9704
Fax:	604 232-9703
Toll-free fax:	1 888 232-9714
Online ordering:	WorkSafeBC.com and click on Publications; follow the links for ordering

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Contents

Introduction

This handbook is intended to be a guide to health and safety for laboratory workers and employers. It is based on the Occupational Health and Safety Regulation, particularly Part 30 and Part 5. Although this handbook discusses various hazards in laboratories and lists safety precautions, the Occupational Health and Safety Regulation is the formal statement of WorkSafeBC (Workers' Compensation Board of British Columbia) policy and forms the rules that will be enforced by WorkSafeBC officers.

A laboratory is a room, building, or area in a building equipped with apparatus, equipment, chemicals, or test animals and used for research, quality control, performance tests, experiments, measurements, photographic development, or the preparation of drugs or other products in the natural sciences. For example, areas used for clinical, optical, dental, veterinary, electronic, non-destructive, and pharmaceutical testing are all considered to be laboratories for the purpose of this handbook and Part 30 of the Occupational Health and Safety Regulation.

This guide is to be used in conjunction with the Occupational Health and Safety Regulation and other pertinent WorkSafeBC publications. For assistance and information on workplace health and safety, call toll-free within B.C. 1 888 621-SAFE (7233) or visit our web site at WorkSafeBC.com.

Understanding general health and safety requirements

Working in a laboratory usually involves working with various chemical, physical, and biological hazards. Because the hazards vary from lab to lab, employers must address the hazards specific to their workplaces by developing and implementing:

- Written safe work and emergency procedures
- Training and education of workers
- Workplace inspections (regular and special inspections of workplace equipment, methods, and practices)
- Investigation of workplace accidents (accident investigations and reports)
- First aid equipment and procedures
- Periodic management meetings to review health and safety activities
- Regular staff safety meetings or an occupational health and safety committee where required
- Records and statistics

Note: The online version of this handbook contains numerous hyperlinks to materials available on the Internet. For the convenience of readers using a printed copy of the handbook, the Internet addresses are written out in the Resources section of this handbook.

An address is provided for the complete Occupational Health and Safety Regulation rather than for individual Parts. In addition, specific links are provided for the Table of Exposure Limits for Chemical and Biological Substances (an important source of information about exposure limits referred to throughout the handbook).

Prepare written safe work and emergency procedures

Employers must prepare written safe work and emergency procedures for hazardous operations at the laboratory. Such procedures might include:

- Work methods involving hazardous chemicals (such as analytical methods or spill response) or the handling of biohazardous material
- Procedures for dealing with accidents involving biological agents (such as spills or accidental injection) or animals (such as bites and escapes)
- Procedures required to minimize or eliminate a risk from a physical hazard (such as musculoskeletal injuries)

Provide worker training and education

Employers must provide workers with adequate education in the hazards of the workplace, and with training and instruction on how to do their work safely. The written safe work procedures should be used as a primary source of information. Many laboratory workers may have advanced formal education, but they still need site-specific training on work methods involving particular hazards such as chemicals, biological hazards, radiation, or animal handling. The training must include proper handling and disposal of hazardous chemicals or materials.

Supervisors are responsible for the adequate training and instruction of all workers under their direction and control. A supervisor is anyone who instructs, directs, and controls workers in the performance of their duties, even if he or she does not hold the title of supervisor. An experienced laboratory worker who is training another worker is acting as a supervisor within the Occupational Health and Safety Regulation definition.

Carry out workplace inspections

Regular inspections of the entire workplace will help ensure that unsafe conditions do not develop over time. Such inspections should be conducted by the occupational health and safety committee or, if there is no committee, by at least one employer representative and one worker representative. Special inspections must be carried out after an accident or equipment malfunction.

The purpose of a workplace inspection is to look for unsafe work conditions, practices, and procedures. Checklists may help identify common safety concerns and ensure that these concerns are consistently checked. For example, a checklist might include sections on labelling, housekeeping, and storage practices. A sample checklist is provided at the end of this handbook. Employers or Joint Health and Safety Committees can modify it to include safety concerns specific to their laboratory.

Besides the regular workplace inspections covered by the checklist, a complete workplace inspection program may also include the following activities:

- Monitoring air velocity in fume hoods
- Daily checks of integrity of animal cages
- Annual testing and certification of biological safety cabinets and fire extinguishers
- Inspections of laboratory equipment as recommended by manufacturers

All unsafe or harmful conditions must be corrected without undue delay. In an emergency, only workers trained and qualified to take corrective action may be exposed to the hazard. Every possible effort must be made to control the hazard while such corrective action is being taken.

Workers must not wait for the regular inspection to identify a workplace hazard. Anyone who becomes aware of a health and safety problem at his or her workplace is required to report it to the supervisor or employer. The person receiving the report must investigate the problem and ensure that any required corrective action is taken without delay. If the problem cannot be solved in-house, contact WorkSafeBC. Procedures for reporting unsafe conditions and for refusing to perform unsafe work are described in detail in Part 3 of the Occupational Health and Safety Regulation.

Investigate accidents

Employers are required to investigate accidents that:

- Resulted in death or a critical condition with serious risk of death
- Caused an injury or disease that required medical attention
- Did not cause injury but had the potential for causing serious injury
- Involved the release or spill of a toxic or hazardous substance

The purposes of an accident investigation are to:

- Determine the cause or causes of the accident
- Identify contributing factors such as unsafe conditions, acts, or procedures
- Develop a corrective action plan to prevent similar accidents in the future

A copy of the accident investigation report must be sent to the occupational health and safety committee and WorkSafeBC. The report must contain:

- The place, date, and time of the accident
- The names and job titles of persons injured in the accident
- The names of witnesses
- A brief description of the accident
- A statement of the sequence of events that preceded the accident
- Identification of any unsafe conditions, acts, or procedures that contributed in any way to the accident
- Recommended corrective action to prevent similar accidents
- The names of the persons who investigated the accident

Provide first aid equipment and services

Laboratory employers must provide equipment, supplies, facilities, first aid attendants, and services that are adequate and appropriate for:

- Promptly rendering first aid to workers if they suffer an injury at work, and
- Transporting injured workers to a place of medical treatment

The employer must conduct an assessment of the workplace to determine what first aid services are needed.

Many laboratories can be classified as having a moderate hazard rating. Table 1 summarizes the recommended minimum levels of first aid for such laboratories that are at most 20 minutes surface travel time to hospital. See Part 3 of the Occupational Health and Safety Regulation and the associated guidelines for details.

Table 1 Minimum first aid recommendations for a moderate risk workplace at most 20 minutes surface travel time to hospital.

Number of workers present	Supplies, equipment, and facility	First aid certificate required for attendant
1	Personal first aid kit	
2–5	Basic first aid kit	
6–25	Level 1 first aid kit	Level 1
26–75	Level 2 first aid kit Dressing Station	Level 2
76 or more	Level 2 first aid kit First aid room	Level 2

Management meetings to review health and safety activities

Periodic management meetings must be held to review health and safety activities and accident trends, and to determine necessary courses of action.

Staff safety meetings/occupational health and safety committee

An occupational health and safety committee is required for laboratories with a work force of 20 or more workers. Occupational health and safety committees must have at least four regular members, representing both the workers and the employer. Their duties are specified in Part 3, Division 4, section 130 of the *Workers Compensation Act.*

Laboratories with less than 20 workers do not need to have occupational health and safety committees. They must, however, hold monthly staff meetings to discuss health and safety matters. Also, a worker health and safety representative is required in each workplace where there are 10 to 19 workers of the employer regularly employed. To the extent practicable, a worker health and safety representative has the same duties and functions as a joint committee.

Records and statistics

Laboratories must maintain adequate records and statistics including first aid records, reports of inspections, and accident investigations. This information must be available to the occupational health and safety committee, to a WorkSafeBC officer, and to the union or the laboratory workers themselves.

Making your laboratory safe

Although there are many types of laboratories, each with very different hazards, many common control measures can be implemented to prevent accidents, injuries, and disease. The following processes can be used to address common laboratory health and safety hazards:

- Identify and assess hazards
- Implement control measures
- Prepare for emergencies
- Dispose of wastes properly

Identify and assess hazards

Employers need to identify hazards and conduct a hazard assessment before any equipment, machinery, or work process is used or started. Potential hazards include exposure to chemicals, biohazardous materials, radiation, heat, noise, vibration, violence, and ergonomic problems. The hazard assessment should be done in consultation with an occupational health and safety committee or, if there is no committee, a worker representative for health and safety issues.

Implement control measures

Once hazards have been identified and assessed, employers need to either eliminate or minimize exposure to the hazards by using substitution of equipment, materials, procedures, engineering controls, or administrative controls. Personal protective equipment is used if implementation of the other control measures cannot provide adequate protection.

Exposure control plan

Different laboratories have different hazards. Depending on the hazard and the level of worker exposure, some laboratories must establish formal exposure control plans. An exposure control plan must contain the following:

- Statement of purpose and responsibilities
- Risk identification, assessment, and control
- Education and training
- Written work procedures
- Hygiene facilities and decontamination procedures
- Health monitoring
- Documentation

For chemical and radiation (ionizing and non-ionizing) hazards, the level of exposure will determine whether an exposure control plan is needed. If there is a potential for occupational exposure to a biological agent designated as a hazardous substance in section 5.1.1 of the Regulation, that could cause an adverse health effect, an exposure control plan is required. For more information on the circumstances that require an employer to develop and implement an exposure control plan, see Parts 5, 6, and 7 of the Occupational Health and Safety Regulation or contact an occupational hygiene officer at the nearest WorkSafeBC office (see the list of offices at the back of this publication).

Personal protective equipment

If workers can be injured by coming in contact with a hazardous substance, employers must:

- Supply appropriate protective clothing
- Launder or dispose of the protective clothing regularly
- Provide adequate washing facilities (see pages 8–9)
- Allow time for washing before each break

Eye and face protection

It is good practice to wear eye protection at all times in laboratories. Proper eye protection includes safety glasses, safety goggles, and face shields.

Regular prescription glasses are not considered proper eye protection unless they have side shields attached. Proper eye protection is required for laboratory workers who are at risk of eye injury (for example, from chemical splashes and flying debris), and for those with 20/200 or less vision in either eye or who are blind in either eye.

If there is danger of impact (such as when working with pressurized systems or containers), bifocal and trifocal eyeglasses must not be used unless they are worn behind safety goggles. Workers exposed to Class IIIB or Class IV lasers must use eye protection specific to the wavelength of the laser hazard and identified as to the wavelength that they protect against.

Assess the hazards that may be present before selecting protective eyewear. For more information about eye and face protection, refer to:

- Protective Eye and Facewear Standard (University of Toronto)
- Personal Protective Equipment (American Industrial Hygiene Association)

For a description of several laboratory safety incidents involving eye injuries, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Hand protection

Suitable hand protection is required for workers handling materials that may cause damage such as punctures, scrapes, cuts, animal bites, chemical burns, heat burns, irritation, sensitization, and exposure to toxic substances. Gloves should be carefully selected because most gloves provide protection from certain types of hazards only. For example, heavy leather gloves provide good protection from cuts and animal bites, but offer little, if any, protection from most chemicals.

Different chemical hazards require different types of gloves; no gloves provide protection from all chemicals. For example, gloves that provide protection from corrosive agents, such as acids and caustics, may offer little or no protection from most organic solvents. Suppliers and manufacturers sometimes publish chemical compatibility charts to help identify the most suitable glove type for specific chemical hazards.

For more information about the properties and selection of protective gloves, refer to:

- Protective Glove Standard (University of Toronto)
- Chemical Guide and Permeation Tables (Oklahoma State University)

The wearing of gloves itself can sometimes also introduce a hazard. For example, gloves may decrease a worker's ability to perform delicate manual tasks, they may cause a worker to exert increased force, they may cause irritation, or, in the case of natural rubber latex gloves, they may cause severe allergic reactions in some workers. For more information about allergies to latex gloves, see the WorkSafeBC publication *Dealing with "Latex Allergies" at Work*.

Consequence of inappropriate personal protective equipment

A researcher was using dimethylmercury as a reference material for nuclear magnetic resonance (NMR) spectroscopy. While transferring an aliquot of the compound in a fume hood, she spilled a few drops on her latex glove. Probably unknown to her, the dimethylmercury rapidly permeated the glove material and was absorbed through her skin. This was the only exposure incident that the worker could recall. She died from mercury poisoning 10 months later.

Remember:

- Always substitute a less toxic material when possible.
- Workers must be trained on the limitations of protective equipment.
- Use glove materials that protect against the chemicals being used.
- Consult the glove manufacturer's guidelines for selection and use, and the chemical material safety data sheet.

Body protection

Lab coats should be worn in laboratories at all times as part of good general practice. Additional protection such as aprons and specialized suits may be required when handling corrosive, toxic, radioactive, biohazardous, or other harmful materials. It is good practice not to wear laboratory coats outside of the laboratory, and they should never be worn outside of the laboratory when toxic, biological, or radioactive substances are handled. To prevent contamination, protective clothing must not be stored with clean work clothes and personal clothing. Employers must provide regular laundering (based on hazard) or disposal of all required protective clothing.

When sending articles for laundering or drycleaning, the employer must provide the following written information to the operator of the laundry or drycleaning facility:

- Identity of any hazardous materials included with the article
- Nature of the hazard
- Any general precautionary measures to be followed when handling the materials

For example, lab coats from fire assay workers might include the following label information:

May contain lead dust!
Inhalation and ingestion hazard!
Avoid breathing or ingesting the dust!

Foot protection

Footwear must be of a design, construction, and material appropriate to the protection required. Shoes with non-slip soles should be worn in laboratories. Open-toed shoes and sandals must not be worn by laboratory workers who work with or near chemical hazards. Workers performing spill clean-up require chemical-resistant footwear. Workers who need to stand for long periods while working need shoes that provide enough cushioning and support for their feet. Workers who frequently change gas cylinders are at increased risk of injury from cylinders falling on their toes, and hard-toed shoes are recommended for this task.

Respiratory protection

Employers must provide appropriate respiratory protective equipment if workers are or may be exposed to concentrations of an air contaminant above an applicable exposure limit. For a list of exposure limits, see the Table of Exposure Limits for Chemical and Biological Substances in Guideline 5.48-1 to Part 5 of the Occupational Health and Safety Regulation.

In general, it should not be necessary for laboratory workers to wear respiratory protection. Respirators may be required, however, during emergency response procedures such as clean-up of hazardous materials or control of gas releases. Workers who are required to use respirators must be trained to properly use and maintain their particular respirator. They must know the limitations of the respirator and be properly fit-tested.

For more information on respiratory protection, see the WorkSafeBC publication *Breathe Safer*.

Prepare for emergencies

Laboratories must have written emergency procedures for accidental release or spills of chemicals or other harmful substances. Employees must be trained in these procedures, which should be posted in work areas where there is a potential for such emergencies. Employers must conduct drills at least once a year to ensure that:

- Emergency exit routes and procedures are effective and employees are aware of them
- Workers and supervisors are familiar with their roles and responsibilities

A record of the drills must be kept.

Written emergency procedures should include the following:

- Assignment of specific responsibilities to individuals and teams
- Instructions for immediate evacuation of workers
- Instructions for providing first aid to and transporting injured workers
- Appropriate emergency telephone numbers, including telephone numbers of nearby medical facilities so that they can be alerted when injured workers are on their way
- Instructions for safely cleaning up spills and properly disposing of the waste afterward
- A list of agencies to notify in case of a major release of a toxic or hazardous substance, e.g., WorkSafeBC and the Provincial Emergency Program (www.pep.bc.ca)
- Re-entry procedures for maintenance and clean-up work
- Instructions for scheduling emergency drills and testing of emergency equipment
- Provisions for worker training (for example, on the availability and use of personal protective equipment during an emergency, and how to extinguish small fires)

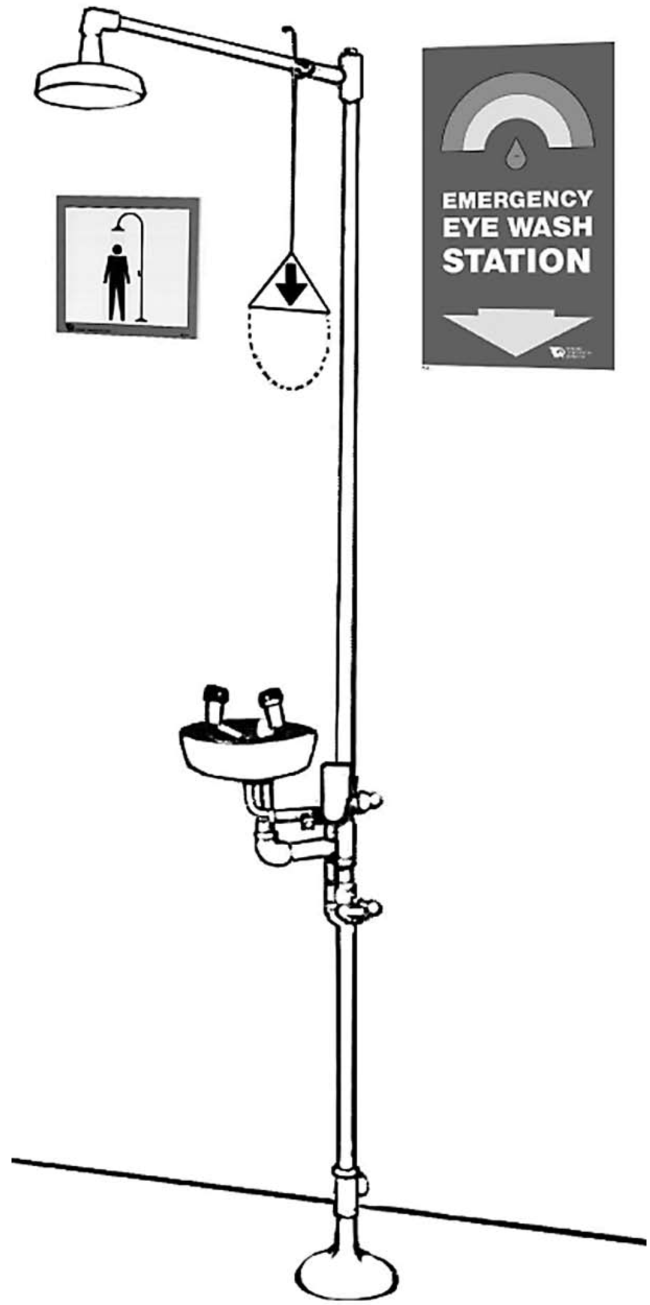
Spill clean-up

Accidental releases and spills of chemicals or other harmful substances must be controlled immediately. Workers who clean up spills of hazardous materials must be adequately instructed in the safe procedures. The clean-up operation must be supervised by someone who is knowledgeable in the hazards involved and the precautions required. Any personal protective equipment that will be required during emergency clean-up or escape must be stored in a condition and location so that it is immediately available.

For more information about cleaning up chemical and biological spills, see pages 32 and 45.

Emergency washing facilities

Laboratories that handle or store corrosive chemicals or other chemicals harmful to the eyes or skin must have appropriate emergency washing facilities. Eyewash and shower facilities must be designed so that, when activated, they provide a flow of tempered water (15–30°C) that continues for at least 15 minutes without requiring the use of the operator's hands. The facilities must be within either 6 metres or 30 metres of work areas, depending on the level of risk. For low-risk workplaces, where chemicals or other materials are used in a manner and quantity that present a risk of mild eye or skin irritation (such as workers grinding optical lenses), any effective means of eye flushing (e.g., a drench hose) may be used instead of eyewash and shower facilities. For specific information on risk assessment and requirements for provision of emergency washing facilities, see Tables 5-2 and 5-3 in the Occupational Health and Safety Regulation.



All workers must know where the eyewash and shower facilities are, and must be trained in their proper use. Each facility must have signs clearly identifying the location and providing clear instructions for proper use.

Eyewash and shower facilities must be tested according to the manufacturer's instructions when first installed. They must be maintained in good working order and plumbed systems must be full-flow-tested at least once a month. Records of maintenance work and testing should be kept.

Fire protection

Eliminate or control all ignition sources (such as open flames, smoking, static discharge, and so on) whenever flammable materials are handled or stored.

Laboratories must be equipped with portable fire extinguishers that are immediately accessible wherever flammable materials are used or stored. Workers who may be required to use the fire extinguishers must be trained in their use. Firefighting equipment must be maintained according to manufacturers' instructions.

Fire suppression[1]

The National Fire Protection Association defines five classes of fire:

Class	Source	Examples
A	Ordinary combustibles	Wood, paper, cloth
B	Liquid fuels	Solvents, oil, gasoline
C	Electrical	Fuse boxes, motors
D	Combustible metals	Sodium, potassium, phosphorus
K	Cooking Media	Oils, lards, fats

Most laboratories have the potential for class A, B, and C fires, and, less commonly, class D and K. Select fire extinguishers appropriate for your laboratory.

Extinguisher type	Classes of fire	Extinguisher characteristics
Carbon dioxide	B, C	Dissipates so quickly that hot fuel may reignite. Ineffective on class A fires.
A-B-C Dry chemical	A, B, C	Most versatile, but leaves mildly corrosive powder that must be cleaned.
Water	A	Dangerous if used in many laboratory situations, such as around equipment or water-reactive chemicals.
Class D dry chemical	D	Designed for metal fires only.
Class K wet chemical	K	Reduces the fire's temperature while extinguishing the flames by reacting with cooking oils. Designed for commercial kitchens.

A fire safety plan must be in place. The local fire department should be contacted for the specific requirements. Fire exits and exit routes must be clearly marked and kept free of obstructions at all times. All workers must be properly trained in the fire prevention and emergency evacuation procedures of their workplace.

If a laboratory uses or stores hazardous materials that may endanger firefighters, the employer must notify the local fire department. The fire department needs to know the nature and location of the hazardous materials, and how to handle them safely. As part of the fire safety plan, there should be a list of chemicals on site. If there is a larger quantity of any product at a given time, the fire department should be notified for their response planning. Water-reactive chemicals should be protected from exposure to water in a sprinklered facility.

1 Adapted from *Laboratory Safety: CSLT Guidelines,* 4th ed., 1996.

Proper waste disposal

Laboratories must have proper waste disposal procedures to prevent injury to laboratory workers and to those who handle laboratory waste. Incompatible and hazardous wastes must be segregated in clearly marked containers, and a workplace label must be applied to each container (for more information about workplace labels, see pages 14–16).

For information on chemical disposal that complies with provincial environmental regulations, contact the B.C. Ministry of Environment Hazardous Waste Management Program.

Glass and sharps

Damaged or broken glassware can cause serious cuts and can spread infection. Broken glass, metal, or other sharp objects that can cut or puncture the skin must be disposed of separately from other laboratory waste, in leakproof, puncture-resistant containers. These containers must be identified and labelled, and should be located near the area where the waste is generated.

Do not overfill sharps containers. Containers should have a maximum fill line clearly marked.

Organic solvents and flammable waste

Organic solvents and other flammable liquid waste must be collected and temporarily stored in separate tightly covered containers until proper final disposal. Disposal of these solvents requires specialized procedures that must meet municipal, regional, provincial, and federal regulations. For this reason, employers often choose to contract disposal services to a commercial disposal company.

Biohazardous waste

Biohazardous waste can include micro-organisms; plant, animal, and human products (such as bacteria, fungi, blood, urine, and organ parts); and any materials contaminated with these products. Such wastes must be collected and temporarily stored in separate tightly covered containers until proper final disposal. Disposal of untreated biohazardous waste to landfills is prohibited by the BC Hazardous Waste Regulations, 2004 and the GVRD Landfill bylaws No. 181 and 183, 2000. Biohazardous waste may be rendered harmless by autoclaving, chemical treatment, or other methods.

Radioactive waste

Radioactive waste includes surplus radioisotope material; items that have come in contact with radioactive material, such as gloves or pipettes; materials used for radioactive decontamination, such as paper towels; and equipment that has become contaminated with radioactive material and cannot be cleaned, such as centrifuges.

Radioactive wastes must be disposed of in accordance with the *Nuclear Safety and Control Act.*

Never mix radioactive waste with non-radioactive waste or place radioactive waste in containers intended for non-radioactive waste. Designated containers of radioactive waste must be labelled. Each time radioactive material is added to a container, a detailed record (including the date and the identity of the radioactive material) must be kept.

Keep solid and liquid radioactive wastes separate. Place solid waste in designated radioactive waste containers. Sharps should go into a cardboard box first, and the box into the waste container. Do not place uncontaminated materials in the container for solid wastes.

Never pour liquids containing radioactive materials into drains. Instead, pour them into plastic bottles containing an absorbent material to soak up the liquid. Place the plastic bottles in a secondary container, such as a plastic tray, to contain any liquid that may leak or spill.

Radioactive waste must not be stored near people who do not work with radioactive materials.

General do's and don'ts

Because most laboratory workers handle hazardous materials and equipment as part of their work, all laboratories must observe some general precautions.

Working alone

Laboratory workers sometimes work alone, either because of shift work or work at an isolated location. If there is a risk of serious injury or if the worker may be unable to summon assistance, the employer must have a written procedure for checking on the worker's well-being. The procedure must:

- Specify time intervals for regular checks
- Contain instructions on what to do if the worker cannot be contacted
- Contain provisions for emergency rescue

A designated person must make contact with the worker at predetermined intervals and record the results of each check. Both the worker required to work alone and the health and safety committee, if any, must be consulted to determine the appropriate time interval for regular checks. Besides regular checks, a check must be done at the end of the work shift.

High-risk activities require shorter intervals between checks. The preferred method for checking is visual contact or two-way voice contact.

Smoking and eating

Do not smoke, eat, drink, or store food in laboratories. Laboratory refrigerators are never to be used to store food or drink. Do not use laboratory glassware, containers, and equipment to prepare or store food. These activities greatly increase the risk of ingestion of harmful substances.

Pipetting

Section 30.17(4) of the Occupational Health and Safety Regulation prohibits the pipetting of substances by mouth. Use one of the many commercially available mechanical pipetting devices.

Contact lenses

Do not wear contact lenses where water-soluble gases, vapours, mists, or dusts may be released into the atmosphere. If they are to be worn and are permitted by the employer, take adequate precautions. These precautions need to be predetermined by the employer as part of a risk assessment and may include increased use of personal protective equipment.

Notify the first aid attendant so that first aid treatment can be given in case of an accident involving the eyes. Do not replace contact lenses after an eye injury or chemical splash to the eye until a physician agrees that it is safe to do so.

Personal hygiene

Wash thoroughly before leaving the laboratory area, before each work break, and before the end of the work shift. Depending on the hazard, you may need to shower at the end of the work shift.

Do not use organic solvents for washing; they remove natural protective oils from the skin, which can cause skin irritation and inflammation.

Washing with organic solvents may also increase the risk of toxic chemicals being absorbed through the skin.

Housekeeping

Cluttered work areas can lead to accidents, so keep work areas tidy and organized. Store chemicals and equipment properly when not in use. Clean work surfaces regularly, and wipe them down with damp paper towels after every use. Use bleach or other appropriate disinfectants to clean work surfaces that may have come in contact with biohazardous materials.

Laboratory workers are often required to carry hazardous substances between work areas. Floors, walkways, hallways, and stairways must therefore be kept clear at all times to eliminate slipping and tripping hazards. Access routes to emergency equipment (emergency showers and eyewash facilities, fire extinguishers, first aid kits) must be kept clear of obstruction.

Keep floors dry. Clean up any liquids, refuse, or waste materials that spill or accumulate on the floors and ramps in work areas.

Understanding WHMIS

The Workplace Hazardous Materials Information System (WHMIS) legislation ensures that workers are provided with adequate health and safety information. Products covered under WHMIS legislation are called **controlled products**, and fall into one or more of the following categories:

- Compressed gas
- Flammable or combustible material
- Oxidizing material
- Poisonous or infectious material (including biohazardous material)
- Corrosive material
- Dangerously reactive material

To help ensure that workers have the required health and safety information to work safely around hazardous chemicals, WHMIS focuses on three main elements:

- Proper labels (supplier labels and workplace labels)
- Material safety data sheets (MSDSs)
- Worker education and training

The two main sources of health and safety information are supplier labels (pages 14–15) and material safety data sheets (page 16). As defined by WHMIS legislation, suppliers are responsible for preparing and providing supplier labels and material safety data sheets for all WHMIS controlled products that they manufacture, import, or sell. For example, when a laboratory imports a specialty chemical that is also a controlled product, the employer becomes a supplier under WHMIS. This means they must provide an up-to-date MSDS and attach a supplier label.

At present, some controlled products are exempt from the federal WHMIS requirements for supplier labels and material safety data sheets, but not from provincial and territorial WHMIS requirements. Employers must still provide workplace labels and worker education for these products. Such *partiall*y exempt controlled products include:

- Pesticides registered with Health Canada under the *Pest Control Products (PCP) Act,* with a valid PCP number
- Consumer products packaged in containers available on the retail market
- Radioactive materials covered under the *Nuclear Safety and Control Act*
- Explosives covered under the *Explosives Act*
- Cosmetics, food, drugs, and medical devices covered under the Food and Drug Regulations

Other products are *totall*y exempt from all aspects of WHMIS:

- Wood and products made of wood
- Tobacco and products made of tobacco
- Manufactured articles
- Products that are handled or transported under the *Transportation of Dangerous Goods Act* (once they are received into the lab, however, they are covered by WHMIS again)
- Hazardous wastes

For more information on WHMIS, see the WorkSafeBC publications *WHMIS at Work* and *WHMIS Core Material*.

Labels

All controlled products other than those that are partially or totally exempt must be labelled according to WHMIS regulations. Two types of labels are required under WHMIS:

- Supplier labels, produced by the supplier of the controlled product
- Workplace labels, produced by the employer for use in the workplace

Supplier labels

Supplier labels carry brief statements to inform workers about the risk posed by the chemical, precautionary measures they should take, and first aid measures in the event of injury. A supplier label is *not* meant to provide complete health and safety information about a product.

There are four different types of supplier labels. They apply to:

- **Laboratory chemicals** − products from a laboratory supply house, packaged in quantities of less than 10 kg and intended for use in a laboratory
- **Laboratory samples** − samples of a controlled product that are intended solely to be tested in a laboratory (such as for analytical or research and development purposes), packaged in quantities of less than 10 kg (diagnostic specimens have different requirements; see "Labelling" on page 39)
- **Workplace chemicals (> 100 mL)** − products other than laboratory chemicals or samples and packaged in containers of more than 100 mL
- **Workplace chemicals (< 100 mL)** − products other than laboratory chemicals or samples and packaged in containers of less than 100 mL

Table 2 summarizes the information required on different supplier labels.

Table 2

Information required on a supplier label	Laboratory chemical	Laboratory sample	Workplace chemical > 100 mL	Workplace chemical < 100 mL
Product identification (usually the name of the product)	●	●[2]	●	●
Hazard symbols (classification)			●	●
Risk phrases	●		●	
Precautionary statements	●		●	
First aid measures	●		●	
Supplier identification		●	●	●
Reference to availability of MSDS	●		●	●
English (and French) within a hatched border	●	●	●	●

Chemical identification and workplace labels

If a chemical is transferred from the original container and is for use exclusively within the laboratory, or if the chemical is a controlled product undergoing analysis (i.e., a lab sample), the employer must ensure that the contents are clearly identified on the container. (**Note**: There are other labelling requirements for biohazardous materials, including diagnostic specimens. For more information, see page 39.)

In cases where chemicals will not be used exclusively in the laboratory, employers must ensure that workplace labels are prepared and applied as required by the Occupational Health and Safety Regulation. If chemicals are transferred from the original container into another container or mixed with other chemicals to produce a different

2 An emergency telephone number and chemical identity must be provided for a laboratory sample.

chemical, a workplace label must be generated and attached to the new container. Workplace labels must be placed on each container of hazardous waste handled or disposed of by the laboratory.

Workplace labels must include:
- The product identity
- Safe handling information
- Reference to material safety data sheet

Labels must be replaced if they become illegible.

Material safety data sheets (MSDSs)

A material safety data sheet is a technical bulletin provided by suppliers for each controlled product they sell. It contains detailed, product-specific hazard, precautionary, and emergency information that workers need to read, understand, and use. The data sheet supplements the information provided on supplier labels. For general information on material safety data sheets, refer to the WorkSafeBC publication *WHMIS at Work*.

Employers must ensure that they have a material safety data sheet for each controlled product used or stored in the laboratory. For hazardous waste containing a controlled product, an MSDS, hazardous waste profile sheet, or equivalent must be prepared. Employers who produce a controlled product for use in the laboratory must develop an MSDS for the product.

Employers must also ensure that no MSDS is more than three years old. Chemicals are constantly being studied and new information can affect the health and safety information on an MSDS.

Material safety data sheets must be readily available at the workplace as a reference for workers and for the occupational health and safety committee.

Worker education and training

Employers are responsible for providing worker education and training. WHMIS education must include the:
- Elements of the WHMIS program
- Hazards of the chemicals used
- Rights and responsibilities of employer and workers
- Information required on labels and material safety data sheets, and the significance of the information

Workers must be trained in how to read and understand supplier labels and material safety data sheets. All employees who work with or near controlled products must have specific training for all such products.

Employers must develop training programs based on written safe work procedures for routine handling of chemicals as well as on detailed emergency procedures. Such programs must include all controlled products used, including those partially exempt from WHMIS, which do not require supplier labels and material safety data sheets.

Maintenance and cleaning personnel who may be exposed to spills and other accidental releases of controlled products must also be given the training.

Controlling chemical hazards

A hazardous chemical is any element, chemical compound, or mixture of elements and/or chemical compounds that can cause fire, explosion, corrosion, toxic reaction, personal injury, or property damage unless appropriate precautions are taken. Laboratory workers must know the hazards and safe work procedures for a particular chemical before handling it. Employers shall develop safe work procedures that address the specific chemical hazards using information from supplier labels, material safety data sheets, the manufacturers' recommendations, and other resource material, including knowledge of the workplace.

A laboratory safety manual should be developed, and should cover the following for the particular laboratory:

- Health and safety information such as written work procedures, respiratory protection program, procedures for controlling spills and accidental releases, and emergency response procedures, including special first aid procedures such as antidotes
- General prohibitions (for example, mouth pipetting or storage of food)
- Safety rules (for example, when to use the various types of personal protective equipment)

General chemical hazards and precautions

Table 3

WHMIS hazard class	Class description	Hazards	Examples of safe work practices
Compressed gas  Example: nitrogen, hydrogen, argon	Includes compressed gases, dissolved gases, and liquefied gases.	• May explode when heated or when cylinder is damaged. • May also be flammable, toxic, corrosive, or dangerously reactive. • May act as a projectile if neck is damaged.	• Protect cylinders from heat and physical damage. • Keep valve caps on all cylinders not in use or when storing or moving them. • Before using cylinders, check all fittings and regulators for defects, leaks, oil, and grease. • Use the smallest cylinder required for the work. • Wear goggles or safety glasses. • Do not empty a cylinder completely. A slight pressure will keep contaminants out. • Use proper storage and transportation procedures. • Use a cart designed for moving cylinders. • Wear steel-toed footwear when handling large cylinders.

WHMIS hazard class	Class description	Hazards	Examples of safe work practices
Flammable and combustible material  Examples: white phosphorus, acetone, propane	Solids, liquids, and gases capable of catching fire or exploding in the presence of an ignition source.	• May readily burn or explode if placed near heat, sparks, or open flames.	• Keep away from heat, sparks, and open flames. • Post NO SMOKING signs in work or storage areas. • Keep the minimum quantity in the work area. • Store away from oxidizers. Label containers FLAMMABLE. • Make sure sprinklers and fire extinguishers are available and working.
Oxidizing material  Examples: organic peroxides, nitrates, perchlorates	Materials that provide oxygen or similar substance.	• May cause fire if in contact with flammable and combustible materials, even without a source of ignition or oxygen. • May increase the speed and intensity of a fire. • May cause materials normally considered non-combustible to burn rapidly. • May react with other chemicals to produce toxic gases.	• If the reaction can be violent, use barriers to isolate it. • Use only the minimum amount necessary. • Keep only the minimum amounts needed in the work area. • Keep the work area clear of unneeded materials that could react with the oxidizers. • Store away from flammable materials, organic materials, and reducing agents. • Do not open peroxide containers where crystals have formed around the lid.
Poisonous materials causing immediate and serious toxic effect  Examples: sodium cyanide, hydrogen sulfide	Materials that can cause the death of a person exposed to small amounts.	• May cause immediate and serious toxic effects. • May cause death or serious injury if inhaled, swallowed, or absorbed through the skin.	• Use appropriate control measures (e.g., fume hood, personal protective equipment). • Use engineering controls and personal protective equipment to eliminate or minimize exposure. • Establish wash-up and clean-up procedures to prevent contamination. • Ensure that workers understand the health hazards and the primary routes of exposure before using chemicals.

WHMIS hazard class	Class description	Hazards	Examples of safe work practices
Poisonous materials causing other toxic effects  Examples: acetone (skin irritant), asbestos (cancer causing), toluene diisocyanate (TDI) (sensitizing agent)	Under WHMIS classification D2, this includes material that may cause long-term and immediate health effects such as cancer, allergic reactions, disease of the organs, neurological problems, reproductive problems, sensitization, and skin, eye, and respiratory system irritation if workers are repeatedly exposed to small amounts of the chemical.		• Know the primary routes of entry (inhalation, skin contact, etc.).
Corrosive material  Examples: hydrochloric acid, sodium hydroxide	Caustic or acid materials that can destroy skin or eat through metals.	• Burns eyes and skin on contact. • Burns tissues of respiratory system if vapours are inhaled.	• Use corrosion-resistant equipment and containers. • Always use eye protection and gloves; use other personal protective equipment as appropriate. • Add acid slowly to water; never add water to acid. • Store acids and bases separately from each other. • In case of skin or eye contact with corrosives, flush area with cool water for 15 minutes, remove affected clothing, and get medical help.
Dangerously reactive material  Examples: plastic monomers such as butadiene and some cyanides	Products that can undergo dangerous reaction (burn, explode, or produce dangerous gases) when exposed to heat, light, physical movement (such as jarring, compression), water, moisture, or incompatible materials.	• May undergo vigorous decomposition, polymerization, or condensation upon standing or when exposed to heat, light, air, or physical movement. • May also be toxic, corrosive, flammable. • May become extremely reactive upon standing from time of purchase.	• If the reaction can be violent, use barriers to isolate it. • Use only the minimum amount necessary. • Keep only the minimum amounts needed in the work area. • Discard unopened materials within 12 months, and opened materials within 6 months.

For more information about safe work procedures, see your laboratory's safety manual.

Special hazards

Compressed gas cylinders

Compressed gas cylinders must be handled and maintained carefully to prevent falling or rolling during transportation, storage, or use, and to prevent the gas from escaping from the cylinder.

- Protect compressed gas cylinders from sparks, flames, excessive heat, physical damage, electrical contact, or corrosion.
- Secure compressed gas cylinders to prevent falling or rolling during storage, transportation, and use. Keep them in the upright position if possible.
- Keep the valve closed when the cylinder is empty or not in use.
- Do not stand directly in front of a regulator attached to a compressed gas cylinder when the cylinder valve is being opened.
- Unless a compressed gas cylinder is equipped with an integral valve guard, make sure the valve cover is in position when the cylinder is not connected for use.
- Use only standard fittings designed for the specific compressed gas service.
- An empty compressed gas cylinder must be identified as being empty and must be stored separately from other compressed gas cylinders.
- Use a compressed gas cylinder containing acetylene only in the upright position. If the cylinder has been stored or transported in a horizontal position, place it in the upright position for at least one hour before use.
- Do not use a fitting or tube made of copper or any alloy containing more than 67% copper in a system carrying acetylene gas, except for copper torch tips and lengths of copper tubing 30 cm (1 ft.) or less in length that are open to the atmosphere.
- Never use oxygen gas in any circumstance where it can contact a substance that oxidizes readily, such as a petroleum product, natural fibre, or metal powder. Never use oxygen gas to clean equipment or clothing, create pressure in a container, or ventilate a workplace.

For a list of safety requirements in working with substances under pressure, refer to Sections 5.36 to 5.47 of the Occupational Health and Safety Regulation.

For a description of several laboratory safety incidents involving compressed gas cylinders, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

For a compilation of safety tips for compressed gas users, see Appendix A on pages 55–57.

Peroxide formers

The formation of explosive levels of peroxides in laboratory solvents and reagents has caused many laboratory accidents. Although ethers are the most notorious peroxide formers, many other types of compounds also produce dangerous levels of peroxides. Peroxide inhibitors are sometimes added to such compounds, but may not be sufficient to control peroxide formation once the container has been opened. Because of this, peroxide-forming compounds must be inspected and tested regularly after the container has been opened. The employer must keep a record of these tests.

Table 4 summarizes the risk of peroxide formation posed by certain compounds, and the testing required as a result.[3]

3 This list provides examples only. Different categories may be found in the literature. Employers should consult the supplier information for specific details about any suspected peroxide former.

Table 4

Risk of peroxide formation	Testing required	Examples
Explosive peroxides formed during storage, without concentration	Regular (i.e., every 3 months) inspection and testing for peroxide formation after opening and before use	• Divinylacetylene • Isopropyl ether • Potassium metal • Tetrafluoroethylene • Vinylidene chloride
Explosive peroxide conditions produced upon concentration (for example, during distillation or upon evaporation during storage)	Regular (i.e., once every 12 months) testing for peroxide formation after opening and before use	• Acetal • Acetaldehyde • Benzyl alcohol • Cyclohexanol • Cyclohexene • Diacetylene • Dicyclopentadiene • Diethylene glycol dimethyl ether (diglyme) • Diethyl ether • Dioxane • Ethylene glycol dimethyl ether (glyme) • Methylacetylene • Tetrahydrofuran • Tetrahydronaphthalene (tetralin) • Vinyl ethers
Explosive polymerization initiated upon peroxide formation	• Regular (i.e., once every 12 months) testing for peroxide formation after opening • Addition of suitable peroxide inhibitor before distillation	• Acrylic acid • Acrylonitrile • Butadiene • Chloroprene • Chlorotrifluoroethylene • Methyl methacrylate • Styrene • Tetrafluoroethylene • Vinyl acetate • Vinylacetylene • Vinyl chloride • Vinylidene chloride • Vinylpyridine

Labelling

All compounds listed in Table 4, and all other compounds known to form peroxides, should be properly labelled. A recommended label for such compounds is:

WARNING: MAY FORM PEROXIDES

Discard or test within ______ months after opening.

Do not use chemical if greater than 100 ppm peroxides are detected.

Date Received ____________ Date Opened _____________

Test Dates ___________ ___________ ___________ ___________

Storage

Each laboratory must keep an inventory of all peroxidizable material. The inventory should be reviewed periodically, and compounds should be tested for peroxide formation or discarded. Store all peroxide-forming compounds in sealed, air-impermeable containers, away from heat and light and protected from physical damage and sources of ignition. Watch for any visible discoloration, crystallization, or liquid stratification, and treat such compounds as potentially explosive.

Purchase, store, and use the minimum quantity of peroxidizable substances necessary.

Detection of peroxides

If the solvent has been stored past the expiry date, disposal is preferable to testing.

Bottles of peroxidizable materials must be tested regularly after being opened. There are several methods to detect peroxides. The simplest is to place a few drops of the solvent onto a peroxidase-containing test strip using a Pasteur pipette. If the paper strip turns blue, peroxides are present at unacceptable levels. The solvent must be disposed of using safe work procedures or must be treated chemically to eliminate the peroxides.

For information on safe disposal of peroxide-containing solvents, refer to:

- Chemicals That Form Peroxides: Handling and Storage (Ohio State University)
- Special Chemical Handling Procedures: Peroxide Forming Compounds & Picric Acid (Medical College of Georgia)

Azide hazards

Soluble azides (for example, sodium azide) in contact with heavy metals such as copper, lead, and brass can produce insoluble heavy metal azides, which are heat- and shock-sensitive explosives. Sinks, drains, and constant-temperature baths containing heavy metals are areas where potentially explosive conditions can exist if azides are present and if the area is allowed to become dry. In laboratories, a common source of azides is the blood analyzers found in diagnostic labs. The drains that capture the effluent from blood analyzers can develop hazardous amounts of azides if they are not properly flushed out.

The best way to deal with azides is to prevent their formation. In places where they might be present, dilution is the best control. Flushing with large quantities of water should eliminate the hazard.

Picric acid

Bottles of picric acid containing less than 10% water should be considered as shock-sensitive high explosives. *Never shake a bottle of picric acid!*

Place the date on bottles and check them regularly to ensure that their moisture content is greater than 10%—the contents of the bottle should be visibly damp. Alternatively, many chemists store picric acid in airtight containers under water. Do not allow solutions to dry around the threads of the cap. If the substance in the bottle looks dry, *dispose of the bottle as soon as possible*.

Workers who dispose of these containers must be instructed in the applicable hazards, precautions, and safe disposal methods. If unsure of how to dispose of anhydrous picric acid, call your local fire department or the nearest WorkSafeBC office for advice (see the list of offices at the back of this publication).

Perchloric acid

Perchloric acid is a colourless, fuming, oily liquid at room temperature. It is a very strong acid, and causes severe burns to the skin, eyes, and respiratory tract. A strong oxidizing agent, it forms explosive mixtures with organic materials such as wood, paper, cardboard, and many organic solvents. Aqueous perchloric acid can cause violent explosions if not handled properly, for example, if it comes in contact with incompatible substances. Clothing and rubber materials become highly flammable if contaminated with perchloric acid.

Perchloric acid is incompatible with the following chemicals and must not be stored with them because of the danger of explosion or fire:

- Acetic acid
- Acetic anhydride
- Alcohols
- Aniline and formaldehyde mixtures
- Antimony compounds (trivalent)
- Bismuth
- Dehydrating agents
- Diethyl ether
- Fluorine
- Glycerine and lead oxide mixtures
- Glycols
- Glycol ethers
- Hydriodic acid
- Hydrochloric acid
- Hypophosphites
- Ketones
- Nitrogen triiodide
- Nitrosophenol
- Organic matter (paper, wood, charcoal, rags, cotton, etc.)
- Sodium iodide
- Sulfoxides
- Sulfur trioxide

Venting

Perchloric acid vapours condense to form perchlorate crystals, which are highly explosive and sensitive to physical shock, especially inside fume hoods and duct linings. For this reason, use perchloric acid only in specially designed fume

Anhydrous perchloric acid is unstable even at room temperature, decomposing spontaneously and exploding violently. For this reason, do not store anhydrous perchloric acid for more than one day. Use only freshly prepared anhydrous perchloric acid, and following appropriate procedures, dispose of any unused portion at the end of each experiment or procedure or at the end of the work day, whichever comes sooner.

hoods that are designated for use exclusively with perchloric acid. A notice posted on the fume hood must identify it as being for perchloric acid use and must prohibit the use or storage of combustibles in the hood, as in the following example:

— PERCHLORIC ACID HOOD —
— KEEP COMBUSTIBLES OUT —

Exhaust ducts must be as short as possible. They must be routed directly outdoors, with no interconnections to other exhaust ducts. The fume hood and duct work are usually made of stainless steel and must have wash-down facilities. The ducting and hood should be washed down at least once a day when in use.

Heating perchloric acid

Use electric hot plates, steam-heated sand baths, or steam baths to heat perchloric acid. Do *not* use direct flame, oil baths, or electric hot plates with electric motor–driven stirrers (use pneumatically driven stirrers only).

Storing

If used daily, a maximum of 6.4 kg (14 lbs) of perchloric acid may be stored in a laboratory. If the laboratory facility consists of several smaller laboratories physically separated by fire retardant partitions, a maximum of 6.4 kg of perchloric acid may be stored in each laboratory. At the point of use, no more than a 0.45 kg (1 lb) bottle should be handled.

Do not store perchloric acid near, or on, wood or similar combustible or flammable materials. Perchloric acid should be stored in bottles on glass or ceramic trays capable of holding a volume greater than that of the stored acid. Store bulk or reserve quantities of perchloric acid on acid-resistant, non-combustible shelves in a non-combustible structure.

Inspect all bottles of perchloric acid once a month, and keep a record of such inspections. If you note any discoloration, dispose of the bottle immediately.

Spill clean-up

Spilled perchloric acid is a fire and explosion hazard in the laboratory or bulk storage area. Clean-up must be done only by trained personnel wearing protective equipment. Contain the spill using non-combustible material such as sand or earth. Immediately neutralize the spilled acid with a reducing agent such as sodium bisulfite or ferrous sulfate. Transfer the sludge to a container of water and neutralize with soda ash before disposal. Keep the waste material moist. Flush the area of the spill with water.

For a description of several laboratory safety incidents involving perchloric acid, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Other potentially explosive compounds

The following compounds are materials that may readily detonate, decompose, or react explosively at normal temperatures and pressures. These examples also include materials that are sensitive to mechanical or local thermal shock. Treat all of these compounds and any other potentially explosive compounds with extreme caution. Use adequate safety equipment when handling them.

- Acetyl peroxide (25% solution in dimethyl phthalate)
- Ammonium perchlorate
- 3-bromopropane (propargyl bromide)
- *tert*-butyl hydroperoxide
- *tert*-butyl perbenzoate

- *tert*-butyl peroxyacetate (75% solution in benzene)
- *tert*-butyl peroxypivalate (75% solution in mineral spirits)
- 1-chloro-2,4-dinitrobenzene
- Cumene hydroperoxide
- Diacetyl peroxide
- Dibenzoyl peroxide
- tert-butyl peroxide
- Diethyl peroxide
- Diisopropyl peroxydicarbonate
- O-dinitrobenzene
- Ethyl methyl ketone peroxide
- Ethyl nitrate
- Nitroglycerine
- Nitromethane
- 2-nitro-p-toluidine
- Peroxyacetic acid (diluted with 60% acetic acid solution)
- Trinitrotoluene
- Trinitrobenzene

Designated substances

"Designated substances" are listed in the Table of Exposure Limits for Chemical and Biological Substances in Guideline 5.48-1 to Part 5 of the Occupational Health and Safety Regulation and defined in Guideline 5.57 to Part 5 of the Regulation. The different designations are as follows:

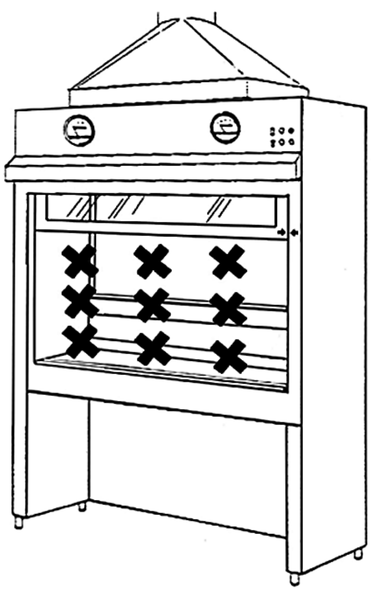
Table 5

Designation	Description
Carcinogens	
ACGIH A1	Confirmed human carcinogen
ACGIH A2	Suspected human carcinogen
IARC 1	Human carcinogen
IARC 2A	Probable human carcinogen
IARC 2B	Possible human carcinogen
Reproductive toxins	
Reproductive critical effects	Substance has the potential for an adverse reproductive effect, including effects on both female and male reproductive organs, tissues, or cells; effects on fertility; effects on the embryo or fetus; effects that have been demonstrated to cause developmental abnormalities; tumour-causing effects; and effects on the newborn.
Sensitizers	
Sensitization critical effect SEN notation	This critical health effect refers to the potential for a substance to produce sensitization as confirmed by human or animal data. Depending on the substance, workers can become sensitized to the substance through the respiratory system, the skin, or the eyes. Sensitization often involves a response by the body's immune system. Initially, there may be little or no response to a sensitizing substance. However, after a person is sensitized, subsequent exposure may cause severe reactions even at low exposure concentrations, including at levels below the exposure limit.
Other	
L endnote	"L" is defined as "exposure by all routes should be carefully controlled to levels as low as possible." Examples of these highly toxic substances include benzo(a)pyrene, polytetrafluoroethylene decomposition products, and rosin core solder thermal decomposition products (colophony).

Designated substances must be replaced with less hazardous substances wherever practicable. A laboratory that works with one of these substance must have an exposure control plan to eliminate workers' exposure or reduce it to a level that meets the Occupational Exposure Limits.

Fume hoods

An important exposure control measure used in many laboratories is the ventilated work enclosure commonly called a **fume hood**. Fume hoods protect workers from hazardous exposure to airborne contaminants by capturing fumes, dusts, vapours, and gases generated inside the hood and discharging them safely. Because of the large amounts of air that pass through an operating fume hood, the fume hood is also an important component of the laboratory's general ventilation system.



There are three common types of fume hoods:

- The air velocity entering a **conventional** fume hood is affected by the height of a vertically travelling sash or the lateral positioning of the two or three horizontal sashes.
- A **bypass** fume hood maintains a relatively constant air velocity regardless of sash setting. It is useful when delicate experiments may be affected by differing air speeds at different sash settings.
- **Canopy-style** fume hoods have poor capture efficiency at any appreciable distance from the hood, and the upwardly drawn fumes pass through the worker's breathing zone. They are not recommended for general laboratory use, but may be useful over furnaces or flames, where convection currents help carry fumes upward.

Using fume hoods safely

Labelling

Fume hoods must be clearly labelled with any use restrictions that apply. For example, a perchloric acid fume hood must be labelled to keep combustibles out. A fume hood used for storing chemicals must be labelled to warn workers against using the hood for other purposes.

Monitoring airflow

Air velocities across the operational face[4] of a fume hood must be measured and recorded at least once a year. Air velocities must also be measured if the system does not seem to be working well, and after any repairs or maintenance that could have affected the airflow. As fan belts age, for example, they may loosen and slip, resulting in a loss of air flow.

Air velocities can be measured with direct reading air velocity meters such as hot-wire anemometers. To determine the average and minimum fume hood air velocity, it is usually enough to measure the air velocity at about nine points in a grid pattern across the operational face.

4 The operational face of a conventional fume hood with a vertical travelling sash is the cross-sectional area of the face opening of the fume hood.

Fume hoods in laboratories must provide *average* air velocities across the operational face opening of between 0.4 metres per second (80 feet per minute) and 0.6 metres per second (120 feet per minute). The face velocity must not be less than 80% of the average face velocity or greater than 120% of the average face velocity. For more information on fume hood airflow requirements refer to Section 30.8 of the Occupational Health and Safety Regulation.

If the average or minimum measured air velocity is less than the required rate when the sash is at maximum height, lower the sash until the required air velocity is achieved. Mark this height as the maximum height to which the sash may be raised.

(**Note:** It may be possible to increase the overall ventilation rate of the fume hood to achieve the required velocity over the operational face.)

If very toxic or radioactive materials are used in a fume hood and harm to workers may result from inadequate air flow, the airflow must be continuously monitored. This involves continuous air velocity or flow measurement (using manometers, pressure gauges, pressure switches, and other devices that measure the static pressure in the air ducts) coupled with an effective warning device to alert workers if the airflow stops or is reduced to unacceptably low levels.

Cross drafts created by personnel traffic, air supply inlets, or the opening and closing of doors or windows can disrupt the airflow across the operational face. Fume hoods must be located so as to prevent or minimize these and other disruptive forces. Smoke tests (for example, using air current tubes) should be made to visually assess the uniformity of air currents entering the fume hood. The baffles of the hood should be adjusted to provide a uniform airflow across the operational face.

Design and construction requirements

Fume hoods must be constructed of materials compatible with their use.

Location of controls

The controls for operating a fume hood must be located outside the fume hood and be immediately accessible to the laboratory worker. Water taps may be located inside the fume hood if the main shutoff valve is outside the hood.

Ducting

Fume hoods located in the same room or separate rooms may be connected to a common exhaust duct or manifold system if the following conditions are satisfied:

- The requirements of section 5.3.2 of *ANSI/AIHA Standard Z9.5-2003, Laboratory Ventilation* are met.
- Effective controls are installed to prevent backdrafts and pressure imbalances between rooms.
- The ventilation design and installation is certified by a professional engineer.

Fume hoods used for perchloric acid or radioactive materials must not be connected to a manifold system. Infectious agents must be handled in biological safety cabinets that exhaust to the outdoors through dedicated ducting. Other restrictions regarding the design and use of fume hoods can be found in the Occupational Health and Safety Regulation.

Storing chemicals

Storage facilities

The first step in organizing chemical stocks in laboratories and storerooms is to establish an inventory. All containers should be labelled with a purchase date and, where applicable, an expiry date. Chemical stocks should be reviewed at least once a year. Chemicals that have expired or deteriorated must be disposed of safely.

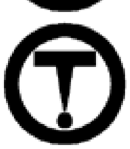
Laboratories should have separate storage facilities for chemicals. Working quantities (small containers of chemicals that are used daily or frequently) can be stored in cupboards or low shelving (below eye level) equipped with either sliding doors or lips that will prevent containers from falling off the shelves. Containers of chemicals stored in laboratories should be the smallest size practicable. Do not store extra containers of the same chemical in the laboratory unless they are being used daily.

Do not store chemicals in fume hoods unless the fume hoods are used exclusively for this purpose and are labelled as a storage area only. Do not store chemicals other than dilute reagents in work areas such as open work benches or shelving on the work benches.

Special storage requirements

Chemical storage facilities may require special cabinets and modified shelving, depending on the chemicals being stored. Table 6 summarizes the laboratory use and storage requirements for specific categories of chemicals. For definitions of the categories, see Table 3 on pages 17–19.

Table 6

Category	Laboratory use	Storage requirements
Flammable and combustible liquids 	• Keep only the amount needed for the work day. • Daily working quantities should be kept to a minimum. • Use only single, small, daily-use-sized containers. • Use safety cans or approved containers whenever practical.	• It is recommended that not more than 454 litres (120 gallons) of flammable and combustible liquids be stored in a storage cabinet. • Storage cabinets must be conspicuously labelled to indicate that they contain flammable liquids and that open flames must be kept away. • Containers should not exceed 4.6 litres (use safety cans or approved containers whenever practical). • No combustible material is permitted in storage rooms. • Do not store in or adjacent to exits, elevators, or routes that provide access to exits. • Consult the 2006 BC Fire Code and your local fire department for specific details. • If flammable liquids are to be stored cold, the refrigerators and freezers must meet explosion proof standards.
Toxic chemicals  	• Use only single, small, daily-use-sized containers.	• Store according to manufacturer's recommendations, away from incompatible chemicals.

Category	Laboratory use	Storage requirements
Explosive and highly reactive chemicals 	• Keep only the amount needed for the work day. • If explosions or implosions may result from laboratory work, provide adequate shielding for equipment used in such work. Workers must wear personal protective equipment.	• Store in cool, dry area away from normal work areas and protected from shock, vibration, incompatible chemicals, elevated temperatures, and rapid temperature changes.
Oxidizing agents 	• Use only single, small, daily-use-sized containers.	• Store in a fire-resistant, cool, and well-ventilated area. • Store according to manufacturer's recommendations, away from incompatible chemicals.
Corrosive chemicals 	• Use only single, small, daily-use-sized containers.	• Store in cool, dry, well-ventilated areas on corrosion-resistant material. • Segregate acids and bases.
Water-sensitive chemicals	• Use only single, small, daily-use-sized containers.	• Store in cool, dry areas designed to prevent accidental contact with water and other incompatible substances. • Storage construction should be fire-resistant. • Protect chemicals from water from sprinkler systems.
Compressed gases 	• Keep in the lab only the number of cylinders in daily use. • Label cylinders with the rated pressure and type of gas. • Keep all compressed gas cylinders upright and fully secured against falling. • Keep valve caps on all cylinders not in use. • Before using cylinders, check all fittings and regulators for defects, leaks, oil, and grease. • Use acetylene cylinders in upright position only. If such cylinders have been stored or transported horizontally, let them stand upright at least 1 hour before use.	• Store compressed gas cylinders in a well-ventilated area, segregated from flammable and corrosive materials. • Separate flammable gases from oxidizing gases with non-combustible partitions. • Protect cylinders from excessive variations in temperature, ignition sources, and direct contact with the ground. • Keep all compressed gas cylinders upright and fully secured against falling. • If pressure testing is required, indicate on the cylinder when it was pressure-tested. • Label empty cylinders and store them separately from other cylinders.

Incompatible chemicals

It is not good practice to simply store chemicals on shelves in alphabetical order by name. Each chemical must be evaluated to determine where and how it should be stored. Manufacturers' recommendations should be followed. As a general rule, flammable or combustible liquids, toxic chemicals, explosive chemicals, oxidizing agents, corrosive chemicals, water-sensitive chemicals, and compressed gases should be segregated from each other. They must be stored in such a way that they will not mix with each other if a container leaks or breaks.

Table 7 provides examples of incompatible chemicals.

Table 7

Chemical	Incompatible with the following common chemicals[5]
Acetaldehyde	Acetic anhydride, acetic acid, acetone, ethanol, sulfuric acid
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures, and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkaline metals such as powdered aluminum or magnesium, sodium, potassium	Water, carbon tetrachloride and other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, chromic acid, hydrogen peroxide
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Diborane, fluorine, sodium
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerine, alcohol, turpentine, all other flammable liquids
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide

5 This column lists common examples but does not provide a comprehensive list of incompatible chemicals for each chemical in column 1.

Chemical	Incompatible with the following common chemicals
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Dimethyl sulfoxide	Perchloric acid, silver fluoride, potassium permanganate, acetylchloride, benzene sulfonyl chloride
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	*Isolate from all other chemicals.*
Hydrocarbons such as butane, propane, benzene, and gasoline	Fluorine, bromine, chlorine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, combustible materials
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia, oxalic acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Oxalic acid	Silver, mercury
Perchloric acid	*See the section on perchloric acid on page 23.*
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (and similar compounds of light metals such as sodium, lithium)

For details on the specific chemicals used in your laboratory, see *Bretherick's Handbook of Reactive Chemical Hazards*, 7th edition (2006), edited by Peter Urben.

A "Chemical Reactivity Worksheet" is also available from the US National Oceanic and Atmospheric Administration. The Chemical Reactivity Worksheet is a free program that can be used to find out about the reactivity of substances or mixtures of substances. It includes a database of reactivity information for more than 4,000 common hazardous chemicals, and enables users to virtually mix chemicals to find out what dangers could arise from accidental mixing.

For a description of several laboratory safety incidents involving incompatible chemicals and oxidizers, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Cleaning up chemical spills

Clean-up of chemical spills must be supervised by workers who are knowledgeable about the hazards involved and who have been trained in safe clean-up procedures. Before attempting to clean up a particular spill, workers must consult the material safety data sheet for information on specific spill clean-up procedures and personal protective equipment required.

Workers must be aware of all hazards associated with the chemical or chemicals that require clean-up. For example, when cleaning up flammable solvents, use an absorbent material that controls flammable vapours as well as the flammable liquid. Commercial spill kits are available for cleaning up hazardous chemicals such as flammable liquids, acids, bases, formaldehyde, cyanide, mercury, and hydrofluoric acid.

Handling chemicals

Containers

Containers must be compatible with and resistant to their contents. For example, hydrofluoric acid must not be stored in glass containers, and tetrahydrofuran-chlorinated solvent mixtures must not be stored in stainless steel safety cans.

Inspect chemical stocks regularly. Dispose of damaged containers or those that have deteriorated. Keep containers securely closed, although some—for example, lithium aluminum hydride, formic acid, nitric acid, and chromic acid—may need to be vented periodically to prevent a potentially explosive build-up of gases.

It is good practice to label containers with the purchase date of the chemical and the date when the container is opened. Chemicals stored in other than their original containers should also be dated.

In general, keep containers sealed or covered when not in use.

Transporting chemicals

Containers of dangerous chemicals must be transported through the laboratory in a safe manner, so that there is no risk of damage to the containers. Use carrying cases of rubber or plastic to transport corrosive materials, such as acids and bases, in laboratory and storage areas. If a bottle breaks, these cases help contain the spill.

Permitted quantities

Bulk amounts or reserve quantities of laboratory chemicals must be stored away from the work area. Only the minimum amounts of combustible, flammable, corrosive, toxic, biohazardous, or highly reactive substances needed for work in progress may be kept in the working area of the laboratory.

Labelling

Employers must comply with WHMIS requirements regarding both supplier and workplace labels (see pages 14–16). Labels must be replaced if they become illegible or damaged. Illegible labels can create first aid, handling, and disposal problems.

Use safe work procedures when handling chemicals

A laboratory technician ran out of acetic acid, which he was using as a reagent for a laboratory analytical procedure. In the chemical storeroom, he found that the glacial acetic acid in the glass carboy had crystallized. He placed the carboy on a warm hot plate to resolubilize the acid. A few minutes later, the carboy broke, spilling 20 litres of acid over the hot plate, bench, and floor. The laboratory was evacuated, and the spill clean-up crew responded and cleaned up the spill. Fortunately, no one was injured in this incident.

Remember:

- Plan experiments and procedures in advance so that the necessary reagents and equipment are available when required.
- Use only safe work procedures when preparing reagents.
- Develop written spill procedures for a trained spill response team to use.

Controlling biological agents

What is a biological agent?

A biological agent is an organism that has a classification given by the World Health Organization or Health Canada as a Risk Group 2, 3, or 4 human pathogen that causes an adverse health effect. Risk group classifications are based on factors such as:

- Severity of disease caused
- Route of infection
- Availability of effective treatment or immunization
- Possible effects on other species of plants or animals

The four risk groups are described in the *Laboratory Biosafety Guidelines* published by Health Canada. Complete definitions of the risk groups and safe work practices are found in the *Guidelines*. Health Canada also publishes material safety data sheets (MSDSs) for selected micro-organisms. More information can be found on Health Canada's Office Of Laboratory Security web site.

Each risk group has a corresponding **containment level** for working safely with the pathogens in the group. *Laboratory Biosafety Guidelines* lists the physical and operational requirements for each level. Your lab should be appropriately equipped and have written procedures for its containment level.

Biological toxins (e.g., insect toxins, fungal allergens, mycotoxins, bacterial endotoxins, etc.) that cause an adverse health effect are also biological agents.

An adverse health effect means an acute or chronic injury, acute or chronic disease or death.

How do laboratory infections occur?

Micro-organisms can enter the body through the skin or through contact with mucous membranes (e.g., eyes, mouth). Laboratory workers can acquire infections through:

- Accidental inoculation resulting from injury with broken glass or sharp objects such as needles and scalpels, or from animal bites or scratches
- Accidental ingestion as a result of mouth pipetting; eating, drinking, and smoking in the lab; or improper personal hygiene
- Splashing of the face or eyes with infectious materials
- Direct transfer of micro-organisms from a contaminated hand to the face or eyes following a spill
- Inhalation of infected airborne particles such as those found in aerosols

For a description of several laboratory safety incidents involving infectious agents, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Aerosols

Aerosols are a major factor in the spread of biological agents. They consist of liquid droplets or solid particles dispersed in a gaseous medium such as air. They are produced when many common laboratory techniques (such as grinding, blending, centrifugation) and instruments (such as loops, pipettes, needles and syringes) are used. Biological aerosols may contain suspensions of bacteria (such as that causing tuberculosis), viruses, parasites, or fungi. The particles can travel great distances on air currents produced by ventilation systems or movements of people. The smaller the particles and the greater their concentration in the aerosol, the greater their chances of reaching the alveoli of the lungs and causing infection.

High efficiency particulate air (or **HEPA)** filters in biological safety cabinets (see page 39) will trap aerosols. A centrifuge can be operated in the laboratory without producing a lot of aerosols if screw-capped safety cups and sealed centrifuge heads are used and are opened in a biological safety cabinet.

Employers' responsibilities

Employers must maintain a list of job titles for which there is a risk of occupational exposure to biological agents. All tasks and procedures that carry this risk must be identified.

Employers of workers who may have occupational exposure to a biological agent must also develop an exposure control plan and educate workers in the contents of the plan. The laboratory should have a safety manual that identifies the biohazards that may be encountered and specifies practices and procedures to minimize or eliminate the risks. Workers must receive training in these practices and procedures, and employers must keep a record of all such education and training.

Laboratories may require a biological safety officer (BSO) or a biological safety committee. The duties of a BSO include providing technical advice on safety procedures and equipment, developing biosafety plans and training, and ensuring that all work is done according to the lab's safety practices and procedures.

Vaccinations

Employers must offer vaccination against the hepatitis B virus at no cost to a worker who has, or may have, exposure to this virus and who requests such vaccination. Employers must also offer vaccines listed in the *Communicable Disease Control Immunization Program Manual* issued by the BC Centre for Disease Control, to all workers who are at risk of occupational exposure to those biological agents.

Acceptance of the vaccination is voluntary on the part of the worker. Employers should make workers aware of the offer and retain a signed record of such an offer.

Medical evaluation

A worker who may have been exposed to a biological agent designated as a hazardous substance in section 5.1.1 of the Regulation must be advised to get a medical evaluation right away. Employers must keep a record of all workers who are exposed to any biological agents on the job.

Measures to minimize or eliminate exposure

A variety of measures are used to minimize or eliminate exposure to biological agents, such as:

- Engineering controls
- Personal protective equipment
- Safe work practices
- Standard or routine infection control precautions and transmission-based precautions
- Housekeeping practices
- Waste disposal procedures
- Labelling

Engineering controls

As mentioned earlier, your lab should be appropriately equipped and have written procedures for its containment level. The higher the containment level, the more specialized the lab's design and equipment needs are. For information about laboratory location, design, operation, and personal hygiene and safety facilities, see the World Health Organization's *Laboratory Biosafety Manual*.

Personal protective equipment

Examples of personal protective equipment include the following:

- **Laboratory clothing** (such as gowns, coats, and aprons) should always be worn, and in most cases must be worn, depending on the risk factors present in the laboratory and should cover the arms and most of the middle part of the body. Properly fasten lab clothing, and wear only in lab areas. Footwear typically must have closed toes and heels and non-slip soles. Shoe covers can be used; workers are strongly advised to change from street shoes.
- **Gloves** must be worn for all procedures where there may be direct skin contact with infectious materials. Remove rings and other jewellery before gloving. After handling infectious material, proper techniques for removing gloves make it difficult to reuse the gloves without risk of contamination when attempting to pull them on again. Do not reuse gloves. Because minute leaks—and therefore possible contamination—can be difficult to detect, wash your hands thoroughly after removing gloves.

  Some people are allergic to latex gloves. For more information, see the WorkSafeBC publication *Dealing with "Latex Allergies" at Work*.
- **Respiratory protection equipment** must be worn when required by a regulation or when other measures fail to eliminate the risk of inhaling toxic or infectious materials.

  A wide range or respiratory equipment is available. Selection should be based upon knowledge of the organisms, procedures, the risks involved, and the level of protection needed. Effective decontamination of reusable respirator units is essential, as the respirators' outer surfaces and cartridges can become incubators or mechanical vectors for pathogenic organisms.
- **Eye or face protection** such as goggles, face shields, and safety glasses. Safety glasses provide protection against projectiles or broken glass, whereas goggles and face shields provide protection against chemical or biological splashes. Wearers of contact lenses or ordinary eyeglasses should use the same protective devices as other workers.

For more information, refer to the University of British Columbia's *Laboratory Biosafety Reference Manual*.

Safe work practices

A number of work practices can minimize the risk of exposure to biohazardous materials.

- Wear appropriate personal protective equipment, as described earlier.
- Do not eat, drink, smoke, store food or utensils, apply cosmetics, or insert or remove contact lenses in the lab.
- Tie back or otherwise restrain long hair.
- Do not pipet by mouth. Always use a mechanical pipetting device. Delivery should be slow to avoid producing aerosols.
- Wash hands frequently, especially after exposure to blood or fluids that might carry bloodborne pathogens, after a glove tear or leak, after removing gloves, before leaving the lab, and anytime you handle materials that may be contaminated.
- To minimize the risk of accidental inoculation, limit your use of needles, syringes, and other sharp objects. Do not reuse needles or return them to their sheaths. Do not recap needles before disposal, unless the recapping device is designed for single-handed use or is otherwise designed for safe

recapping. After using a needle, place it in a puncture-resistant “sharps” container.

Because aerosols can be produced when fluid is ejected from a needle or when a needle is separated forcefully from a syringe, certain procedures involving needles may need to be done in a biological safety cabinet. Consult your laboratory’s safety manual for details.

- Minimize production of and exposure to aerosols that may contain biohazardous materials. For example:
  - Eject fluid from needles or pipettes slowly.
  - Perform aerosol-generating procedures in a fume hood or biological safety cabinet.
  - When working with risk group 2 agents, open sealed centrifuge safety heads, rotors, or trunnion caps in a fume hood or biological safety cabinet, unless you can determine visually (for example, by using clear safety caps) that no breakage or leaking has occurred.
  - When working with risk group 3 agents, load and unload sealed centrifuge safety heads, rotors, or trunnion caps in a biological safety cabinet.
- Report all spills, accidents, and actual or potential exposure to the laboratory supervisor.

For more information, refer to:

- *Laboratory Biosafety Manual* (World Health Organization)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

All work involving risk group 4 micro-organisms must be done according to WHO guidelines or other standards acceptable to WorkSafeBC.

Standard precautions

Workers handling biological agents must use a system of **standard precautions** for all tasks and procedures identified as having the potential for occupational exposure. The term *standard precautions* refers to a system of infection control designed to prevent the transmission of pathogens. Standard precautions require that all patients are assumed to be positive for a pathogen, and that *all* human blood and other potentially infectious material be treated as though they were known to be infectious.

For lab workers, standard precautions complement, and to some extent overlap with, the other practices and procedures described in this handbook. They include the following:

- Wear gloves and a lab coat if you anticipate coming in contact with blood or other potentially infectious material. Change the gloves if they become contaminated and periodically during the day. Do not reuse gloves. (Some persons are allergic to latex gloves. For information, see the WorkSafeBC publication *Dealing with “Latex Allergies” at Work*.)
- Remove gloves when touching non-contaminated items such as telephones, computer keyboards, and so on. Designate “clean” areas and “dirty/clean” pencils, pens, notepads, and so on.
- Wash hands frequently, including after removing gloves.
- If a leaking specimen arrives at the lab, dispose of it appropriately and request a new specimen.
- Wear face shields, masks, or goggles to protect against splashes or aerosols.
- Perform aerosol-generating procedures and open specimen tubes in a fume hood or biological safety cabinet.

The laboratory should have or provide for:

- Medical assessments and immunizations of workers
- Worker education about the risks associated with biological agents
- Emergency procedures after an accidental exposure
- Post-accident follow-up and counselling
- Procedures for treatment and disposal of contaminated items
- A biological spill response procedure

For more information, refer to:

- *Infection Control Guidelines—Hand Washing, Cleaning, Disinfection and Sterilization in Health Care* (Health Canada)

Housekeeping practices

A number of housekeeping practices can minimize the risk of exposure to biohazardous materials.

- Keep the lab clean and orderly. Minimize the storage of materials not pertinent to the work.
- Keep lab clothing separate from street clothing.
- Decontaminate all infectious liquids or solids before disposing of them. For more information on decontamination procedures, see pages 42–43.
- Clean and decontaminate work surfaces at the end of the day or after any spill of potentially hazardous material.
- Inform cleaning and maintenance staff of the hazards that might be found in the lab. Cleaning staff should clean only the floors.
- Do not wear lab clothing outside the lab. For containment levels 3 and 4, lab clothing should be removed after the work is done, and autoclaved before being laundered. Do not wear street clothing under the protective clothing. After leaving the lab, shower before putting street clothing back on.
- Contaminated laundry must be isolated and bagged, and handled as little as possible. Make sure that sharps are not accidentally discarded in laundry.

For more information, refer to:

- *Guidelines for Laundry in Health Care Facilities* (CDC/NIH)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

Waste disposal

Each lab must have well-defined waste disposal procedures to protect not only lab workers but also maintenance and cleaning staff from exposure to biohazardous materials. Cleaning staff, for example, are vulnerable to injury from needles or broken glass that have not been properly disposed of.

- Place used needles, syringes, scalpel blades, and other sharp items in puncture-resistant sharps containers. These containers must be identified and labelled. *Do not overfill sharps containers.* Containers should have a maximum fill line clearly marked.
- Place glass waste in "Glass Waste Only" containers. *Do not fill the containers more than ¾ full or use them for needles and other sharps.*
- Autoclave microbiological waste (cultures, specimens) before disposal. Incinerate pathological waste if possible.
- Before transporting contaminated materials from the lab, disinfect the outside of the container or double-bag the materials.
- Decontaminated bulk blood, fluids, and secretions may be carefully poured down drains connected to the sewer system. Avoid splashes or contact with these fluids.

If a system of standard precautions is used when handling waste contaminated with a biological agent, a distinctive-coloured bag may be used to identify the hazard.

For more information, refer to:

- *NIH Guide to Waste Disposal* (National Institutes of Health)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)
- *Selecting, Evaluating, and Using Sharps Disposal Containers* (National Institute of Occupational Safety and Health)

Labelling

A container holding a known or suspected biological agent must be clearly identified by the biohazard symbol as described in the *Controlled Products Regulations* (Canada) or by other means that indicates the presence of a biological agent. Other means may include:

- Product identifier (such as a product name or product number)
- Name of the organism known or suspected to be present
- Biohazard symbol or information on the safe handling of the material
- Reference to a material safety data sheet (MSDS), if one has been prepared

A laboratory sample of a known or suspected biological agent must be transported in accordance with the federal *Transportation of Dangerous Goods Act* (Canada).

For more information about labelling and transporting of biohazardous materials, refer to:

- *Guidelines for the Safe Transport of Infectious Substances and Diagnostic Specimens* (World Health Organization)
- *Laboratory Biosafety Guidelines* (Health Canada)
- *Biosafety in Microbiological and Biomedical Laboratories* (CDC/NIH)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

Biological safety cabinets

Biological safety cabinets (BSC) are ventilated cabinets designed to protect workers and the environment from infectious agents, especially those found in aerosols. Some cabinets also protect the material being handled from the environment.

All biological safety cabinets have a system of air supply and removal that minimizes the escape of aerosols from the cabinet. They use one or more high efficiency particulate air (HEPA) filters to remove biological agents from the air before the air is recirculated in or discharged from the cabinet. HEPA filters remove particles as small as 0.3 micrometres at an efficiency rate of 99.99%.

Classes of BSC

There are three classes of BSC. In order of increasing protection provided, these are Class I, II, and III. Cabinets of all classes protect workers from infectious agents. Class II and III cabinets also protect the material being handled from inadvertent contamination by particles and aerosols carried in surrounding laboratory air. The limitations of a biological safety cabinet must be clearly posted on the unit and followed by lab workers.

The major functional differences between the classes have to do with their air circulation and filtration systems. Organisms belonging to risk groups 3 and 4 (as described on page 34) must be contained in accordance with the World Health Organization guidelines.

Class I

Class I cabinets exhaust HEPA-filtered air back into the laboratory or are ducted to the outside. The air passing over the work surface is not HEPA-filtered. Glove ports, with attached rubber gloves for accessing the work area, may be present or absent.

Class II

Class II cabinets may be used for handling biological agents of low to moderate risk. Both the air supply and the exhaust air are HEPA-filtered. There are four designs:

- Type A1 Cabinets:
  - Maintain a minimum average face velocity of 0.38 m/s (75 ft/min).
  - 70% of the exhaust air recirculates through the HEPA filter back into the work zone.
- Type A2 Cabinets:
  - Maintain a minimum average face velocity of 0.5 m/s (100 ft/min).
- Type B1 Cabinets:
  - Maintain a minimum average face velocity of 0.5 m/s (100 ft/min).
  - Recirculate 30% of the air within the cabinet.
- Type B2 Cabinets:
  - Do not recirculate air within the cabinet.
  - Maintain a minimum average face velocity of 0.5 m/s (100 ft/min).

Recirculation of air into the workspace is prohibited if volatile toxic materials or flammable liquids or gases are used in the cabinet, or if radioactive materials are used in amounts greater than the exemption quantity specified by the Canadian Nuclear Safety Commission (www.nuclearsafety.gc.ca). Specified amounts may be identified on the licence for radioactive materials that must be displayed in the workplace. The suitability of these cabinets for volatile toxic chemicals and radionuclides is dependent on cabinet design and engineering. Table 2 in *Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets* (CDC/NIH) and Appendix A, Table 1 in *Biosafety in Microbiological and Biomedical Laboratories* (CDC/NIH) compare the characteristics of the different cabinets and should be consulted before working with these materials.

Class III

Class III cabinets are totally enclosed and gas-tight with HEPA filtered supply and exhaust air. Work is performed with attached long-sleeved gloves. The cabinet is kept under negative pressure of at least 120 Pa (0.5 in. w.g.), and airflow is maintained by a dedicated exterior exhaust system. The exhaust air is double HEPA filtered or treated by HEPA filter and incineration. Removal of materials from the cabinet must be through a dunk tank, double door autoclave or air-lock pass-through for decontamination. Interlock or protocols must be used for the autoclave and pass-through doors to prevent both doors from being open at the same time.

Certification requirements

Because of their critical role in minimizing occupational exposure to airborne pathogens, biological safety cabinets must be certified at least annually. They must also be certified before being used after:

- Initial installation
- Change of the HEPA filter
- Movement of the unit
- Any repair or maintenance that could affect the seal of the HEPA filter

The certification must be performed by a qualified person. A qualified person is one with knowledge, training, and experience acceptable to WorkSafeBC, such as a field certifier accredited with the National Sanitation Foundation (NSF) to perform testing of biological safety cabinets. The certification requirements are listed in *NSF Standard 49-1992, Class II (Laminar Flow) Biohazard Cabinetry*. The employer must keep a record of the certification results. (For more information, go to the NSF web site: www.nsf.org/biohazard-accredit)

Operating guidelines for class II biological safety cabinets[6]

1. **Preparation**
   - The cabinet should be left on at all times. If not, check air grilles for obstructions, then switch on the blower. Allow air to purge the workspace for at least five minutes before the next use.
   - Turn off UV lamp and turn on fluorescent lamp. Never work in a unit with the UV lamp illuminated.

2. **Disinfection**
   - Spray or swab all interior surfaces with appropriate disinfectant.
   - Allow surfaces to air-dry.

3. **Material assembly**
   - Introduce all materials necessary to perform procedure and no more. Do not obstruct air grilles.
   - Place the material such that clean and contaminated items will not come into contact with each other.
   - Place a container for contaminated materials at rear of the cabinet.
   - Ensure that the glass view panel is properly located and secured.

4. **Pre-use purge**
   - Allow an air-purge period after loading.

5. **Personal procedures**
   - Use personal protective equipment (such as appropriate respiratory protection) when required. Always wear gloves and a lab coat.

6. **Work procedures**
   - Use methodical work procedures. For example, always move hands from clean area to work area to discard area.
   - Keep all materials at least 10 cm inside the sash and perform all contaminated operations as far to the rear of the work area as possible.
   - Control small, light, loose items such as tissues or needle packages to avoid having them get caught in the airstream and drawn towards the blower motor or HEPA filter.
   - Do not remove hands from the workspace until procedures are complete and all critical materials are secure.
   - Remove gloves directly into a container clearly marked for contaminated materials.

7. **Post-use purge**
   - After work has been completed, allow air to be purged by leaving the blower on when there is no activity in the cabinet.

8. **Personal procedures**
   - Remove mask and other protective clothing as appropriate.
   - Wash hands thoroughly.

9. **Terminal disinfection**
   - Using gloves, remove materials to incubator, biohazard bag, or autoclave, as appropriate.
   - Spray or swab all interior surfaces with appropriate disinfectant (do not rely on the UV lamp for disinfection).

10. **Shutdown**
    - Turn off the blower (if necessary) and fluorescent lamp.
    - Turn on the UV lamp (where desired).

6 Adapted from *Laboratory Safety: CSLT Guidelines*, 4th ed., 1996.

For more information, refer to:

- *Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets* (CDC/NIH)
- *Laboratory Biosafety Guidelines* (Health Canada)
- *Biosafety in Microbiological and Biomedical Laboratories* (CDC/NIH)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

For a description of several laboratory safety incidents involving biological safety cabinets, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Decontamination

Objects that may be contaminated with disease-causing agents can be decontaminated, or made safe for use or disposal, by **sterilization** or **disinfection**. Sterilization is the complete destruction or removal of all micro-organisms from equipment or materials, generally through autoclaving (using steam under pressure). Disinfection is the destruction, usually with chemical disinfectants, of many or all pathogenic micro-organisms on surfaces or objects so that they can no longer transmit disease.

All infectious materials or contaminated objects must be decontaminated before being washed, stored, or disposed of. All surfaces—such as floors, counters, and laboratory benches—should be decontaminated regularly, especially after aerosol-generating procedures such as centrifuging or pipetting. Each laboratory should have adequate supplies of chemical disinfectants.

Each laboratory must also have adequate facilities for personal decontamination of workers who come in contact with biohazardous materials. For example, an eye-flushing capability is required for workers who may be splashed with material containing a bloodborne pathogen.

For general decontamination procedures, refer to the University of British Columbia's *Laboratory Biosafety Reference Manual*.

Sterilization

Autoclaving is the most reliable method of destroying micro-organisms. The items to be sterilized are heated in a chamber (the autoclave) with saturated steam at a pressure of 103 kPa (15 psi) for at least 15 minutes after the temperature reaches 121°C. For all micro-organisms to be destroyed, the materials being sterilized must be in actual contact with steam for the required length of time.

Example procedure for autoclaving:

- Remove any soiling from the items.
- Wrap items in muslin or other approved wrap that steam can penetrate. Do not *use* aluminum foil.
- Place items into containers made of metal or heat-resistant plastic. Do not stack or pack them tightly in the autoclave.
- Remove lids from containers and autoclave them separately.

Indicators

Biological or chemical indicators are used to let laboratory staff know whether sterilization has occurred. Biological indicators are strips, filter-paper discs, or closed vials of *Bacillus stearothermophilus* spores that are placed among the items to be sterilized. An absence of bacterial growth in the strip, disc, or vial within an appropriate period after autoclaving (24 to 48 hours) indicates that all micro-organisms in the load have been killed.

Chemical indicators include:

- Tapes that change colour when air has been removed (because these are not sensitive to time and temperature, make sure the colour change occurs only after the desired temperature has been maintained for the minimum period)
- Glass tubes or paper strips containing a chemical that changes from one colour to another under the proper conditions for sterilization

For more information, refer to

- *Infection Control Guidelines—Hand Washing, Cleaning, Disinfection and Sterilization in Health Care* (Health Canada)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

For a description of several laboratory safety incidents involving autoclaves, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Disinfection

Chemical disinfectants are used to decontaminate surfaces and equipment that cannot be autoclaved or areas where spills of biohazardous material have occurred. They are usually supplied as liquid concentrates or solids that must be diluted before being used.

Disinfectants differ from one other in a number of ways:

- Types of micro-organisms against which they are effective
- "Shelf life," ranging from hours to weeks, during which they are effective against micro-organisms once they have been diluted to the proper concentration
- Materials or conditions that may inactivate them
- Mode of action
- Toxicity and corrosiveness
- Cost

Table 8 summarizes the six general classes of disinfectants.

Table 8*

Class	Purpose	Mode of action	Advantages	Disadvantages	Examples
Alcohols	• Cleaning some instruments and surfaces • Cleansing skin	• Denature proteins	• Inexpensive • Easy to use • Not corrosive • Effective against most micro-organisms	• Evaporates quickly • Long contact times needed • Flammable • Inactivated by organic matter	• Ethanol • Isopropanol • (70–85%)
Formaldehydes	• Cleaning surfaces • Decontamination of large spaces (as a gas)	• Denature proteins (requires presence of water vapour)	• Very effective against all forms of biohazards, including spores • Gas can enter small cracks and spaces	• Special personal protective equipment needed	• 37% Formalin • Paraformaldehyde • Cidex 7® Sporociden®
Phenolics	• Effective bacteriostatic agent when diluted	• Corrode tissues and cells	• Effective against viruses and vegetative bacteria	• Corrosive, irritating to skin • Sticky • Strong odour	• Pheno-kill® • Phenola® • Mikro-Bac®
Quaternary ammonium compounds	• Cleaning surfaces	• Affect proteins and cell membranes	• Contains deter-gents to aid in cleaning • Rapid action • Non-corrosive, non-staining	• May not be active against some bacteria, spores, and viruses • Rapidly inactiv-ated by soap and organic matter	• Roccal® • Tor® • Miko-Quat®
Chlorine compounds	• Cleaning spills of human body fluids	• Free available chlorine binds with contents within micro-organism; reaction by-products cause death	• Broad-spectrum • Fast acting • Inexpensive	• Corrosive • Short shelf life • Inactivated by organic matter • Irritates skin and eyes	• Sodium hypochlorite • Javex® • PRESEPT® • Alcide®
Iodine compounds	• Disinfecting some semi-critical medical equipment	• Free iodine enters micro-organism and binds with cellular components • Needs 30-50 ppm	• Broad-spectrum • Cleansing action • Built-in colour indicator • Inexpensive • Few health or disposal problems	• Inactivated by hard water • May stain • Weakly corrosive • Reacts with organic matter	• Wescodyne® • Mikroclene® • Hi-Sine®

* Adapted from University of British Columbia *Laboratory Biosafety Reference Manual,* 4th ed.

For more information, refer to:
- *Infection Control Guidelines—Hand Washing, Cleaning, Disinfection and Sterilization in Health Care* (Health Canada)
- *Laboratory Biosafety Reference Manual* (University of British Columbia)

Biological spills

Spills of biological agents are second only to aerosols in terms of health hazard posed to those working with biohazardous agents. Spills may be large or small, confined or spread out, liquid or dry. Each laboratory must have written procedures for dealing with spills. The procedures must be specific to the biological agents, equipment, and techniques used in the lab. All workers must be trained in these procedures.

Biological spill kit

Laboratories should have a biological spill kit containing materials needed to clean up and decontaminate spills. Such materials may include:
- Latex and heavy-duty gloves
- Protective clothing and equipment, including HEPA filter masks, shoe covers or rubber boots, and safety glasses
- Absorbent materials such as paper towels, cotton balls, swabs, incontinent pads, or cloth rags
- Forceps for picking up broken glass and sharps
- Heavy-duty, leakproof, autoclavable plastic bags for disposing of contaminated items (with biohazard label)
- Appropriate chemical disinfectant, such as 5% Wescodyne or 5-10% sodium hypochlorite
- Tape or sign pen to mark out the spill area
- "Keep Out" sign

Because different chemical disinfectants have different shelf lives, note the expiry dates and prepare fresh batches when necessary.

Spill clean-up

The following are some generic guidelines for dealing with spills. For more information specific to your situation, refer to your laboratory's safety manual.
- When a spill occurs, immediately notify everyone else in the area. If aerosols have been released, everyone should leave the area at once and wait 10 to 30 minutes for the aerosols to disperse and settle.
- Before cleaning up the spill, check whether your clothing or skin has been contaminated. If so, take the steps specified in your lab's spill control procedure.
- Don appropriate personal protective equipment.
- Cover the spill area with paper towels or other absorbent material, then gently pour disinfectant onto the paper towels in a circular fashion, moving from the outside towards the centre. Wait for 30 minutes before removing the towels with a forceps and placing them into a disposal bag. Repeat this decontamination procedure.
- After clean-up, remove gloves and place them with other contaminated materials in clearly marked containers for further decontamination or disposal. Wash hands thoroughly.
- As with all accidents and actual or potential exposures to biohazardous materials, report spills to the laboratory supervisor. Workers involved in a spill should receive medical evaluation and treatment if necessary.

For more information, refer to:
- *Laboratory Biosafety Reference Manual* (University of British Columbia)
- *Laboratory Biosafety Manual* (World Health Organization)

Physical hazards

A significant proportion of injuries suffered by laboratory workers is caused by factors other than chemical or biological hazards. These include:

- The physical requirements of a job, coupled with the workplace environment, that increase the risk of musculoskeletal injuries
- Cryogenic liquids
- Radioactive materials
- Sharps
- Animals

Musculoskeletal injury (MSI)

Like most workers, laboratory workers are at risk for MSI, which can result in sprains, strains, and inflammation of soft tissues such as muscles, tendons, and ligaments. Employers must identify and assess the factors in the laboratory that may expose workers to this risk. They must then try to eliminate or minimize the risk using engineering or administrative controls.

Risk factors to consider for MSI include the following:

- **Physical demands of the work being performed**, such as the force needed, the amount of repetitive motion, the duration of such tasks, the postures employed, and exposure to local contact stresses
- **Layout and conditions of the workplace or workstation**, such as how far workers are required to reach, the height of the work surface compared with that of the worker, seating conditions, and floor surface conditions
- **Characteristics of objects handled**, such as size, shape, weight distribution, and types of handles and grips
- **Environmental conditions**, such as illumination and exposure to cold and vibration
- **Organization of the work**, such as work-recovery cycles, the amount of variability in the tasks, and the rate at which workers are required to work

Control measures may include mechanical aids, work procedures, and appropriate use of personal protective equipment. Workers must be educated in the signs and symptoms of MSI and trained in the use of the control measures. The following tips will help reduce the risk of MSI in laboratory workers:

- Use an ergonomically designed workstation (height-adjustable chair and workbench, good back, elbow, and foot support, etc.).
- Ensure that lighting is proper for the task being performed, and that glare is avoided.
- Use appropriate personal protective equipment if necessary (for example, gloves that improve your grip if you have to grasp slippery objects).
- Keep your head aligned with your spine.
- Avoid slouching or bending forward or to the side.
- Design tasks so that they encourage you to change positions frequently.
- Place materials at a comfortable working level, at or slightly below elbow height.
- Organize the work area so that materials and actions are within easy reach.
- Avoid handling heavy or unbalanced objects while sitting down.
- Avoid sitting for more than 50 minutes at a time.
- Use rest periods to relax or move around.

Work safely with microscopes

A technologist in a small laboratory in the interior of British Columbia began experiencing neck and shoulder pain. The pain became so serious that she was unable to work. Physiotherapy and massage gave her some relief, but when she returned to work, the pain recurred and persisted. An investigation showed that the scheduling of the work required the technologist to spend two to four hours at a time looking into a microscope that was placed too low for her. With the advice of an occupational hygienist, the workstation was redesigned at minimal cost. The technologist was able to return to work and made a full recovery.

Remember:

- Sit back in the chair instead of perching on it.
- Adjust the chair so that your feet rest comfortably, flat on the floor or on a footrest.
- Ensure that the seat is adjusted to put even pressure along the backs of your thighs.
- Adjust the chair back to keep your back in an upright position.
- Adjust the chair's tilt control to ensure that the chair supports your lumbar (lower back) region, or use a lumber cushion if necessary.
- Ensure that the microscope eyepieces are in line with, or extend over, the front edge of the workbench.
- For comfort, set the vertical position of the eyepieces a little high. This will force you to keep your head upright and prevent strain on your neck.
- If necessary, raise the chair so you can see into the eyepieces. (You may need a footrest to keep your feet in the correct position.)
- Gaze slightly downward into the eyepieces instead of tilting your head down and looking straight ahead. Keep your back vertical and your head and neck upright.
- Ensure that there is no clutter around your legs.
- If the workbench is suitable for microscopy, your thighs should not be touching its undersurface.
- The most comfortable position for your hands is as for shaking hands. Your forearms should rest on the workbench or on microscope armrests, to avoid the static loading problems that result when arms are held above the bench for long periods.
- To reduce eyestrain, adjust the eyepieces for your interpupillary distance, and adjust each individually so that the image in each is sharp.
- Make sure the eyepieces are clean.
- Make sure that any personal visual problems are corrected. Often microscopy makes vision problems such as astigmatism, nearsightedness/farsightedness, and poor eye coordination more obvious.
- Reduce glare and reflection, both in your surroundings (by repositioning your workstation, using blinds, and removing highly reflective surfaces) and in the microscope image (by adjusting the transformer or using filters to ensure an appropriate level of light and contrast).
- Take regular breaks and focus your eyes on a distant object periodically.
- To reduce the risk of repetitive strain injuries, take a 2–3 minute break every 30–40 minutes when working at the microscope. Try to rotate work activities to reduce the amount of time you spend at the microscope.
- During your work breaks, do simple stretching exercises.

For more information, refer to:

- WorkSafeBC Ergonomics Information Site (WorkSafeBC)
- Ergonomics (American Industrial Hygiene Association [AIHA])
- OSH Answers: Working in a Sitting Position (Canadian Centre for Occupational Health and Safety)
- OSH Answers: Working in a Standing Position (Canadian Centre for Occupational Health and Safety)

Cryogenic liquids

Cryogenic liquids are used in laboratories to achieve very cold temperatures (below −50°C). Specially designed containers must be used to store, transport, or dispense these liquids, as many materials will become very brittle at the low temperatures involved. Containers for cryogens are usually double-walled and well insulated in order to minimize loss from evaporation and prevent the outside of the container from becoming dangerously cold. The outside of glass Dewars should be wrapped in strong tape or otherwise encased in order to contain glass fragments in the event of an implosion.

Table 9 lists some common cryogens.

Table 9 Characteristics of some cryogenic liquids

Cryogenic liquid	Normal boiling point (°C)	Liquid-to-gas expansion factor
Carbon dioxide	−78.5	553
Methane	−161	578
Oxygen	−183	860
Argon	−186	847
Nitrogen	−196	696
Helium	−269	757

Cryogenic liquids pose a number of hazards to those who work with or near them.

- **Flammability**. There is an obvious risk of fire or explosion from evolved gases when cryogenic liquids such as acetylene, hydrogen, or methane are used. Also, many materials that are not normally very combustible will burn readily and even violently in the presence of oxygen. Liquid nitrogen and liquid helium can condense oxygen from the air to create an extremely explosive condition.
- **Pressure**. Cryogenic liquids are normally stored and used near or above their boiling point. Containers must be designed to withstand the very high pressures when the liquid evaporates and expands, or have a safety vent to prevent the buildup of pressure.
- **Contact**. Because of the high water content of human tissues, cryogenic liquids quickly cause cold burns and frostbite. Eyes are particularly at risk. Full-face protection, an impervious apron or coat, cuffless trousers, and high-topped shoes should be worn. Loose-fitting gloves or potholder-type protection should be worn.
- **Air displacement**. Because of the high liquid-to-gas expansion factor, an evaporating cryogenic liquid can displace the oxygen in an enclosed area. Indoor dispensing stations and storage locations must be adequately ventilated and monitored to prevent the development of harmful atmospheres. Dispensing stations and freezers with automatic filling cycles must carry signs identifying the materials, the hazards, and the precautions required.

For a description of several laboratory safety incidents involving animals, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Radiation

In general, employers of workers who may be exposed to radiation must:

- Develop an exposure control plan for workers who may receive occupational doses greater than the general public
- Provide workers with adequate training in the hazards and safe use of the equipment or materials causing the exposure
- Provide workers with personal protective equipment (such as gloves, lab coats, and safety glasses) if required

Ionizing radiation

Ionizing radiation is radiation that has enough energy to displace one or more electrons from an atom, converting the atom into an electrically charged particle known as an ion. Examples of ionizing radiation include cosmic rays from the sun; X-rays and gamma rays, which are emitted by radioactive materials; and neutrons, which are emitted when atoms are split in a nuclear reactor. Ionizing radiation has many medical uses (such as diagnosis by means of X-rays and radiation therapy for cancer) and analytical uses (such as X-ray diffraction and X-ray fluorescence). On the other hand, because it can affect rapidly dividing cells, high doses can cause burns and radiation sickness, and chronic exposure can lead to leukemia and other cancers. The developing fetus, whose cells are dividing rapidly, are especially vulnerable, so it is important to protect pregnant workers from exposure as early as possible.

Dose limits for ionizing radiation

A worker's exposure to ionizing radiation must not exceed any of the following:

- An annual effective dose[7] of 20 milliSievert (mSv)
- An annual equivalent dose[8] of:
  - 150 mSv to the lens of an eye
  - 500 mSv to the skin, averaged over any 1 cm^2 area at a nominal depth of 7 mg/cm^2, regardless of the area exposed
  - 500 mSv to the hands and feet

Once a worker has notified the employer that she is pregnant, her effective dose for the remainder of the pregnancy must be limited to the lesser of 4 mSv or the dose limit specified for pregnant workers under the *Nuclear Safety and Control Act* (Canada).[9]

Employer's responsibilities

Employers must keep the exposure of workers to ionizing radiation as low as reasonably achievable below the exposure limits. If a worker exceeds, or may exceed, a dose of 1 mSv in a year, the employer must:

- Develop and implement an exposure control plan
- Prepare written instructions for the following, and post them in the work area or near the appropriate equipment controls:
  - Safe operation of the equipment
  - Boundaries of the hazard area
  - Work procedures to be followed
  - Correct use of any required personal protective equipment
  - Emergency procedures

7 The "effective dose" is the amount of ionizing radiation, in mSv, absorbed by the worker's whole body, adjusted for the energy level and type or radiation and differing susceptibilities of the organs and tissues irradiated. If only part of the body is exposed, the effective dose is the sum of the weighted equivalent doses in all irradiated tissues and organs.

8 The "equivalent dose" is the amount of ionizing radiation, in mSv, absorbed by a specific body part and adjusted for the energy level and type of radiation.

9 Refer to the *Nuclear Safety and Control Act* for details.

- Provide the worker with an appropriate personal dosimeter in order to monitor the exposure (for example, a ring dosimeter for hand exposures to small amounts of radioisotopes, or a badge for X-ray crystallographers).
- Conduct a radiation survey to measure radiation levels in the work area that may be influenced by radiation-producing equipment or material. The radiation survey must be conducted in accordance with the standard practice specified under the applicable safety code listed in section 7.23(a) of the Occupational Health and Safety Regulation or the regulations under the *Nuclear Safety and Control Act* (Canada) and when:
  - The equipment is initially installed.
  - The equipment has been damaged or modified.
  - A radioisotope or radioactive sample has been spilled or accidentally released.
  - A worker has been exposed to unusually high levels of ionizing radiation.
  - The equipment manufacturer's instructions or a standard acceptable to WorkSafeBC.
- Keep radiation survey records for at least 10 years or at the direction of the Canadian Nuclear Safety Commission (whichever is longer), and personal dosimetry data for the employment period plus 10 years or at the direction of the Canadian Nuclear Safety Commission (whichever is longer). All these records should be available to workers.
- Provide education and counselling regarding reproductive hazards associated with exposure to ionizing radiation, especially to pregnant workers or those intending to conceive.

Radiation safety tips

- Minimize the exposure time to radioactive material.
- Maximize the distance between yourself and a radiation source.
- Use personal protective equipment such as gloves, safety glasses, and lab coats where appropriate.
- Use shielding that is appropriate to the type and energy of radiation.
- Do not eat, drink, smoke, apply cosmetics, store food, or take medication in the laboratory.
- Never pipet anything by mouth. Use a mechanical pipetting device instead.
- Wear your assigned personal dosimeter or radiation detection badge when working in the laboratory.
- Use a fume hood when working with radioactive materials that may become airborne.
- Store and transport radioactive materials in spill-resistant containers. When transporting radioactive materials, place containers in a tray to contain any leaks.
- Post prominent radiation warning signs at entrances to labs or in areas where radioactive materials are handled or stored.
- Label all materials used for radioactive work.
- In accordance with the dilution requirements and any other restrictions specified in the licence, only one sink may be used for washing contaminated items. This sink should be clearly labelled.
- Dispose of radioactive wastes in designated containers only.
- Dispose of wastes in accordance with the *Nuclear Safety and Control Act*.

For more information, refer to:

- Part 7 of the Occupational Health and Safety Regulation
- *Radiation Safety Manual* (Michigan State University)
- *Nuclear Safety and Control Act*

Non-ionizing radiation

Non-ionizing radiation can come from a number of sources. Examples of non-ionizing radiation include visible, infrared, and ultraviolet light; microwaves; ultrasound; radiofrequency electromagnetic fields; and radiation from lasers. The mechanisms of the health effects of these radiations vary in scope and intensity, and are not as clearly understood as those from ionizing radiation.

Sections 7.19 and 7.23 of the Occupational Health and Safety Regulation list the standards that must be adhered to in limiting exposure to non-ionizing radiation.

For more information, refer to:

- Safety Code 6—Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 kHz to 300 GHz (Health Canada, 1999)
- Non-Ionizing Radiation (American Industrial Hygiene Association [AIHA])
- Lasers (American Industrial Hygiene Association [AIHA])

For a description of several laboratory safety incidents involving ultraviolet burns and lasers, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Animals

The most common hazards associated with laboratory animals are bites, transmission of disease, and development of allergic reactions.

The following measures must be used to reduce the risks from working with laboratory animals:

- Use appropriate equipment and techniques for handling or restraining animals.
- Use work procedures and handling methods designed to control the spread of aerosols.
- Keep animal quarters and handling areas clean and hygienic.
- Use gloves, lab coats, and other protective clothing and equipment to minimize contact with animal products such as hair, fur, dander, saliva, and urine. Do not wear street clothes when working with animals.

Animal health must be monitored by qualified personnel, and sick or infected animals must be quarantined as required.

Workers should be educated about animal-related allergies and ways of avoiding them. Those who have become sensitized to animals or develop allergic reactions should be given medical attention and counselling.

For more information, refer to:

- *Preventing Asthma in Animal Handlers* (National Institute of Occupational Safety and Health [NIOSH])
- Animal Research (American Industrial Hygiene Association [AIHA])

For a description of several laboratory safety incidents involving animals, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Animal-induced allergies and asthma

A worker at a pharmaceutical company prepared rats for experiments. She had no prior respiratory illnesses, but she had a family history of allergies. Three months after she started working, the worker noted hives on her forearms and hands. Her symptoms worsened until every direct contact with rats produced hives. Wearing gloves alleviated the problem, but she could not perform her work adequately when using them.

The worker then began to suffer episodes of sneezing, nasal drainage, watery eyes, and tightness in the chest. She was transferred to another department, where her symptoms ceased. They recurred, however, if she entered a room containing rats or where rats had previously been housed. The worker had positive skin tests to animal dander and to rat hair. She also had elevated antibodies to various rat proteins.

Remember:

- Perform animal manipulations within ventilated hoods where possible.
- Use absorbent pads for bedding. Keep cages and animals clean.
- Reduce skin contact with animal products such as dander, serum, and urine by wearing appropriate gloves, lab coats, and approved particulate respirators and eye protection.
- Use an animal species or sex that is known to be less allergenic than others.

Personal protective equipment when handling animals

A research assistant was carrying a macaque monkey in an animal laboratory. She received a splash in one eye, presumably from the saliva or urine of the monkey, and she towelled off the eye. Two weeks later she showed signs of eye inflammation and headache. Her health deteriorated, and despite the best medical care she died from herpes B virus infection contracted from the monkey.

Remember:

- Healthy laboratory animals may be infected with organisms pathogenic to humans.
- We are usually aware of hazards from animal bites and scratches, but harmful contact may also result from splashes of their body fluids onto our mucous membranes or into non-intact skin.
- Workers must wear all necessary personal protective equipment when exposed to hazards from animals.

Laboratory equipment is designed to help reduce exposure to hazardous materials, but can also pose hazards unless used properly. Laboratory equipment must be set up, operated, and maintained in accordance with the manufacturer's instructions. Any electrical services must be installed as required by the Electrical Safety Regulation. Workers operating the equipment should have ready access to the manufacturer's operating instructions, and must be adequately trained in safe operating procedures and precautions. If a piece of equipment is determined to be unsafe, it must be identified as such and removed from service until it has been made safe.

Safeguarding of equipment

Laboratory equipment that presents a physical hazard to workers must be adequately safeguarded, shielded, or isolated by location. For example, an open and visible flame may be acceptable while being used by a worker on a benchtop. If left unattended, however, the flame presents a significant hazard to anyone passing by and must be guarded. Evacuated or pressurized glassware can be placed behind a protective shield or wrapped with protective tape. Sharp items, such as microtome blades, must be stored with the blade edge guarded.

Any hazards associated with the use of a piece of equipment must be identified on the equipment through a label or sign.

Local ventilation and flushing of equipment

Laboratory equipment or instrumentation that may emit harmful airborne quantities of a substance must be equipped with effective local exhaust ventilation. Some analytical equipment (such as gas chromatographs) and some process equipment (such as microwave ovens and reaction vessels) may require this control measure.

The drains that capture the effluent from blood analyzers must be properly flushed out to prevent hazardous amounts of azides from developing (for more information on azides, see page 22).

Vacuum breaks

The BC Plumbing Code requires that connections to potable water systems be designed and installed to prevent substances capable of making the water non-potable from entering the system. A **vacuum break** prevents back-siphonage of contaminated water from tubing or devices attached to faucets into the potable water supply used for eyewash heads, emergency showers, laboratory sinks, drinking fountains outside the laboratory, and so on.

A device commonly used in laboratory goose-neck faucets is an atmospheric-type vacuum break that is installed after the last control valve. An in-line pressure-type vacuum break may be installed to prevent back-siphonage at several sinks simultaneously, as long as these two conditions are met:

- Back-siphonage into any part of the potable water system is prevented.
- The device supplies the same level of protection as a faucet-mounted atmospheric-type vacuum break.

The location of an in-line vacuum break must be clearly identified through signage. Vacuum breaks must be kept in good repair and tested according to the manufacturer's instructions.

Besides a backflow preventer, the BC Plumbing Code also requires premise or zone isolation for laboratories where backflow would result in a potentially severe health hazard.

Centrifuges

A number of potential hazards are associated with centrifuges:

- Physical hazards from moving parts or mechanical failure
- Chemical hazards from contact with spilled material
- Biological hazards from generation of aerosols

Always balance a centrifuge load by distributing the samples evenly. Prevent exposure of workers to biohazardous, carcinogenic, or radioactive materials by using sealed, aerosol-proof centrifuge cups or rotors, and loading or unloading these in a biological safety cabinet as necessary. Store centrifuge rotors in a manner that will prevent damage.

Centrifuge doors must be interlocked to prevent workers from coming into contact with spinning rotors. *CSA Standard C22.2 No. 151-M1986 Laboratory Equipment* requires that, in centrifuges where Emax exceeds 1 kiloJoule, the catch be locked in the engaged position when the motor is energized, and remain locked until the energy level drops to 1 kiloJoule or less.

Centrifuges where Emax is less than 1 kiloJoule can have a readily accessible lever or knob for releasing the catch, as long as it is designed to minimize the chance of unintentional operation. In this case, the following warning must be prominently displayed next to the lever or knob: WARNING: DO NOT OPEN THE ACCESS COVER UNTIL THE HEAD HAS STOPPED.

Ultracentrifuge rotors and other critical components must be inspected regularly and non-destructively tested according to the manufacturer's instructions. Rotors have a use life specified by the manufacturer that should not be exceeded.

For a description of several laboratory safety incidents involving centrifuges, together with the key safety concepts and principles involved, see the American Industrial Hygiene Association's Laboratory Safety Incidents.

Electrophoresis apparatus

Electrophoresis is a separation technique that involves the migration of charged molecules through fluid medium under the influence of an electrical field. The apparatus must be designed and maintained so that electrical current is shut off when the cover is opened. A label must warn workers of the electrical hazard. All high-voltage components must be guarded to prevent worker contact. Cracked or broken Plexiglas™ parts should be replaced. Always follow the manufacturer's operational instructions and safety guidelines.

For a description of several laboratory safety incidents involving electrical apparatus and electrophoresis, together with the key safety concepts and principles involved, see the AIHA's Laboratory Safety Incidents.

Additional information

For a list of links to online resources, refer to the AIHA's Laboratory Equipment.

Appendix F: Safety Tips for Compressed Gas Users[10]

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 General Hazards

Thoroughly know the hazards of the gas you are using. All compressed gases have the pressure hazard, but a gas can also have more hazards; gases can be toxic, corrosive, flammable, asphyxiating, oxidizing, pyrophoric, and/or reactive. All these factors can impact the design of the system and how the gases are utilized.

F.2 Eye Protection

Always wear eye protection when working on or near compressed gas systems. Make it your job not to let anyone without eye protection into any area where compressed gases are used or stored.

F.3 Train Users

Never let anyone use or connect a cylinder to any system unless that person is trained and knowledgeable in the dangers of pressure, the chemical properties of the compressed gas, and the proper CGA compressed gas fittings and connections.

F.4 Cylinder Identification

Do not use a compressed gas cylinder unless the cylinder is clearly marked or labeled with the cylinder's contents. Reject any cylinder that is unmarked or has conflicting markings or labels. Never rely on the color of the cylinder to identify the contents. If there is any conflict or doubt concerning the contents, do not use the cylinder. Return it to your vendor.

F.5 Cylinder Content

Be certain that the content of the cylinder is the correct product for use in the system to which you are connecting it.

F.6 Regulator Use

Never use a compressed gas cylinder without a pressure-reducing regulator or device that will safely reduce the cylinder pressure to the pressure of your system. Only use regulators that have both a high-pressure gauge and a low-pressure gauge. This allows you to monitor both the pressure in the compressed gas cylinder and the pressure in the system.

F.7 Pressure Gauge Use

As per ANSI B-40.1, Gauges—Pressure Indicating Dial Type—Elastic Element, never use a gauge above 75 percent of its maximum face reading. For example, a 3000 psi system should use at least 4000 psi gauges. If your system can achieve a maximum pressure of 75 psi, the gauge monitoring the system should be at least 100 psi. (Immediately replace any gauge whose pointer does not go back to its zero point when pressure is removed.)

F.8 Valves

Be sure the valve on the compressed gas cylinder and the pressure-reducing regulator you are using have the proper CGA connections for the pure gas (CGA V-1) or gas mixture (CGA V-7) you are using. NEVER USE AN ADAPTOR BETWEEN A CYLINDER AND A PRESSURE-REDUCING REGULATOR.

F.9 Proper Connection

Be certain the CGA connection(s) on the cylinder and the pressure-reducing regulator fit together properly without being too loose or too tight Proper connections will go together smoothly. Never use excessive force to connect a CGA connection. NEVER USE AN AID, such as pipe dope or Teflon® tape, TO CONNECT A REGULATOR TO A CYLINDER.

10 Reprinted with permission from NFPA 45-2000, *Standard for Laboratories Using Chemicals,* copyright © 2000 National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the NFPA on the referenced subject, which is represented only by the standard in its entirety.

F.10 Connections

Be certain that the pressure-reducing regulator you are using is compatible with the gas, and be certain that it is rated and marked for the maximum pressure rating of the CGA connection on the compressed gas cylinder valve you are attaching it to. All compressed gas cylinder connections can be found listed with their recommended gases and the maximum allowed pressures in CGA/ANSI V-1, Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections.

F.11 Regulator Compatibility

Never replace the CGA connection that the regulator manufacturer has put on a regulator with one for a different gas service. Only the regulator manufacturer or a trained service representative knows the gas compatibility of the regulator's internal design and can properly reclean the regulator.

F.12 Procedures

After attaching a pressure-reducing regulator to a compressed gas cylinder, do the following:

1. Turn the regulator's adjustment screw out (counter-clockwise) until it feels loose.
2. Stand behind the cylinder with the valve outlet facing away from you.
3. Observe the high-pressure gauge on the regulator from an angle, do not pressurize a gauge while looking directly at the glass or plastic faceplate.
4. Open the valve handle on the compressed gas cylinder S-L-O-W-L-Y, until you hear the space between the cylinder valve gently fill the gas. (You can also watch the pressure rise on the high-pressure gauge. If you turned the regulator's adjustment screw back properly, there should be no gas flow out of the regulator or pressure rise on the low-pressure gauge.)
5. If you are using a nontoxic, nonflammable gas, you can ensure purity by shutting off the cylinder valve and gently cracking the CGA connection at the cylinder valve. (Generally, three pressurizations with venting will ensure the interior of the connection has a clean, representative sample of the gas in the compressed gas cylinder. For toxic or flammable gases, you can purchase special venting regulators that can be safely vented to a fume hood or vented gas cabinet.)
6. When you are ready to use the compressed gas cylinder, fully open the cylinder valve until you feel it stop. Then, close it one-quarter turn. (A fully open valve that has no play in it can confuse a person who is checking to see if it is open. Many accidents have been recorded by people trying to open a previously fully opened valve by using a large wrench.)
7. Use the following practices on acetylene cylinders to allow quick closing of the valve in the event of an emergency:
   a. Open acetylene cylinder valves no more than one and one-half turns.
   b. Leave the wrench on the valve spindle when the cylinder is being used, if the acetylene cylinder has a T-wrench instead of a hand-wheel valve.

F.13 Pressure Relief

Make sure any system you are pressurizing (piping, manifolds, containers, etc.) that can be isolated or closed off has its own pressure-relief device. It is the user's responsibility to see that the system has proper pressure-relief device(s) built into it. Do not rely on the relief device on the compressed gas cylinder's regulator; it is not designed to protect downstream systems. This is very critical when cryogenic liquids are used. Pressure-relief discharge points should be vented to safe locations (not directed towards people or routed to safe locations for hazardous gases).

F.14 Cylinders Not in Use

Shut off cylinders that are not in use. Always have a cylinder cap on any cylinder that is being stored or is not in use.

F.15 Backflow Precautions

Use backflow check valves where flammable and oxidizing gases are connected to a common piece of equipment or where low- and high-pressure gases are connected to a common set of piping. Do not rely on a closed valve to prevent backflow.

F.16 Pressure Relief

The relief device on a cylinder of liquefied flammable gas (generally found on the cylinder valve) always should be in direct contact (communication) with the vapor space of the cylinder in both use and storage. Never lay a cylinder of liquefied flammable gas on its side unless it is so designed (and so marked) to allow that positioning, as in the case of propane cylinders for forklift trucks.

F.17 Protection of Cylinders in Use

Cylinders in use should be secured by a holder or device specifically designed to secure a cylinder. Never stand a single cylinder in an open area unsecured. Always protect cylinders from dangers of overhead hazards, high temperatures, and other sources of damage, such as vehicle traffic.

F.18 Moving Cylinders

Always use a cylinder cart to move large cylinders or specially designed cylinder holders to carry small cylinders. Never pick up a cylinder by its cap.

F.19 Refilling

Never refill a cylinder or use a cylinder for storing any material. If gas is accidentally forced back or sucked back into a cylinder, mark the cylinder well and inform your gas supplier. (Almost all recent deaths involving compressed gas cylinders occurred as users were putting gas back into cylinders and fillers at the compressed gas plants.)

F.20 Asphyxiation

Possibly the greatest hazard to a user of compressed gases—and especially users of cryogenic fluids—is asphyxiation. Remember, except for oxygen and air (with at least 19.5 percent oxygen), ALL GAS IS AN ASPHIXIANT. Only vent gas into safe and properly ventilated locations outside of the building or fume hood. EXPOSURE TO AN ATMOSPHERE THAT HAS 12 PERCENT OR LESS OXYGEN WILL BRING ABOUT UNCONSCIOUSNESS WITHOUT WARNING AND SO QUICKLY THAT THE INDIVIDUALS CANNOT HELP OR PROTECT THEMSELVES.

F.21 Cryogenic Gases

If you are transferring cryogenic gases inside or have equipment using cryogenic gases that vents anything more than a few cubic centimeters of gas per minute inside (i.e., not to a hood), you should have adequate 24-hour ventilation and install continuous oxygen meter(s)/monitor(s) with a "low oxygen" alarm.

Remember, all compressed gases are hazardous; understand those hazards completely and design your system accordingly. The major compressed gas vendors have the technical expertise available to support users. NEVER BECOME COMPLACENT WHEN USING A COMPRESSED GAS. Always respect the hazards and treat them accordingly. Regular maintenance by qualified persons must follow manufacturers' instructions.

Appendix B: Laboratory safety checklist

General laboratory safety

Administrative matters

- ☐ Written safe work and emergency procedures have been developed and are being implemented.
- ☐ Workers have received education in the hazards of the workplace and training in all safe work and emergency procedures.
- ☐ Emergency drills are conducted at least annually.
- ☐ Regular workplace inspections are carried out.
- ☐ Special inspections are carried out after an accident or equipment malfunction.
- ☐ Unsafe conditions are corrected immediately.
- ☐ Accidents are investigated and complete accident investigation reports are prepared if required.
- ☐ Adequate first aid equipment and services are available.
- ☐ A formal exposure control plan has been developed and implemented, if required.
- ☐ A written procedure for checking on employees who work alone has been developed and is being implemented.

Housekeeping

- ☐ All containers have complete, legible labels.
- ☐ Aisles are free of obstructions.
- ☐ Floors are free of oil, grease, and sharp objects.
- ☐ Stairs are in good condition and stairwells are well lit.
- ☐ Workers do not pipette by mouth, smoke, eat, or drink in the laboratory.
- ☐ Trash is placed in proper containers and disposed of properly.
- ☐ Cleaning and maintenance staff have been informed of hazards that may be found in the laboratory.

Equipment

- ☐ Equipment guards are used where appropriate.
- ☐ In-line vacuum breaks in the plumbing system are installed where necessary, and are clearly identified.
- ☐ Vacuum breaks are kept in good repair and tested according to the manufacturer's instructions.
- ☐ Centrifuge loads are balanced by distributing samples evenly.
- ☐ Ultracentrifuge rotors and other critical components are inspected and tested regularly.
- ☐ Electrophoresis apparatus have labels warning workers of the electrical hazard.
- ☐ Equipment producing hazardous fumes is effectively vented.
- ☐ Lockout procedures exist for equipment maintenance and servicing.

Personal protective equipment

- ☐ Personal protective equipment is available for all hazards encountered in the laboratory.
- ☐ Workers have been trained in the correct use of personal protective equipment.
- ☐ Workers use proper eye protection (safety glasses, goggles, face shields) when appropriate.
- ☐ Workers use gloves when appropriate.

- ☐ Workers use appropriate protective footwear.
- ☐ Workers wear lab coats in the laboratory at all times, and additional protective clothing when necessary.
- ☐ Workers do not wear protective clothing outside the work area, and store them separately from clean clothing.
- ☐ When protective clothing is sent for laundering, the laundry operator is provided with written information about hazardous materials that may be included with it as well as precautions to take.
- ☐ Respiratory protective equipment is available and is used when appropriate.
- ☐ Workers who are required to use respirators have been properly trained and fit-tested, and records for these are up-to-date.

Emergency washing facilities

- ☐ Properly designed and located eyewash and shower facilities are available and clearly identified.
- ☐ Workers know where such facilities are located, and have been trained in their use.
- ☐ Eyewash and shower facilities are tested at least monthly, and records of maintenance and testing are kept.

Fire protection

- ☐ Sources of ignition are eliminated or controlled where flammable materials are handled or stored.
- ☐ Fire extinguishers are readily available, and their maintenance is up-to-date.
- ☐ Fire exits are unobstructed and are clearly marked.
- ☐ Workers have been trained in the use of fire extinguishers and in fire prevention and emergency evacuation procedures.
- ☐ Sprinklers are unobstructed and work properly.
- ☐ The local fire department has been informed about the nature, location, and safe handling procedures of hazardous materials used in the laboratory.
- ☐ A list of chemicals is available for the fire department.
- ☐ A fire safety plan is in place.

Waste disposal

- ☐ Incompatible and hazardous wastes are properly segregated in clearly marked containers affixed with workplace labels.
- ☐ Cleaning and maintenance staff understand the markings used to designate hazardous wastes.
- ☐ Waste containers are properly labelled, tightly closed, and stored in a designated area.
- ☐ Material safety data sheets, hazardous waste profile sheets, or equivalent are available for wastes containing controlled products.
- ☐ Disposal of solvents meets all municipal, provincial, and federal regulations.
- ☐ Sharp objects are disposed of separately from other laboratory wastes, in leakproof, puncture-resistant “sharps” containers.

WHMIS requirements

- ☐ When chemicals are transferred from their original containers, workplace labels are prepared and applied to the new containers.
- ☐ Workplace labels are applied to each container of hazardous waste.
- ☐ A material safety data sheet is available for each controlled product used or stored in the laboratory. For hazardous wastes containing a controlled product, an MSDS, hazardous waste profile sheet, or equivalent is prepared.
- ☐ All material safety data sheets are not more than three years old.
- ☐ Workers are provided with education and training in the Workplace Hazardous Materials Information System (WHMIS).
- ☐ Workers who work with or near controlled products are provided with specific training on all such products.
- ☐ Maintenance and cleaning staff who may be exposed to accidental release of controlled products are provided with appropriate training.

Controlling chemical hazards

Administrative matters

- ☐ A laboratory safety manual has been developed and is being implemented.
- ☐ Written emergency procedures are in place and workers are familiar with them.
- ☐ Written procedures for working with hazardous chemicals are in place and workers are familiar with them.
- ☐ Designated materials (as listed in the Table of Exposure Limits for Chemical and Biological Substances) are replaced with less hazardous substances wherever possible.
  An exposure control plan to eliminate or minimize workers' exposure to designated materials has been developed and is being implemented.

General chemical hazards and precautions

- ☐ Workers follow safe work procedures when working with compressed gas.
- ☐ Workers follow safe work procedures when working with flammable and combustible material.
- ☐ Workers follow safe work procedures when working with oxidizing material.
- ☐ Workers follow safe work procedures when working with poisonous material.
- ☐ Workers follow safe work procedures when working with corrosive material.
- ☐ Workers follow safe work procedures when working with dangerously reactive material.

Special hazards

Peroxide formers

- ☐ Peroxide-forming compounds are inspected and tested regularly after the container has been opened, and records of these tests are kept.
- ☐ If peroxides are detected, the solvent is disposed of safely or treated chemically to remove peroxides.
- ☐ Peroxide-forming compounds are adequately labelled.

- ☐ An up-to-date inventory of peroxidizable compounds is kept.
- ☐ Peroxide-forming compounds are kept away from heat and light, and are protected from physical damage and sources of ignition.
- ☐ Laboratory apparatus and equipment are shielded if laboratory work may result in an explosion or implosion.
- ☐ Solvents stored past the expiry date are disposed of safely.

Azides

- ☐ Water solutions containing azides are inactivated before disposal in sinks and drains.
- ☐ Constant-temperature baths using soluble azides are decontaminated before heavy metal components are handled.

Picric acid

- ☐ Picric acid containers are dated and are checked regularly to ensure that their moisture content is greater than 10%.
- ☐ Bottles of picric acid containing less than 10% water are disposed of immediately by calling the RCMP or municipal police bomb squad.
- ☐ Workers who dispose of picric acid containers have received proper training.

Perchloric acid

- ☐ When anhydrous perchloric acid is needed, only freshly prepared anhydrous perchloric acid is used. Any unused portion is disposed of at the end of each experiment or procedure or at the end of the work day, whichever comes sooner.
- ☐ Perchloric acid is not stored with incompatible chemicals.
- ☐ Perchloric acid is used only in specially designed fume hoods designated for use exclusively with perchloric acid.
- ☐ Perchloric acid is heated with electric hot plates, steam-heated sand baths, or steam baths only.
- ☐ Perchloric acid is stirred with pneumatically driven stirrers only.
- ☐ No more than 6.4 kg of perchloric acid is stored in a laboratory, and no more than a 0.45 kg bottle is handled at the point of use.
- ☐ Perchloric acid is kept away from flammable or combustible materials.
- ☐ Perchloric acid is inspected monthly, and bottles with discoloration are discarded.
- ☐ Spill clean-up procedures are in place.

Storing chemicals

- ☐ A complete and up-to-date inventory of chemicals is maintained.
- ☐ Chemicals that have expired are disposed of safely.
- ☐ Chemical containers are in good condition, are securely closed, and are properly labelled with complete, legible labels.
- ☐ Chemicals in storage are segregated by hazard class and are stored appropriately for their hazard category.

- ☐ Incompatible chemicals are not stored together.
- ☐ Chemicals are not stored on the floor or on work benches.
- ☐ Liquid chemicals are not stored above eye level.
- ☐ Compressed gas cylinders are properly secured against falling.
- ☐ Only minimum working amounts of chemicals are kept in the laboratory.

Safe handling and clean-up

- ☐ Labels are replaced if they become illegible or are damaged.
- ☐ Dangerous chemicals are transported through the laboratory in a safe manner.
- ☐ Protective clothing contaminated with hazardous chemicals are disposed of or laundered properly.
- ☐ Personal protective equipment and engineering controls such as fume hoods are tested regularly.
- ☐ Clean-up of chemical spills is supervised by workers who have been trained in safe clean-up procedures.

Fume hoods

- ☐ Fume hoods are located so that cross drafts and other forces do not disrupt airflow across their operational face.
- ☐ Fume hoods are not used for storing chemicals unless they are used exclusively for this purpose and are properly labelled.
- ☐ Fume hoods are labelled with any use restrictions.
- ☐ Air velocities are measured and recorded at least once a year, and the required air velocities are maintained.
- ☐ The maximum height to which the fume hood sash may be raised has been marked.
- ☐ Fume hoods discharge their exhaust to the outside.
- ☐ Fume hoods are not connected to a common exhaust duct if such a connection would create additional hazards.

Controlling biological agents

Administrative matters

- ☐ The employer has carried out risk identification and assessment for all job titles for which there is a risk of occupational exposure to biological agents.
- ☐ An exposure control plan has been developed.
- ☐ Workers have received training in the contents of the exposure control plan and in safe work procedures for the biological hazards they work with.
- ☐ A laboratory safety manual has been developed.
- ☐ There is a biological safety officer or biological safety committee.
- ☐ Records are kept of all exposures to biohazardous or potentially biohazardous material on the job.

Engineering controls

- ☐ Laboratories are separated from public areas by a door carrying the appropriate biohazard warning sign.
- ☐ Work surfaces are easy to clean and disinfect. Floors are slip-resistant.
- ☐ Laboratories are equipped with the appropriate air-handling systems such as fume hoods and biological safety cabinets equipped with HEPA filters.
- ☐ Laboratories are equipped with handwashing facilities and a storage area for laboratory clothing.

Personal protective equipment

- ☐ Workers use proper laboratory clothing.
- ☐ Workers use gloves properly for all procedures where there may be direct skin contact with infectious materials.
- ☐ Workers use respiratory protection equipment when required.
- ☐ Workers use proper eye protection (safety glasses, goggles, face shields) when appropriate.

Safe work practices

- ☐ Workers wash hands frequently.
- ☐ Workers limit their use of needles, syringes, and other sharp objects, and dispose of them in a puncture-proof "sharps" container.
- ☐ Workers take steps to minimize production of and exposure to aerosols that may contain biohazardous materials.
- ☐ Workers report all spills, accidents, and actual or potential exposures to the laboratory supervisor.

Housekeeping

- ☐ Infectious liquids and solids are decontaminated before disposal.
- ☐ Work surfaces are cleaned and decontaminated at the end of the day or after any spill of potentially hazardous material.
- ☐ Workers ensure that sharps are not accidentally discarded in laundry.

Waste disposal

- ☐ Sharp objects are disposed of in leakproof, puncture-resistant "sharps" containers.
- ☐ Glass waste is placed in "Glass Waste Only" containers.
- ☐ Microbiological waste is autoclaved before disposal.
- ☐ Before contaminated materials are transported from the lab, the outside of the container is disinfected or the materials are double-bagged.

Biological agents

- ☐ Workers understand how to reduce the risk of exposure to biological agents by using personal protective equipment.

- ☐ Workers who may be exposed to biological agents understand the concept of standard precautions and use these precautions in their work.
- ☐ Workers know what to do in the event of an exposure incident such as a puncture, cut, spill, or splash.
- ☐ Workers who have or may have exposure to the hepatitis B virus are offered vaccination at no cost upon request. Workers are informed of the offer, and a signed record of such offer is kept.
- ☐ Workers who have been exposed to a biological agent designated as a hazardous substance in section 5.1.1 of the Regulation are advised to get a medical evaluation right away.

Labelling

- ☐ Containers of known or suspected biohazardous materials are properly labelled.
- ☐ Known or suspected biohazardous materials not in a container are properly identified.

Biological safety cabinets

- ☐ Biological safety cabinets are certified by a qualified person at least once a year and before being used after initial installation, change of HEPA filter, movement of the unit, and any repair or maintenance that could affect the seal of the HEPA filter.
- ☐ Workers follow approved operating guidelines when using a biological safety cabinet.

Decontamination

- ☐ Adequate supplies of chemical disinfectants are available.
- ☐ There are adequate facilities for personal decontamination of workers who come in contact with biohazardous materials.
- ☐ Workers follow approved procedures for autoclaving.
- ☐ Workers know how to select and dilute disinfectants to be used.

Biological spills

- ☐ Written procedures for dealing with biological spills are available.
- ☐ Workers have been trained in these procedures.
- ☐ Biological spill kits are readily available in the laboratory.
- ☐ Workers follow the procedures and guidelines for dealing with biological spills.

Physical hazards

Musculoskeletal injury (MSI)

- ☐ Hazards that may cause musculoskeletal injury have been identified, and control measures are in place to minimize their effect.
- ☐ Workers have been educated in the signs and symptoms of musculoskeletal injury and trained in the use of the control measures.

Cryogenic liquids

- ☐ Workers have been educated in the hazards posed by cryogenic liquids and in safe work procedures for handling them.

Radiation

Ionizing

- ☐ An exposure control plan has been developed and is being implemented.
- ☐ All persons working with radioactive materials have been properly trained in their hazards and safe use.
- ☐ Workers use personal protective equipment when handling radioactive materials.
- ☐ Containers of radioactive materials are properly labelled.
- ☐ Warning signs are posted on doors of labs where radioactive materials are used.
- ☐ Food and radioactive materials are stored separately.
- ☐ Written work instructions are posted in the work area.
- ☐ Workers' exposure to ionizing radiation is monitored and kept as low as possible below the exposure limits specified in the Occupational Health and Safety Regulation.
- ☐ A radiation survey is conducted when necessary.
- ☐ Keep radiation survey records for at least 10 years or at the direction of the CNSC (whichever is longer), and exposure monitoring and personal dosimetry data for the employment period plus 10 years or at the direction of the CNSC (whichever is longer). All these records should be available to workers.
- ☐ Education and counselling regarding reproductive hazards associated with exposure to ionizing radiation are provided, especially to pregnant workers or those intending to conceive.

Non-ionizing

- ☐ Exposure to radiofrequency electromagnetic fields adheres to the standards listed in section 7.19 of the Regulation.
- ☐ Exposure to non-ionizing radiation from lasers adheres to the standards listed in section 7.19 of the Regulation.
- ☐ Exposure to ultraviolet radiation adheres to the standards listed in section 7.19 of the Regulation.
- ☐ Exposure to ultrasonic energy from equipment adheres to the standards listed in section 7.23 of the Regulation.

Animals

- ☐ Animal quarters and handling areas are kept clean and hygienic.
- ☐ Animal health is monitored by qualified personnel, and sick or infected animals are quarantined.
- ☐ Appropriate equipment and techniques are used in handling or restraining animals.
- ☐ Work procedures and handling methods are designed to control the spread of aerosols.
- ☐ Appropriate protective clothing and equipment are used to minimize contact with animal products.
- ☐ Workers are educated about animal-related allergies and ways of avoiding them.

Laboratory equipment

Safeguarding of equipment

- ☐ Laboratory equipment that present a physical hazard to workers are adequately safeguarded, shielded, or isolated by location.
- ☐ Any hazards associated with the use of a piece of equipment are identified on the equipment through a label or sign.
- ☐ Lockout procedures exist for equipment maintenance and servicing.

Local ventilation and flushing of equipment

- ☐ Laboratory equipment or instrumentation that may emit harmful airborne quantities of a substance are equipped with effective local exhaust ventilation.

Vacuum breaks

- ☐ Vacuum breaks are installed in plumbing systems. The locations of in-line breaks are clearly identified through signage.
- ☐ Vacuum breaks are kept in good repair and tested according to manufacturer's instructions.

Centrifuges

- ☐ Sealed, aerosol-proof centrifuge cups or rotors are used for biohazardous, carcinogenic, or radioactive materials.
- ☐ Centrifuge rotors are stored in a manner that prevents damage.
- ☐ The interlocks on centrifuges so equipped are operational and prevent workers from coming into contact with spinning rotors.
- ☐ In centrifuges where Emax exceeds 1 kiloJoule, the catch is locked in the engaged position when the motor is energized, and remains locked until the energy level drops to 1 kiloJoule or less.
- ☐ Any centrifuges equipped with a lever or knob for releasing the catch should have:
    - An Emax less than 1 kiloJoule
    - A lever or knob for releasing the catch designed to minimize the chance of unintentional operation
    - The following warning displayed next to them: WARNING: DO NOT OPEN THE ACCESS COVER UNTIL THE HEAD HAS STOPPED.
- ☐ Ultracentrifuge rotors and other critical components are inspected regularly and non-destructively tested according to the manufacturer's instructions.
- ☐ The manufacturer-specified use life for ultracentrifuge rotors is not exceeded.

Electrophoresis apparatus

- ☐ Electrical current is shut off when the cover is opened.
- ☐ A label warns workers of the electrical hazard.
- ☐ High-voltage components are guarded to prevent worker contact.
- ☐ There are no broken or cracked Plexiglas™ parts.

Resources

General

WorkSafeBC. Occupational Health and Safety Regulation.
http://regulation.healthandsafetycentre.org/s/Home.asp

- Table of Exposure Limits for Chemical and Biological Substances in Guideline G5.48-1 to Part 5 of the Occupational Health and Safety Regulation.
  http://regulation.healthandsafetycentre.org/s/GuidelinePart5.asp?ReportID=32895

Workers Compensation Act, Part 3, Division 4.
http://regulation.healthandsafetycentre.org/s/WorkersCompensationAct.asp

Laboratory safety

American Industrial Hygiene Association (AIHA), Laboratory Health and Safety Committee. Links to online resources:

- Exposure Assessment, Risk Assessment and Process Safety.
  http://www2.umdnj.edu/eohssweb/aiha/technical/exposure.htm
- Fire, Building and Building Codes Affecting Laboratories.
  http://www2.umdnj.edu/eohssweb/aiha/technical/codes.htm

American Industrial Hygiene Association (AIHA), Laboratory Health and Safety Committee. Laboratory Safety Incidents (compilation of laboratory safety incidents, with key safety and health teaching concepts/principles).
http://www2.umdnj.edu/eohssweb/aiha/accidents/index.htm

Canadian Centre for Occupational Health and Safety (CCOHS). Safety Infograms for various laboratory hazards.
http://www.ccohs.ca/

Center for Research on Occupational and Environmental Toxicology (CROET), Oregon Health & Science University. Occupational Safety and Health: Resource Directory—Laboratory.
http://www.croetweb.com/links.cfm?topicID=19

Oklahoma State University, Environmental Health and Safety. *Laboratory Safety Manual*. 2002.
http://www.pp.okstate.edu/ehs/HAZMAT/Labman.htm

Shematek G, Wood W. *Laboratory Safety*. CSLT Guidelines, 4th ed. Hamilton, ON: Canadian Society of Laboratory Technologists (now the Canadian Society for Medical Laboratory Science), 1996.
http://www.csmls.org/

WHMIS and MSDSs

American Industrial Hygiene Association (AIHA), Laboratory Health and Safety Committee. Chemical Safety/MSDS (links to online resources).
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Canadian Centre for Occupational Health and Safety (CCOHS). OSH Answers: Legislation.
http://www.ccohs.ca/oshanswers/legisl/

Government of Canada. Explosives Act (R.S. 1985, c. E-17).
http://laws.justice.gc.ca/en/E-17/index.html

Government of Canada. Food and Drug Regulations (C.R.C., c. 870).
http://laws.justice.gc.ca/en/F-27/C.R.C.-c.870/

Government of Canada. Pest Control Products Act (R.S. 1985, c. P-9).
http://laws.justice.gc.ca/en/P-9/

Government of Canada. Transportation of Dangerous Goods Act, 1992 (1992, c. 34).
http://laws.justice.gc.ca/en/T-19.01/

Government of Canada. Hazardous Products Act (R.S. 1985, c. H-3).
http://laws.justice.gc.ca/en/H-3/

Government of Canada. Controlled Products Regulations (SOR/88-66).
http://laws.justice.gc.ca/en/H-3/SOR-88-66

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University of Manitoba, Environmental Health and Safety Office. MSDS on the Internet.
http://www.umanitoba.ca/campus/health_and_safety/msds-links.shtml

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http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/whmis.pdf

WorkSafeBC. *WHMIS Core Material: A Resource Manual for the Application and Implementation of WHMIS*. Richmond: WorkSafeBC.
http://www.worksafebc.com/publications/health_and_safety/whmis/pub_40_20_20_20.asp

WorkSafeBC. WorkSafeBC WHMIS Information Site.
http://whmis.healthandsafetycentre.org/s/Home.asp

Personal protective equipment

American Industrial Hygiene Association (AIHA), Laboratory Health and Safety Committee. Personal Protective Equipment (links to online resources).
http://www2.umdnj.edu/eohssweb/aiha/technical/ppe.htm

Canadian Centre for Occupational Health and Safety (CCOHS).
OSH Answers: Personal Protective Equipment.
http://www.ccohs.ca/oshanswers/prevention/ppe/

Oklahoma State University. Chemical Guide and Permeation Tables.
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Oklahoma State University. Eye Protection.
http://www.pp.okstate.edu/ehs/modules/ppe/eye.htm

University of Toronto. *Protective Eye and Facewear Standard*
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University of Toronto. *Protective Glove Standard*.
http://www.utoronto.ca/safety/Standards/glovestd.htm

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WorkSafeBC. *Dealing with "Latex Allergies" at Work*. Richmond: WorkSafeBC, revised, 2005.
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Chemical hazards

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Medical College of Georgia. Special Chemical Handling Procedures: Peroxide Forming Compounds & Picric Acid.
http://www.mcg.edu/services/ehs/chemsafe/SpeChemHanProc.htm

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  http://www2.umdnj.edu/eohssweb/aiha/technical/animal.htm
- Ergonomics
  http://www2.umdnj.edu/eohssweb/aiha/technical/ergonomics.htm
- Lasers
  http://www2.umdnj.edu/eohssweb/aiha/technical/lasers.htm
- Non-Ionizing Radiation
  http://www2.umdnj.edu/eohssweb/aiha/technical/nonionizing.htm
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Laboratory equipment

American Industrial Hygiene Association (AIHA), Laboratory Health and Safety Committee. Laboratory Equipment (links to online resources).
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