

## Laboratory Safety Audit Categories

### Standards and Explanations

The following are descriptions of audit items organized by category. They are supported by government regulations or are considered best practices by accredited and respected sources.

#### Lab Safety Plan

All laboratories working with hazardous materials or performing hazardous procedures are required to have a [Laboratory Safety Plan](#). The plan shall be available to all laboratory personnel, be reviewed annually, and updated as necessary. **Standard Operating Procedures** and lab-specific training must be provided and documented. In addition to the PI/supervisor, one or more laboratory safety contact(s) should be identified for each laboratory group. **Personnel** and **hazard profiles** for the laboratory should be kept up-to-date in the DRS database. This ensures that training requirements are met and accurate door signs are posted.

The following materials require [registration with the IBC](#): recombinant or synthetic nucleic acid molecules; transgenic animals (use or creation); transgenic plants; all pathogens; human materials; nonhuman primate materials; and biotoxins.

All laboratories that are operating at **BSL-2** must have a Laboratory Safety Plan that includes complete BSL-2 information relevant to the work performed in the laboratory. Work with **risk group 2 toxins** must be supported with lab-specific training on the toxins used. BSL-2 training has to be repeated annually.

In all BSL-2 laboratories working with **human materials**, researchers are required to be offered the Hepatitis B vaccination series at no cost to the researcher. A declination or request statement for the Hepatitis B vaccine must be kept on file in a secure location. The current **exposure control plan** must be readily available for all laboratory personnel. The exposure control plan is updated annually.

Laboratories using class 3b or class 4 **lasers** must cover information specific to their laser operation, alignment and policies in their Lab Safety Plan. The DRS laser safety online training must be repeated annually.

Access to **Safety Data Sheets** (SDS) for chemicals and other references for handling hazardous materials should be available.

All class 3b and 4 **lasers** must be **registered** with DRS

Laboratories should have **access control** measures to secure laboratory materials and equipment from unauthorized persons.

#### 29 CFR 1910.1450 Laboratory Standard

*(e)(1) "Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is..."*

*(f)(1) "The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area."*

*(h)(1)(ii) "Employers shall maintain any safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees."*

*(e)(3)(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan...*

*(e)(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually*

and update it as necessary.

## **29 CFR 1910.1450 Appendix A**

*D. 7. Prominent signs of the following types should be posted:*

- (a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers;*
- (b) Location signs for safety showers, eyewash stations, other safety and first aid equipment, and exits; and*
- (c) Warnings at areas or equipment where special or unusual hazards exist.*

BL1 Section IV-A-9

*“A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. The sign may include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor or other responsible personnel. Agent information should be posted in accordance with the institutional policy.”*

## **NIH Guidelines Appendix G-I. Standard Practices and Training**

*“The first principle of containment is strict adherence to good microbiological practices (see Appendices G-III-A through G-III-J, Footnotes and References of Appendix G). Consequently, all personnel directly or indirectly involved in experiments using recombinant or synthetic nucleic acid molecules shall receive adequate instruction (see Sections IV-B-1-h, Responsibilities of the Institution--General Information, and IV-B-7-d, Responsibilities of the Principal Investigator Prior to Initiating Research). At a minimum, these instructions include training in aseptic techniques and in the biology of the organisms used in the experiments so that the potential biohazards can be understood and appreciated.”*

NIH Guidelines Section IV-B-2. Institutional Biosafety Committee (IBC)

*The institution shall establish an Institutional Biosafety Committee whose responsibilities need not be restricted to recombinant or synthetic nucleic acid molecule research.*

**BMBL 5<sup>th</sup> ed,**

BL2 Section IV-B-4

*“A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible.”*

BL1 Section IV-A-1

*“The laboratory supervisor must enforce the institutional policies that control access to the laboratory.”*

## **29 CFR 1910.1030(c)(1)(i) Bloodborne Pathogens**

*“Each employer having an employee(s) with occupational exposure as defined by paragraph (b) of this section shall establish a written Exposure Control Plan designed to eliminate or minimize employee exposure.”*

## **29 CFR 1910.1030 App A**

*“I understand that due to my occupational exposure to blood or other potentially infectious materials I may be at risk of acquiring hepatitis B virus (HBV) infection. I have been given the opportunity to be vaccinated with hepatitis B vaccine, at no charge to myself. However, I decline hepatitis B vaccination at this time. I understand that by declining this vaccine, I continue to be at risk of acquiring hepatitis B, a serious disease. If in the future I continue to have occupational exposure to blood or other potentially infectious materials and I want to be vaccinated with hepatitis B vaccine, I can receive the vaccination series at no charge to me.”*

## **IEMA part 315.100**

a) 1:

*“The registrant shall provide personnel operating lasers written operating and safety procedures.”*

a) 2

*“The registrant shall provide for initial and annual in-service training in laser safety for individuals using laser systems to ensure their awareness of the registrant’s laser practices and policies.”*

### **IEMA part 315.60 Registration**

#### **ANSI Z136.1 4.4.3.8: Alignment procedures.**

*“Written SOPs outlining alignment methods should be approved by the LSO for Class 3b and shall be approved for Class 4 lasers or laser systems.”*

*“The use of lower power visible lasers for path simulation of higher power lasers is recommended for alignment of higher power Class 3b or Class 4 visible or invisible lasers and laser systems.”*

#### **Prudent Practices 2011: Chapter 6.D.4 Access Control**

*“Restrict access to laboratories where highly toxic chemicals are in use to personnel who are authorized for this laboratory work and trained in the special precautions that apply. Administrative procedures or even physical barriers may be required to prevent unauthorized personnel from entering these laboratories.*

*Keep laboratory doors closed and locked to limit access to unattended areas where highly toxic materials are stored or routinely handled. However, security measures must not prevent emergency exits from the laboratory...”*

## **PPE**

Appropriate PPE shall always be worn when handling hazardous materials.

**Gloves** to protect against the hazards present in the lab shall be available. Because of potential allergic reactions, alternatives to latex gloves should be provided. If cryogenics are handled, loose-fitting cryogenic gloves should be available. Gloves must not be worn in public spaces or when touching objects like door knobs, elevator buttons, or keyboards.

Appropriate **eye/face protection** for the hazards present in the lab shall be available. At a minimum, safety glasses with side shields should be available for every person working with chemicals. Splash goggles or a face shield are recommended for splash/spray hazards and for handling highly corrosive or toxic liquids. Regular prescription eyeglasses are not sufficient for splash and impact hazards.

Full face protection is required for BL-2 laboratories when handling microorganisms outside the BSC or containment device. For laboratories using a BSC, full face protection must still be available in the case of a spill outside the cabinet.

All personnel required to wear a **respirator** shall follow the UIUC Respiratory Protection Policy and implement their own respirator protection program. The program is administered on campus by the Division of Safety and Compliance. For more information view the [Respiratory Protection Fact Sheet](#).

**Laboratory coats** that provide protection adequate for the hazards present in the laboratory shall be available. All BSL-2 laboratories must have dedicated lab coats for the room. These coats must not be removed from the BSL-2 laboratory unless properly done so for decontamination. A plan for regular decontamination of lab coats must be in place.

See the DRS safety guide on [PPE](#) for more information.

Adequate **laser** eye wear protecting against the wavelength in use and with sufficient optical density (OD) must be available. Eye protection must be in good condition without scratches, discolorations or holes that could compromise protection. Eye protection must be worn inside the NHZ. Eyewear needs to be inspected every six months and documented. High powered lasers may require gloves, clothing, or shields.

### **29 CFR 1910.1450 App A**

*E 1(f) Wear appropriate PPE at all times.”*

### **29 CFR 1910.132 General Requirements**

*“Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided,*

*used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.”*

### **29 CFR 1910.138 Hand Protection**

*“General requirements. Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes. Selection. Employers shall base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified.”*

### **29 CFR 1910.133 Eye and face protection**

*“The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation...”*

### **BMBL 5<sup>th</sup> ed**

BL2 Section IV -C-3

*“Eye and face protection (goggles, mask, and face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials when the microorganisms must be handled outside the BSC or containment device.”*

BL1 Section IV-C-3

*“Wear protective eyewear when conducting procedures that have the potential to create splashes of microorganisms or other hazardous materials. Persons who wear contact lenses in laboratories should also wear eye protection.”*

BL1 Section IV-C-4

*“Gloves must be worn to protect hands from exposure to hazardous materials. Glove selection should be based on an appropriate risk assessment. Alternatives to latex gloves should be available... Do not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste.”*

BL2 Section IV-C-2

*“Gowns, uniforms, laboratory coats and personal protective equipment are worn while in the areas where infectious materials and/or animals are housed or manipulated and removed prior to exiting.”*

### **29 CFR 1910.134 Respiratory Protection**

*“...When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to this section... A respirator shall be provided to each employee when such equipment is necessary to protect the health of such employee. The employer shall provide the respirators which are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protection program... The employer shall include in the program the following provisions of this section, as applicable... Fit testing procedures for tight-fitting respirators; Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations...”*

### **IEMA part 315.100**

b) 5

*Protective eyewear, when specified by the laser safety officer, when engineering or other procedural and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE, shall be worn by all individuals with access to Class 3b and Class 4 levels of laser radiation. The protective eyewear devices shall meet the following requirements:*

- A) *Provide a comfortable and appropriate fit all around the area of the eyes sufficient to protect the eyes from laser radiation*
- B) *Be in proper condition to ensure the optical filters and holders provide the required optical density or greater at the desired wavelengths, and retain all protective properties during use of the device.*
- C) *Be suitable for the specific wavelength of the laser and be of optical density adequate for the energy of the laser.*
- D) *Have the optical density or densities and associated wavelengths permanently labeled on the filters or otherwise permanently identified.*
- E) *Be examined by the registrant's laser safety officer, or designee, at intervals not to exceed 6 month, to ensure the reliability of the protective filters and integrity of the protective filter frames.*
- F) *Eyewear not meeting the requirements of this subsection (b)(5) shall not be utilized as protective eyewear.*

b) 6

*When there is a possibility of exposure to laser radiation that exceeds the MPE limits for skin as specified in Table B, the registrant shall require the appropriate use of protective gloves, clothing and shields.*

## Laboratory Housekeeping

**Food and beverages** must not be permitted in laboratories or stored in refrigerators that are used to store biological, chemical, or radioactive materials. Empty food containers must not be used to collect hazardous waste.

**Cluttered work spaces** increase the risks of spills and accidents. **Spills** that have not been properly cleaned are potentially hazardous and can lead to accidental exposures as well as damage to surfaces and equipment.

**Aisles and exits** must be free of objects to provide unimpeded access to emergency equipment and emergency exits. Emergency response personnel need to be able to access all areas of the laboratory and move freely even in poor visibility when smoke is present. Access to exits must be at least 28 inches wide at all points. See the Division of Research Safety (DRS) safety guide on [Laboratory Housekeeping](#) for more information.

**Sprinklers** require an 18-inch vertical clearance to function properly.

**Soap and paper towels** are required in laboratories to wash hands and surfaces.

All **floors** and **work surfaces** must be made of a material that can be easily decontaminated. They should be impervious to liquids and chemically resistant so that they can be cleaned and decontaminated easily.

**Pest management** protocols must be in place for all BSL-2 laboratories.

**Animals and plants** should not be in laboratories where BSL-2 work is done. Only animals and plants associated with the research can be present.

Laboratories at BSL-2 must have all **exterior windows** fitted with screens or fixed in a way that they cannot be opened.

### 29 CFR 1910.141(g)(2)

*“Eating and drinking areas. No employee shall be allowed to consume food or beverages in a toilet room nor in any area exposed to a toxic material.”*

### 29 CFR 1910.1450 Appendix A

*E.1. (k) “Eating, drinking, smoking, gum chewing, applying cosmetics, and taking medicine in laboratories where hazardous chemicals are used or stored should be strictly prohibited.”*

*E.1. (l) “Food, beverages, cups, and other drinking and eating utensils should not be stored in areas where hazardous chemicals are handled or stored.”*

*C1(a) “Work surfaces should be chemically resistant, smooth, and easy to clean.”*

*E1(j) “Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.”*

### Prudent Practices in the Laboratory 2011 Chapter 6.C.3

*“A definite correlation exists between orderliness and the level of safety in the laboratory. In addition, a disorderly laboratory can hinder or endanger emergency response personnel.”*

### **29 CFR 1910.22 Walking-Working Surfaces**

*(a)(1) “All places of employment, passageways, storerooms, and service rooms shall be kept clean and orderly and in a sanitary condition.”*

*(b)(1) “Aisles and passageways shall be kept clear and in good repairs, with no obstruction across or in aisles that could create a hazard.”*

### **29 CFR 1910.36(g)(2) Means of Egress**

*“An exit access must be at least 28 inches (71.1 cm) wide at all points. Where there is only one exit access leading to an exit or exit discharge, the width of the exit and exit discharge must be at least equal to the width of the exit access.”*

### **29 CFR 1910.37 Means of Egress**

*(a)(3) “Exit routes must be free and unobstructed.”*

### **29 CFR 1910.159(c)(10) Automatic Sprinkler Systems**

*“Sprinkler spacing. The employer shall assure that sprinklers are spaced to provide a maximum protection area per sprinkler, a minimum of interference to the discharge pattern by building or structural members or building contents and suitable sensitivity to possible fire hazards. The minimum vertical clearance between sprinklers and material below shall be 18 inches (45.7 cm).”*

### **BMBL 5<sup>th</sup> ed,**

#### **BL1 Section IV-A-3**

*“Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.”*

#### **BL1 Section IV-A-2**

*“Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.”*

#### **BL1 Section IV-D-3**

*“The laboratory should be designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.”*

#### **BL1 Section IV-D-3a**

*“Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.”*

#### **BL2 Section IV-B-9**

*“Animal and plants not associated with the work being performed must not be permitted in the laboratory.”*

### **NIH Guidelines**

#### **Appendix G-II-B-4-e.**

*“If the laboratory has windows that open, they are fitted with fly screens.”*

#### **Appendix G-II-B-2-e**

*“An insect and rodent control program is in effect.”*

#### **Appendix G-II-B-2-g.**

*“Animals not involved in the work being performed are not permitted in the laboratory.”*

## **Electrical**

Extension cords should be used only temporarily. They should not be run through holes in walls, doors, or windows, or be attached to building surfaces. Power strips with circuit breakers may be used but should not be connected in a series or to an extension cord.

Extension cords that have a three-wire design shall have the ground plug intact. Three-to-two-prong adapters should never be used to plug a three-wire plug into a two-wire system.

All electrical cords should be inspected by the user for damage to the integrity of the cord. Electrical cords with damage to the insulation (i.e., wires are visible or tape is needed to hold it together) or frayed cords should be replaced immediately. Equipment with cords that have obvious shorts should be taken out of service until the cords are replaced.

Electrical circuits should not be overloaded. "Overloaded" is defined as excessive electrical cords plugged into a circuit through the use of adapters, which allow multiple-plug capability. Power strips with internal fuses may be used but should not be used in a series or with adapters.

Ground Fault Circuit Interrupter (GFCI) protection must be used for electrical appliances that will operate within six feet of water sources. For outlets that must be used within the six feet of a water source, portable GFCIs are available for purchase.

Equipment with high voltage (> 600 V) or equipment with exposed live parts of > 50 V must be guarded against accidental contact and labeled with a sign warning of the electrical shock hazard.

Electrical panels must be kept accessible for repair and maintenance by service personnel. See the DRS guide on [Electrical Safety in the Laboratory](#) for more information.

### **29 CFR 1910.305 Wiring methods, components, and equipment for general use**

*(a)(2)(ii) "Temporary Wiring: Temporary wiring shall be removed immediately upon completion of the project or purpose for which the wiring was installed."*

*(g)(1)(iv) "Unless specifically permitted otherwise in paragraph (g)(1)(ii) of this section, flexible cords and cables may not be used:*

- (A) As a substitute for the fixed wiring of a structure;*
- (B) Where run through holes in walls, ceilings, or floors;*
- (C) Where run through doorways, windows, or similar openings;*
- (D) Where attached to building surfaces;*
- (E) Where concealed behind building walls, ceilings, or floors; or*
- (F) Where installed in raceways, except as otherwise permitted in this subpart."*

### **29 CFR 1910.334 Use of equipment**

*(a)(2)(ii) "If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made."*

*(a)(3)(iii) "Adapters which interrupt the continuity of the equipment grounding connection may not be used."*

### **29 CFR 1910.303 General-Electrical**

*(g)(1) "Space about electric equipment. Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment."*

*(g)(2) Guarding of live parts.*

*(g)(2)(i) "Except as elsewhere required or permitted by this standard, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by use of approved cabinets or other forms of approved enclosures or by any of the following means:..."*

*(g)(2)(iii) "Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter."*

*(h)(5)(iii) "The following requirements apply to the entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal:*

*(h)(5)(iii)(A) "The entrances shall be kept locked unless they are under the observation of a qualified person at all times; and*

*(h)(5)(iii)(B) "Permanent and conspicuous warning signs shall be provided, reading substantially as follows: "DANGER HIGH VOLTAGE KEEP OUT."*

## **29 CFR 1910.304 Wiring design and protection**

*(e)(2)(ii) "Signs warning of high voltage shall be posted where unqualified employees might come in contact with live parts."*

### **NFPA, electrical safety tips**

*"U.S. fire departments responded to an estimated annual average of 47,820 reported home structure fires involving electrical failure or malfunction in 2007-2011. These fires resulted in 455 civilian deaths, 1,518 civilian injuries and \$1.5 billion in direct property damage.*

- Replace or repair damaged or loose electrical cords.*
- Avoid running extension cords across doorways or under carpets.*
- In homes with small children, make sure your home has tamper-resistant (TR) receptacles.*
- Consider having additional circuits or outlets added by a qualified electrician so you do not have to use extension cords.*
- Follow the manufacturer's instructions for plugging an appliance into a receptacle outlet.*
- Avoid overloading outlets. Plug only one high-wattage appliance into each receptacle outlet at a time.*
- If outlets or switches feel warm, frequent problems with blowing fuses or tripping circuits, or flickering or dimming lights, call a qualified electrician.*
- Place lamps on level surfaces, away from things that can burn and use bulbs that match the lamp's recommended wattage.*
- Make sure your home has ground fault circuit interrupters (GFCIs) in the kitchen bathroom(s), laundry, basement, and outdoor areas.*
- Arc-fault circuit interrupters (AFCIs) should be installed in your home to protect electrical outlets."*

### **NFPA 70.210.8.**

*"Ground-fault circuit-interruption for personnel shall be provided as required in 210.8(A) through (C). The ground-fault circuit-interrupter shall be installed in a readily accessible location.*

*B.5 Sinks – where receptacles are installed within 1.8 m (6 ft) of the outside edge of the sink."*

## **Engineering Controls**

**Chemical fume hoods** are inspected annually by Safety and Compliance to ensure that airflow meets established standards and that it is not impeded by material in the hood. In addition, sashes and sidewalls must be intact for the hood to function properly. Proper use of the fume hood is also essential to properly protect laboratory personnel. See the DRS safety guide on [Chemical Fume Hood](#) for more information.

**Biosafety cabinets** should be present to minimize exposure hazardous biological materials. They should be located away from doors, windows that open, and heavily traveled areas.

**Biosafety cabinets** should be inspected annually by a qualified professional certifier.

**All gas lines** connected to a biosafety cabinet must have an accessible shut-off valve on the outside of the cabinet.

**Engineering controls** such as adequate ventilation is required to keep concentrations of airborne contaminants below permissible exposure limits.



**Machine guards** should be kept in place to avoid injury. All safety features for instruments and machines must be kept intact and not tampered with.

### **29 CFR 1910.1450**

*(e)(3)(iii) "A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;"*

### **NFPA 45 2011, 8.13.1**

*When installed or modified and at least annually thereafter, chemical fume hoods, chemical fume hood exhaust systems, and laboratory special exhaust systems shall be inspected and tested as applicable, as follows:*

- 1. Visual inspection of the physical condition of the hood interior, sash, and ductwork*
- 2. Measuring device for hood air flow*
- 3. Low airflow and loss-of-airflow alarms at each alarm location*
- 4. Face velocity*
- 5. Verification of inward airflow over the entire hood face*
- 6. Changes in work area conditions that might affect hood performance*

### **Prudent Practices in the Laboratory 2011**

#### **9 C.2.5 Housekeeping**

*"Keep laboratory chemical hoods and adjacent work areas clean and free of debris at all times. Keep solid objects and materials (such as paper) from entering the exhaust ducts, because they can lodge in the ducts or fans and adversely affect their operation. The chemical hood will have better airflow across its work surface if it contains a minimal number of bottles, beakers, and laboratory apparatus; therefore, prudent practice keeps unnecessary equipment and glassware outside the chemical hood at all times and stores all chemicals in approved storage cans, containers, or cabinets. Furthermore, keep the workspace neat and clean in all laboratory operations, particularly those involving the use of chemical hoods, so that any procedure or experiment can be undertaken without the possibility of disturbing, or even destroying, what is being done."*

### **BMBL 5<sup>th</sup> ed.**

#### **BL2 Section IV-D-6**

*"BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, windows that can be opened, heavily traveled laboratory areas, and other possible airflow disruptions."*

### **BMBL 5<sup>th</sup> ed. Appendix A**

#### **Section VII - Certification of BSCs**

*"The operational integrity of a BSC must be validated before it is placed into service and after it has been repaired or relocated. Relocation may break the HEPA filter seals or otherwise damage the filters or the cabinet. Each BSC should be tested and certified at least annually to ensure continued, proper operation."*

#### **Section IV - Utility Services**

*"When propane or natural gas is provided, a clearly marked emergency gas shut-off valve outside the cabinet must be installed for fire safety."*

### **29 CFR 1910.1450(c)**

*Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposure to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.*

### **29 CFR 1910.1450 Appendix A**

*A General Principles. 4. Provide Ventilation: The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices.*

### **29 CFR 1910.212 General requirements for all machines**

*(a)(1) “Types of guarding. One or more methods of machine guarding shall be provided to protect the operator and other employees in the machine area from hazards such as those created by point of operation, ingoing nip points, rotating parts, flying chips and sparks. Examples of guarding methods are-barrier guards, two-hand tripping devices, electronic safety devices, etc.”*

## Other Equipment

**Chairs** used near work areas in both Biosafety Level 1 and Biosafety Level 2 spaces must be covered with non-porous material that can be decontaminated easily.

Systems under **vacuum** must use appropriate-sized traps in a manner that prevents damage to vacuum sources and reduces the dispersal of volatile substances in the building. The vacuum exhaust of pumps has to be vented correctly to prevent hazardous vapors from escaping into the room. All vacuum equipment must be constructed of appropriate material, in good working order, and coated in a manner that will minimize flying glass in the event of an implosion. See the DRS guide on [Vacuum Safety](#) for more information.

**Tubing** should be kept in good condition as cracks can lead to vapors escaping into the room or poor vacuum that can lead to the pump overheating.

**Equipment** such as vacuum traps, filtration funnels and flasks, etc. should be secured to prevent them from falling over, breaking, and causing a spill.

**Mercury thermometers** should not be used in ovens due to the high toxicity of mercury vapors that could result if the thermometer broke within the oven. See the DRS safety guide on [Mercury](#) for more information.

**Sinks** are necessary in laboratories using hazardous materials to allow personnel to wash hands immediately after glove removal. Soap and paper towels must be available.

### BMBL 5<sup>th</sup> ed, BL1

#### Section IV-A-2

*“Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.”*

#### Section IV-D-2

*“Laboratories must have a sink for hand washing.”*

#### Section IV-D-4-b

*“Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.”*

### 29 CFR 1910.1450 App A

*E1(j) “Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.”*

### NFPA 45 2011 12.1.6.3

*“Glass apparatus containing gas or vapors under vacuum or above ambient pressure shall be shielded, wrapped with tape, or otherwise protected from shattering (such as engineering control or by apparatus design) during use.”*

### Prudent Practices in the Laboratory 2011

#### 7.C.2 Vacuum Pumps.

*“Distillation or similar operations requiring a vacuum must use a trapping device to protect the vacuum source, personnel, and the environment. This requirement also applies to oil-free Teflon-lined diaphragm pumps. Normally the vacuum source is a cold trap cooled with dry ice or liquid nitrogen..*

*Vent the output of each pump to a proper air exhaust system. This procedure is essential when the pump is being used to evacuate a system containing a volatile toxic or corrosive substance. Failure to observe this precaution results in pumping the untrapped substances into the laboratory atmosphere. Scrubbing or*

*absorbing the gases exiting the pump is also recommended. Even with these precautions, volatile toxic or corrosive substances may accumulate in the pump oil and thus be discharged into the laboratory atmosphere during future pump use. Avoid this hazard by draining and replacing the pump oil when it becomes contaminated.*

*Belt-driven mechanical pumps must have protective guards. Such guards are particularly important for pumps installed on portable carts or tops of benches where laboratory personnel might accidentally entangle clothing or fingers in the moving belt or wheels. Glassware under vacuum is at risk for implosion, which could result in flying glass. (For more information about working under vacuum, see Chapter 4, section 4.E.4.).”*

#### 7.C.5.1 Ovens

*“Bimetallic strip thermometers are preferred for monitoring oven temperatures. Do not mount mercury thermometers through holes in the tops of ovens with the bulb hanging into the oven. If a mercury thermometer is broken in an oven of any type, close the oven and turn it off immediately to avoid mercury exposure. Keep it closed until cool. Remove all mercury from the cold oven with the use of appropriate cleaning equipment and procedures (see Chapter 6, section 6.C.10.8). After removal of all visible mercury, monitor the heated oven in a laboratory chemical hood until the mercury vapor concentration drops below the threshold limit value. (For information about reducing the use of mercury in thermometers, see Chapter 5, section 5.B.8.).”*

## Work Practices

**Needles** should not be bent, sheared, broken, recapped, removed, from disposal syringes or otherwise manipulated by hand without proper training.

**Safety cups or o-ringed tubes** must be used to centrifuge potentially infectious material in order to contain aerosols.

All spaces that generate “redbag” waste must have access to an **autoclave** in the building the waste is generated. To determine if your access to an autoclave is adequate, contact DRS.

**Doors to BSL-2 laboratories** must be closed when work is ongoing.

All **risk group 2 toxins** must be inventoried. When in use, a “Toxins in Use – Authorized Personnel Only” sign must be visibly displayed. All risk group 2 samples must be stored in a secure location. Freezers must be locked if they are not behind a room’s locked door. Samples must be segregated from other materials to avoid potential exposures. All materials must be labeled properly with contents and “biohazard.”

### 29 CFR 1910.1030 Bloodborne Pathogens

*(d)(2)(vii) “Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except as noted in paragraphs (d)(2)(vii)(A) and (d)(2)(vii)(B) below. Shearing or breaking of contaminated needles is prohibited.”*

*(d)(2)(vii)(A) “Contaminated needles and other contaminated sharps shall not be bent, recapped or removed unless the employer can demonstrate that no alternative is feasible or that such action is required by a specific medical or dental procedure.”*

*(d)(2)(vii)(B) “Such bending, recapping or needle removal must be accomplished through the use of a mechanical device or a one-handed technique.”*

### NIH Guidelines

Appendix G-II-B-1-g.

*“All procedures are performed carefully to minimize the creation of aerosols.”*

Appendix G-II-B-3-a-(2).

*“High concentrations or large volumes of organisms containing recombinant or synthetic nucleic acid molecules are used. Such materials may be centrifuged in the open laboratory if sealed beads or centrifuge safety cups are used and if they are opened only in a biological safety cabinet.”*

Appendix G-II-B-4-f.

*“An autoclave for decontaminating laboratory wastes is available.”*

**BMBL 5<sup>th</sup> ed,**

BL2 Section IV-D-11

*“A method for decontaminating all laboratory wastes should be available in the facility (e.g., autoclave, chemical disinfection, incineration, or other validated decontamination method).”*

BL2 Section IV-D-1

*“Laboratory doors should be self-closing and have locks in accordance with the institutional policies.”*

## **Emergency Equipment**

Fire extinguishers must be appropriate for the hazards in the laboratory and readily accessible. They are replaced annually by Facilities and Services (F&S). Monthly condition checks should be performed to ensure the pressure gauge is in the green, the safety pin is in place, and the tamper indicator is intact. If there is any indication of use, the extinguisher must be serviced through F&S, Campus Code Compliance and Fire Safety.

A plumbed or self-contained eyewash must be provided in all work areas where the eyes of any person may be exposed to hazardous material (corrosives, eye irritants, acutely toxic, chronic health effects, biological materials that require biosafety level 2 containment or greater). An emergency shower must be provided in all work areas where a person may be exposed to hazardous material (corrosive or irritating to the skin, acutely toxic, or chronic health effects). Researchers should have unobstructed, rapid (10 seconds) access from their workspace. Emergency showers and eye washes must be marked with a highly visible sign. Showers and plumbed eye washes should be tested annually according to ANSI Standard. Plumbed eye washes should be activated weekly by lab occupants and repairs scheduled immediately if equipment is not functioning properly. Self-contained eye washes should be maintained according to manufacturer's specifications. Researchers must not alter the design of the eyewash and shower units.

See [Emergency Eyewashes and Showers](#) for more information.

A spill kit should be readily available and stocked with material needed to clean up spills of all chemicals present in the laboratory. If any materials are used, compromised, or contaminated, they should be replaced immediately.

All work surfaces where biological materials are used should be cleaned with appropriate disinfectant following the procedure.

Based on current knowledge on the best first aid treatment, antidotes for HF must be present in labs where HF is stored or used. See the DRS safety guide on [Hydrofluoric Acid](#) for more information.

### **29 CFR 1910.157 Portable fire extinguishers**

*(c)(1) “The employer shall provide portable fire extinguishers and shall mount, locate and identify them so that they are readily accessible to employees without subjecting the employees to possible injury.”*

*(d)(1) “Portable fire extinguishers shall be provided for employee use and selected and distributed based on the classes of anticipated workplace fires and on the size and degree of hazard which would affect their use.”*

*(e)(2) “Portable extinguishers or hose used in lieu thereof under paragraph (d)(3) of this section shall be visually inspected monthly.”*

*(e)(3) “The employer shall assure that portable fire extinguishers are subjected to an annual maintenance check. Stored pressure extinguishers do not require an internal examination. The employer shall record the annual maintenance date and retain this record for one year after the last entry or the life of the shell, whichever is less. The record shall be available to the Assistant Secretary upon request.”*

### **29 CFR 1910.151 Medical services and first aid**

*(c) “Where the eyes or body of any person may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use.”*

## **ANSI/ISEA Z358.1-2014 American National Standard for Emergency Eyewash and Shower Equipment**

*“This standard establishes minimum performance and use requirements for eyewash and shower equipment for the emergency treatment of the eyes or body of a person who has been exposed to hazardous materials.”*

### Section 4 Emergency Showers

*4.5.2 Be in accessible locations that require no more than 10 seconds to reach. The emergency shower shall be located on the same level as the hazard and the path of travel shall be free of obstructions that may inhibit its immediate use.*

*4.5.3 Be located in an area identified with a highly visible sign positioned so the sign shall be visible within the area served by the emergency shower. The area around the emergency shower shall be well-lit.*

*4.6.5 All emergency showers shall be inspected annually to assure conformance with Section 4.5 requirements of this standard.*

### Section 5 Eyewashes

*5.4.2 Be in accessible locations that require no more than 10 seconds to reach. The eyewash shall be located on the same level as the hazard and the path of travel shall be free of obstructions that may inhibit its immediate use.*

*5.4.3 Be located in an area identified with a highly visible sign positioned so the sign shall be visible within the area served by the eyewash. The area around the eyewash shall be well-lit.*

*5.5.2 Plumbed eyewashes shall be activated weekly for a period long enough to verify operation and ensure that flushing fluid is available.*

*5.5.5 All eyewashes shall be inspected annually to assure conformance with Section 5.4 requirements of this standard.*

## **29 CFR 1910.1450 App A**

### D Chemical Hygiene Plan

#### “7. Signs:

*Prominent signs of the following types should be posted:*

- (a) Location signs for safety showers, eyewash stations, other safety and first aid equipment, and exits; and*
- (b) Warnings at areas or equipment where special or unusual hazards exist.*

#### 8. Spills and Accidents:

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

## **BMBL 5<sup>th</sup> ed, BL1 Section IV-A-7**

*“Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.”*

## **First aid for a unique acid, HF: A sequel, Chemical Health & Safety, January/February 2000:**

<http://depts.washington.edu/cosmolab/chem/hfsafety.pdf>

## Storage and Transport

Hazardous materials should be stored safely in cabinets or on stable shelving to prevent containers from falling or being knocked over. Chemicals should not be stored on the floor. If storage on the floor cannot be avoided, secondary containment should be used.

Chemicals should not be stored in hallways or locations that would jeopardize egress.

Incompatible chemicals may react dangerously with each other when mixed. To avoid accidental mixing, incompatible chemicals should be stored separately, i.e., in different cabinets or separated by secondary containment in the same cabinet.

Secondary containment should be used for highly corrosive and toxic chemicals, especially when stored outside of storage cabinets. Secondary containment is necessary when transporting chemicals through buildings and outdoors.

The container materials should be appropriate for the chemical contents (i.e., hydrofluoric acid should never be stored in glass; nitric acid and other oxidizers should be stored only in glass). Food containers are never to be used for chemical storage, even if the label has been removed. Containers must be leak proof and in good condition with intact, leak-proof lids. Containers must be closed at all times unless in immediate use, meaning that someone is actively adding or removing chemicals from the container.

Contents and hazards shall be indicated on all containers of chemical, biological, and radioactive materials. The original label shall not be removed, and if it becomes illegible a new label must be applied. Temporary containers should be labeled so that another person can identify its contents.

All appliances (refrigerators, ice chests, cold rooms, and ovens) that are used for hazardous materials shall be marked with the appropriate label to prevent storage of food, beverages, or other consumables in these appliances.

See the DRS safety guides on [Chemical Storage](#) and [Labeling Chemicals in Laboratories](#) for more information.

Storing certain chemicals for an extended period of time can result in elevated hazards. Chemicals kept past the expiration date or under conditions not recommended by the manufacturer can result in decomposition of the chemical to a potentially more hazardous substance. Chemicals must be maintained properly or disposed of as recommended in order to eliminate these hazards.

### 29 CFR 1910.1450

*(h)(1)(i) "Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced."*

### 29 CFR 1910.1450 App A

#### Section D 2 chemical storage

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

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

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

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

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

#### Section E 1

*(m) "Laboratory refrigerators, ice chests, cold rooms, and ovens should not be used for food storage or preparation."*

## Prudent Practices in the Laboratory 2011

### 2.D.2 Chemical Storage

*“Do not store chemicals in the laboratory chemical hood, on the floor, in the aisles, in hallways, in areas of egress, or on the bench top.”*

### 2.D.5 Transporting, Transferring, and Shipping Chemicals

*“It is prudent practice to use a secondary containment device (i.e., rubber pail) when transporting chemicals from the storeroom to the laboratory or even short distances within the laboratory.”*

### 5.E.2 Storage according to compatibility

*“It is prudent to store containers of incompatible chemicals separately. Separation of incompatibles will reduce the risk of mixing in case of accidental breakage, fire, earthquake, or response to a laboratory emergency. Even when containers are tightly closed, fugitive vapors can cause deleterious incompatibility reactions that degrade labels, shelves, cabinets, and containers themselves.”*

### 5.E.3 Containers and Equipment

*“Specific guidelines regarding containers and equipment to use in storing chemicals are as follows:*

- Use of corrosion-resistant storage trays as secondary containment for spills, leaks, drips, or weeping is a good idea. Polypropylene trays are suitable for most purposes.*
- Use secondary containment (i.e., an overpack) to retain materials if the primary container breaks or leaks.*
- Seal containers to minimize escape of corrosive, flammable, or toxic vapors.”*

### 6.C.3 Housekeeping

*“Keep chemical containers closed when not in use.”*

*“Do not use floors, stairways, and hallways as storage areas. Items in these areas can become hazardous in the event of an emergency.”*

### 7.C.3 Refrigerators and Freezers

*“laboratory refrigerators are never used to store food or beverages for human consumption. Add permanent labels warning against the storage of food and beverages to all laboratory refrigerators and freezers.”*

## Appendix A

*“Passageways. Stairways and hallways should not be used as storage areas. Access to exits, emergency equipment, and utility controls should never be blocked.”*

## NFPA 101 2012 Life Safety Code

*“8.4.3.2\* No storage or handling of flammable liquids or gases shall be permitted in any location where such storage would jeopardize egress from the structure, unless otherwise permitted by 8.4.3.1.”*

## Waste

The main requirements pertaining to waste generated in laboratories are:

- Waste containers must be appropriate for the type of waste and in good condition
- All containers must be labeled with the word "Waste" and the complete names of the chemicals. Abbreviations and chemical formulas are not sufficient. A generic label such as "Waste Halogenated Solvents" may be used, but a list of the contents must be kept nearby. The containers must be labeled before or at the time the first drop of waste is added.
- Waste containers must be closed at all times, except when waste is adding, removing, or consolidating waste; or during **temporary** venting of a container is necessary for the proper operation of equipment, or to prevent dangerous situations, such as build-up of extreme pressure.
- For waste streams that evolve gas, vented caps should be used to prevent over-pressurization.
- Incompatible waste streams should be stored in separate areas.
- Waste containers should be placed in secondary containment, especially when stored on the floor or

near sinks.

- DRS should be contacted when waste containers are full to avoid excessive accumulation.
- Dispose of all sharps in a puncture-resistant, leak-proof sharps disposal container. This includes needles, syringe barrels, Pasteur pipettes, scalpels, razor blades, blood vials, microscope slides and coverslips, and glassware contaminated with infectious agents.
- All “red bag” waste containers and bags used for the collection of biological materials or biologically-contaminated items must be labeled with the international biohazard symbol.
- Clean laboratory glassware (broken or unbroken) must be placed in a sturdy cardboard box. The glassware must be free of liquids and solids. The sealed box, properly labeled with “Clean Laboratory Glass – Trash” may be placed into the trash or a dumpster.

For more information on waste disposal, see the DRS guides on [Chemical Waste](#), [Sharps Disposal](#), and [Biological Waste Information](#).

#### **40 CFR 262.11 Hazardous waste determination and recordkeeping.**

*“A person who generates a solid waste, as defined in 40 CFR 261.2, must make an accurate determination as to whether that waste is a hazardous waste in order to ensure wastes are properly managed according to applicable RCRA regulations. A hazardous waste determination is made using the following steps:*

*(a) The hazardous waste determination for each solid waste must be made at the point of waste generation, before any dilution, mixing, or other alteration of the waste occurs, and at any time in the course of its management that it has, or may have, changed its properties as a result of exposure to the environment or other factors that may change the properties of the waste such that the RCRA classification of the waste may change.”*

#### **40 CFR 262.15 Satellite accumulation area regulations for small and large quantity generators.**

*“(a) A generator may accumulate as much as 55 gallons of non-acute hazardous waste and/or either one quart of liquid acute hazardous waste listed in §261.31 or §261.33(e) of this chapter or 1 kg (2.2 lbs) of solid acute hazardous waste listed in §261.31 or §261.33(e) of this chapter in containers at or near any point of generation where wastes initially accumulate which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of parts 124, 264 through 267, and 270 of this chapter, provided that all of the conditions for exemption in this section are met. A generator may comply with the conditions for exemption in this section instead of complying with the conditions for exemption in §262.16(b) or §262.17(a), except as required in §262.15(a)(7) and (8). The conditions for exemption for satellite accumulation are:*

*(1) If a container holding hazardous waste is not in good condition, or if it begins to leak, the generator must immediately transfer the hazardous waste from this container to a container that is in good condition and does not leak, or immediately transfer and manage the waste in a central accumulation area operated in compliance with §262.16(b) or §262.17(a).*

*(2) The generator must use a container made of or lined with materials that will not react with, and are otherwise compatible with, the hazardous waste to be accumulated, so that the ability of the container to contain the waste is not impaired.*

*(3) Special standards for incompatible wastes.*

*(i) Incompatible wastes, or incompatible wastes and materials, (see appendix V of part 265 for examples) must not be placed in the same container, unless §265.17(b) of this chapter is complied with.*

*(ii) Hazardous waste must not be placed in an unwashed container that previously held an incompatible waste or material (see appendix V of part 265 for examples), unless §265.17(b) of this chapter is complied with.*

*(iii) A container holding a hazardous waste that is incompatible with any waste or other materials accumulated nearby in other containers must be separated from the other materials or protected from them by any practical means.*

*(4) A container holding hazardous waste must be closed at all times during accumulation, except:*



*(i) When adding, removing, or consolidating waste; or*

*(ii) When temporary venting of a container is necessary*

*(A) For the proper operation of equipment, or*

*(B) To prevent dangerous situations, such as build-up of extreme pressure.*

*(5) A generator must mark or label its container with the following:*

*(i) The words "Hazardous Waste" and*

*(ii) An indication of the hazards of the contents (examples include, but are not limited to, the applicable hazardous waste characteristic(s) (i.e., ignitable, corrosive, reactive, toxic); hazard communication consistent with the Department of Transportation requirements at 49 CFR part 172 subpart E (labeling) or subpart F (placarding); a hazard statement or pictogram consistent with the Occupational Safety and Health Administration Hazard Communication Standard at 29 CFR 1910.1200; or a chemical hazard label consistent with the National Fire Protection Association code 704).*

*(6) A generator who accumulates either acute hazardous waste listed in §261.31 or §261.33(e) of this chapter or non-acute hazardous waste in excess of the amounts listed in paragraph (a) of this section at or near any point of generation must do the following:*

*(i) Comply within three consecutive calendar days with the applicable central accumulation area regulations in §262.16(b) or §262.17(a), or*

*(ii) Remove the excess from the satellite accumulation area within three consecutive calendar days to either:*

*(A) A central accumulation area operated in accordance with the applicable regulations in §262.16(b) or §262.17(a);*

*(B) An on-site interim status or permitted treatment, storage, or disposal facility, or*

*(C) An off-site designated facility; and*

*(iii) During the three-consecutive-calendar-day period the generator must continue to comply with paragraphs (a)(1) through (5) of this section. The generator must mark or label the container(s) holding the excess accumulation of hazardous waste with the date the excess amount began accumulating.*

*(8) All satellite accumulation areas operated by a large quantity generator must meet the Preparedness, Prevention and Emergency Procedures in subpart M of this part."*

## **Compressed Gases**

Gas cylinders shall be stored in an upright position and secured to a wall or solid surface at or slightly above the mid-point to prevent tipping. Cylinders should not be exposed to extreme temperatures. Tubing and pipe material should be compatible with the gas to avoid material degradation and leakage. The tubing should not hinder movement through passageways or pose any other hazard. Regulators with the proper [CGA connection](#) must be used depending on the type of gas. See the DRS guide on [Compressed Gas Cylinder Safety](#) for more information. Transporting cylinders on carts must be done with the protective cap in place.

## **Flammable and Oxidizing Gases**

Flammable and oxidizing gases are incompatible and are to be kept a minimum of 20 feet away from each other or separated by a non-combustible material with a half-hour fire resistance rating built between the two storage areas. The amount of flammable and oxidizing gases permitted in a laboratory is limited by the size of the lab space.

## **Toxic Gases**

Toxic gases shall be stored in a continuously mechanically ventilated hood (for lecture size bottles) or

continuously ventilated gas cabinets (for cylinders larger than lecture size).

## **NFPA 45 2011**

### 1.1.4 Special Ventilation Requirements for Gas Cylinders

*“Lecture bottle-sized cylinders of the following gases located in laboratory units shall be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure:*

- (1) All gases that have health hazard ratings of 3 or 4.*
- (2) All gases that have a health hazard rating of 2 without physiological warning properties*
- (3) Pyrophoric gases*

*Cylinders of all gases that are greater than lecture bottle size and have health hazard ratings of 3 or 4 and cylinders of gases that have a health hazard rating of 2 without physiological warning properties that are located in laboratory units shall meet both the following conditions:*

- (1) Storage in approved continuously mechanically ventilated gas cabinets*
- (2) Compliance with NFPA 55, Compressed Gases and Cryogenic Fluids Code.”*

#### 11.1.5.1 Cylinder Safety

*“Cylinders shall be secured from tipping over by holders designed for such service.”*

#### 11.1.6.5 Cylinders in Use

*“The quantity of compressed and liquefied gases in Class A, Class B, and Class C laboratory units shall be in accordance with the amounts listed in Table 6.3.1 of NFPA 55, Compressed Gases and Cryogenic Fluids Code.”*

## **NFPA 55 2010**

### 7.1.10.2 Incompatible Materials

*“Gas containers, cylinders, and tanks shall be separated in accordance with table 7.1.10.2.”*

According to the table a distance of 20 ft is required between different gas categories.

### 7.1.10.5 Temperature Extremes

*“Compressed gas containers, cylinder, and tanks, whether full or partially full, shall not be exposed to temperatures exceeding 125 °F (52 °F) or subambient (low) temperatures unless designed for use under such exposure.”*

### 7.1.9.1 Valve Protection General.

*Compressed gas container, cylinder, and tank valves shall be protected from physical damage by means of protective caps, collars or similar devices.*

### 7.1.9.2 Valve-Protective Caps.

*Where compressed gas containers, cylinders, and tanks are designed to accept valve protective caps, the user shall keep such caps on the compressed gas containers, cylinders, and tanks at all times, except when empty, being processed, or connected for use.*

## **29 CFR 1910.22(b)(1) Walking-Working Surfaces**

*“Aisles and passageways shall be kept clear and in good repairs, with no obstruction across or in aisles that could create a hazard.”*

## **29 CFR 1910.37(a)(2)- Means of Egress**

*“Exit routes must be arranged so that employees will not have to travel toward a high hazard area, unless the path of travel is effectively shielded from the high hazard area by suitable partitions or other physical barriers.”*

## **Prudent Practices in the Laboratory 2011 chapter 7.D.2.2.3 Piping, Tubing, and Fittings**

*“The proper selection and assembly of components in a pressure system are critical safety factors.*

*Considerations include the materials used in manufacturing the components, compatibility with the materials to be under pressure, the tools used for assembly, and the reliability of the finished connections. Use no oil or lubricant of any kind in a tubing system with oxygen because the combination produces an explosion hazard. Use all-brass and stainless steel fittings with copper or brass and steel or stainless steel tubings, respectively. Fitting of this type must be installed correctly. Do not mix different brands of tube fittings in the same apparatus assembly because construction parts are often not interchangeable.”*

## **Cryogenics**

Due to the rapid expansion of evaporating cryogenic liquids into gas, adequate room ventilation is required to prevent oxygen depletion and asphyxiation. The extreme cold requires special containers to avoid material embrittlement and pressure build-up. Condensation of oxygen from the surrounding air poses a fire and explosion hazard, especially in contact with organic material. See the DRS safety guide on [Cryogenics and Dry Ice](#) for more information.

### **NFPA 45 2011**

#### 11.4.1

*“All system components used for cryogenic fluids shall be selected and designed for such service.”*

#### 11.4.2

*“Pressure relief of vessels and piping handling cryogenic fluids shall comply with the applicable requirements of section 11.2 Storage and Piping Systems.”*

#### 11.4.3

*“The space in which cryogenic systems are located shall be ventilated commensurate with the properties of the specific cryogenic fluid in use.”*

## **Flammable Liquids**

The National Fire Protection Association (NFPA) has set limits on flammable liquids stored in laboratories.

Flammable chemicals should be stored in a spark-free environment and in approved flammable storage cabinets.

Grounding and bonding of bulk storage (>4L) and receiving vessels should be used when transferring flammable liquids to prevent static charge buildup.

Flammable materials that require refrigerator storage must be stored in one designed or modified for flammable storage or one that is spark-proof. Standard household refrigerators have exposed ignition sources, making the refrigerator unsuitable for flammable material storage.

See the DRS guide on [Flammable Liquids](#) for more information.

### **29 CFR 1910.1450 App A section D 2 chemical storage**

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

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

### **NFPA 45 2011, Chapters 10 Flammable and Combustible Liquids and NFPA 45 2011, Table 10.1.1(a)**

#### **NFPA 45 2011, 12.2.2**

*“Each refrigerator, freezer, or cooler shall be prominently marked to indicate whether it meets the requirements for safe storage of flammable liquids. Refrigerators, freezers, and other cooling equipment used to store or cool flammable liquids shall be listed as special purpose units for use in laboratories or equipment listed for Class I, Division 1 locations, as described in Article 501 of NFPA 70 National electrical Code.”*

## Campus Administrative Manual V-B-6.6

*“All enclosed laboratory equipment subject to explosion should bear on the door or lid a label specifying that the unit has been safeguarded against explosion or that it is not safe and no flammable solvents or materials should be stored therein.”*

## Peroxide-Forming Chemicals

Documentation is necessary to keep track of the age of peroxide-forming chemicals. Containers shall be dated when received and when opened. The chemical shall be checked for peroxides according to the guidelines presented in the [Peroxide-Forming Chemicals](#) safety guide.

### 29 CFR 1910.1450 App A section D 2 chemical storage (g)

*“Peroxide formers should be dated upon receipt, again dated upon opening, and stored away from heat and light with tightfitting, nonmetal lids.”*

### NFPA 45 2011

#### 9.2.3.4

*“Containers of materials that might become hazardous (i.e. time sensitive) during prolonged storage shall be dated when first opened, and properly managed.”*

#### 9.2.3.4.1

*Proper management shall consist of the following elements:*

- (1) Defining those materials present that are time sensitive*
- (2) Defining each time-sensitive materials inspection frequency*
- (3) Defining proper or approved inspection methodologies to determine the relative hazard of the time-sensitive material*
- (4) Defining pass/fail criteria for inspection results*

## Pyrophoric Materials

Gas cylinders shall be stored in an upright, secured position in a ventilated gas cabinet with a sprinkler. Tubing and pipe material has to be compatible with the pyrophoric gas to avoid material degradation and leakage.

Pyrophoric gases are extremely hazardous and must not be stored next to exits.

Sprinkler systems are required in rooms where pyrophoric materials are being used. Appropriate PPE, including flame-resistant lab coats, shall be provided.

### NFPA 45 2011, 11.1.4.4

*“Cylinders of pyrophoric gases that are greater than lecture bottle size that are located in laboratory units shall be kept in approved continuously mechanically ventilated, sprinklered gas cabinets.”*

### NFPA 400 Table 5.2.1.1.3

*Pyrophoric gases, liquids, solids: “Permitted only in buildings equipped throughout with an automatic sprinkler system in accordance with NFPA 13.”*

## Prudent Practices in the Laboratory 2011

### 7.D.2.2.3 Piping, Tubing, and Fittings

*“The proper selection and assembly of components in a pressure system are critical safety factors. Considerations include the materials used in manufacturing the components, compatibility with the materials to be under pressure, the tools used for assembly, and the reliability of the finished connections. Use no oil or lubricant of any kind in a tubing system with oxygen because the combination produces an explosion hazard. Use all-brass and stainless steel fittings with copper or brass and steel or stainless steel tubing, respectively.”*

*Fitting of this type must be installed correctly. Do not mix different brands of tube fittings in the same apparatus assembly because construction parts are often not interchangeable.”*

### **29 CFR 1910.37(a)(2) Means of egress**

*“Exit routes must be arranged so that employees will not have to travel toward a high hazard area, unless the path of travel is effectively shielded from the high hazard area by suitable partitions or other physical barriers.”*

### **29 CFR 1910.132 Personal Protective Equipment**

*“Application. Protective equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.”*

## **Explosive Material**

It is important to have a protocol in place that prevents potentially explosive chemicals from drying out and becoming an explosion hazard.

Proper storage of explosives is required in the correct magazines. All necessary licenses and documentation for use must be maintained. Standard Operating Procedures and proper training for all personnel using explosives must be up-to-date.

### **NFPA 45 2011, 9.2.3.4**

*“Containers of materials that might become hazardous (i.e. time sensitive) during prolonged storage shall be dated when first opened, and properly managed.”*

### **29 CFR 1910.109 Explosives and blasting agents**

*(c)(1)(i) All Class A, Class B, and Class C explosives, and special industrial explosives, and any newly developed and unclassified explosives, shall be kept in magazines which meet the requirement of this paragraph.*

*(c)(1)(ii) Blasting caps, electric blasting caps, detonating primers, and primed cartridges shall not be stored in the same magazine as other explosives.*

*(c)(1)(v) Class I magazines shall be required where the quantity of explosives stored is more than 50 pounds. Class II magazines may be used where the quantity of explosives stored is 50 pounds or less.*

## **Lasers**

Controls to minimize fire potential are sufficient.

### **IEMA part 315 110 (a):**

*“The beam from an infrared laser (wavelength greater than 710 nm) shall be terminated in fire-resistant material where necessary.”*

All safety interlocks perform as intended.

**IEMA part 315 100 (c) 2 A:** *“A safety interlock, which ensures that laser radiation is not accessible above MPE limits, shall be provided for any portion of the protective housing that, by design, can be removed or displaced without the use of tools during normal operation or maintenance.”*

### **ANSI Z136.1 4.4.2.3:**

*“Protective housings that enclose class 3b or class 4 lasers or laser systems shall be provided with an interlock system that is activated when the protective housing is opened or removed during operation and maintenance.”*

Protective housing is in place.

### **IEMA part 315 100 (c) 1:**

*“Each laser product shall have a protective housing that prevents, during operation, human access to laser*

*radiation that exceeds the limits of a Class 1 laser (see 21 CFR 1040.10, Table I), wherever and whenever human access is not necessary in order for the laser system to perform its intended function.”*

Laser is mounted on optical bench or another stable platform.

The laser beam is not at eye level.

The laser beam control is adequate.

#### **ANSI Z136.1 4.4.3.5.1**

*“A Class 3b laser controlled area should and a Class 4 laser controlled area shall:*

- i) Have the laser secured such that the exposed beam path is above or below eye level of a person in any standing or seated position, if possible, except as required for medical use.”*

Warning system is available.

#### **IEMA part 315 100 (c) 4 A:**

*“Each laser system shall provide visual or aural indication during the emission of accessible laser radiation.”*

#### **ANSI Z136.1 4.4.2.8 A:**

*“class 3b laser controlled area should and a class 4 laser controlled area shall have an area warning device that is visible prior to entering the area.”*

Entryway controls are in place.

#### **ANSI Z136.1 4.4.2.10.3:**

*All class 4 laser controlled area shall incorporate one of the following alternatives:*

- a) Non-defeatable area or entryway safety controls (latches, interlocks).*
- b) Defeatable Area or Entryway Safety Controls (latches, interlocks).*
- c) Procedural Area or Entryway Safety Controls:*
  - 1) All authorized personnel shall be adequately trained and adequate PPE shall be provided upon entry.*
  - 2) A door, blocking barrier, screen, curtains, etc., shall be used to block, screen or attenuate the laser radiation at the entryway.*

Emergency disconnect switch is available.

#### **IEMA part 315 100 (c) 5: Additional requirements for indoor Class 4 laser controlled areas**

- A) Latches, interlocks or other appropriate means shall be used to restrict access to controlled areas.*
- B) Measure shall be designed to allow both rapid exit by the laser personnel at all times and entrance to the controlled area in an emergency condition.*
- C) For emergency conditions, a control-disconnect switch or equivalent device (panic button) shall be available for deactivating the laser or closing the shutter.*

Area is appropriately posted.

#### **IEMA part 315.150 b):**

*“controlled areas shall be conspicuously posted with appropriate sign or signs as specified in subsection (c).”*

All lasers and barriers are labeled when required.

A laser barrier should be labeled if:

- The barrier or its door are not interlocked and
- No eyewear is required for operation and
- The barrier is routinely opened or removed during operation (e.g. for inserting samples)

#### **ANSI Z136.1**

#### **4.6.6: Laser equipment Labels:**

*“... lasers and laser systems classified in accordance with this standard shall have an equipment label that includes the following information:*

- a) class of the laser system*
- b) emitted wavelength*
- c) precautionary statement”*

4.3:

*“...The LSO shall assess the adequacy of the CDRH required engineering controls and labeling in the installation as the product will be used and shall require additional engineering controls and labels as appropriate.”*

## **Radioactive Materials**

Use of radioactive materials is pursuant to the license held by DRS with the Illinois Emergency Management Agency (IEMA). Most requirements are based on regulations issued by the US Nuclear Regulatory Commission and IEMA.

Radioactive Materials - General Practices

### **IEMA part 340**

340.810 Security and Control of Licensed or Registered Sources of Radiation

*a) The licensee shall secure licensed radioactive material from unauthorized removal or access.*

340.920 Posting Requirements

*a) Posting of Radiation Areas. The licensee or registrant shall post each radiation area with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA".*

*e) Posting of Areas or Rooms in Which Licensed Material is Used or Stored. The licensee shall post each area or room in which there is used or stored an amount of licensed material exceeding ten times the quantity of such material specified in Appendix C to 10 CFR 20, effective January 1, 2004, exclusive of subsequent amendments or editions, with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)".*

340.940 Labeling Containers and Radiation Machines

*(a) The licensee shall ensure that each container of licensed material bears a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". The label shall also provide information (such as the radionuclides present, an estimate of the quantity of radioactivity, the date for which the activity is estimated, radiation levels, kinds of materials and mass enrichment) to permit individuals handling or using the containers, or working in the vicinity of the containers, to take precautions to avoid or minimize exposures.*

340.950 Exemptions to Labeling Requirements

*A licensee is not required to label:*

*a) Containers holding licensed material in quantities less than the quantities listed in appendix C to 10 CFR 20, published at 60 Fed. Reg. 20186, April 25, 1995, exclusive of subsequent amendments or editions; or*

*b) Containers holding licensed material in concentrations less than those specified in Table 3 of appendix B to 10 CFR 20, published at 72 Fed. Reg. 55922, October 1, 2007, exclusive of subsequent amendments or editions; or*

*c) Containers attended by an individual who takes the precautions (e.g., controlling access) necessary to prevent the exposure of individuals in excess of the limits established by this Part; or*

*d) Containers when they are in transport, provided the containers are packaged and labeled in accordance with the regulations of the U.S. Department of Transportation; or*

*AGENCY NOTE: Labeling of packages containing radioactive materials is required by the U.S. Department of Transportation if the amount and type of radioactive material exceeds the limits for an excepted quantity or article*

*as defined and limited by 49 CFR 173.403 and 173.421 through 173.424, revised October 1, 2008, exclusive of subsequent amendments or editions.*

- e) Containers that are accessible only to individuals authorized to handle or use them, or to work in the vicinity of the containers, if the contents are identified to these individuals by a readily available written record (examples of containers of this type are containers in locations such as water-filled canals, storage vaults or hot cells). The record shall be retained as long as the containers are in use for the purpose indicated on the record; or*
- f) Installed manufacturing or process equipment, such as piping and tanks.*

#### 340.110 Radiation Protection Programs

*b) "The licensee or registrant shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and public doses that are as low as is reasonably achievable (ALARA)".*

#### **IEMA part 310**

##### 310.40 Records

*Each licensee and registrant shall maintain records showing the receipt, transfer, use, storage and disposal of all sources of radiation.*

#### Radioactive Materials – Surveys

#### **IEMA part 340**

##### 340.320 a)

*The licensee or registrant shall make or cause to be made surveys of radiation levels in unrestricted areas. In addition, licensees shall survey radioactive materials in effluents released to unrestricted areas. These surveys are to demonstrate compliance with the dose limits for individual members of the public in Section 340.310.*

##### 340.510 General

*a) Each licensee or registrant shall make, or cause to be made, surveys, including surveys of the subsurface, where appropriate:*

- 1) That demonstrate compliance with this Part; and*
- 2) That evaluate:*
  - A) The extent of radiation levels;*
  - B) Concentrations or quantities of radioactive material; and*
  - C) The potential radiological hazards of radiation levels and residual radioactivity detected.*

*b) The licensee or registrant shall ensure that instruments and equipment used for quantitative radiation measurements (e.g., dose rate and effluent monitoring) are calibrated at intervals not to exceed 12 months for the radiation measured or at alternative intervals specified in regulations of the Agency, the U.S. Nuclear Regulatory Commission, an Agreement State or a Licensing State*

##### 340.1130 Records of Surveys and Calibrations

*a) Each licensee or registrant shall maintain records showing the results of surveys and calibrations required by Sections 340.510 and 340.960(b). The licensee or registrant shall retain these records for 5 years after the record is made.*

*1) Records of surveys shall include:*

- A) The location and date of the survey and the model and serial number of the instrument used to perform the survey;*
- B) The identity of the individual performing the survey; and*
- C) The results of the survey and any corrective actions that were taken as a result.*



## Radioactive Materials - Training

### **IEMA part 400**

#### 400.120 Instructions to Workers

*a) All individuals working in, or the performance of whose duties requires access to, any portion of a restricted area or who frequent areas where radioactive material is used or stored:*

- 1) Shall be kept informed of the storage, transfer or use of sources of radiation in such portions of the restricted area;*
- 2) Shall be instructed in the health protection problems associated with exposure to radiation or radioactive material, in the risks of radiation exposure to the embryo and fetus, in precautions or procedures to minimize exposure and in the purposes and functions of protective devices employed;*
- 3) Shall be instructed in, and instructed to observe to the extent within the worker's control, the conditions of the license, the provisions of this Part and 32 Ill. Adm. Code: Chapter II, Subchapters b and d for the protection of personnel from exposures to radiation or radioactive material occurring in such areas;*
- 4) Shall be instructed to report promptly to the licensee or registrant any condition that may constitute, lead to or cause a violation of the Act, the conditions of the license, the provisions of this Part or 32 Ill. Adm. Code: Chapter II, Subchapters b and d or unnecessary exposure (i.e., exposure that results when prescribed safety measures are not followed) to radiation or radioactive material;*
- 5) Shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and*
- 6) Shall be advised as to the radiation exposure reports that workers are furnished pursuant to Section 400.130.*

*b) These instructions shall be of sufficient detail to avoid radiological health protection problems and shall be given directly to each worker either in writing or in an orientation course, with the workers signing a statement that they have received the information listed in subsection (a) and understand it. Training shall be provided initially before assigning duties involving radioactive material and following changes in duties or procedures or potential radiation hazards. Refresher training that covers all of the required topics shall be provided at intervals not to exceed 12 months.*

### **Regulations Explanations:**

ANSI: American National Standards Institute

BMBL: Biosafety in Microbiological and Biomedical Laboratories

CFR: Code of Federal Regulations

10 CRF 20 Standards for Protection Against Radiation

29 CFR: OSHA Regulations

29 CFR 1910: Occupational Safety and Health Standards

29 CFR 1910.1030 Bloodborne Pathogens

29 CFR 1910.1450: Occupational Exposure to hazardous chemicals in laboratories  
("OSHA Lab Standard")

IEMA: Illinois Emergency Management Agency

NFPA: National Fire Protection Association

NIH: National Institute of Health