Zambia
National Biomedical Laboratory Safety Manual

Ministry of Health
Central Board of Health

In collaboration with:

Rational Pharmaceutical Management Plus Program,
Management Sciences for Health

Ministry of Health

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FOREWORD

The *National Biomedical Laboratory Safety Manual* has been developed to fulfill the implementation of the national medical laboratory policy objective on safety and ethics.

The manual is intended to provide guidelines for all laboratory workers, including those responsible for the administration and planning of laboratory services.

We hope that this manual will go a long way in securing not only the health and safety of workers but also in protecting equipment, infrastructure, and the environment.

All laboratory workers have a responsibility to adhere to and enforce the safety practices at all times.

Dr. B. U. Chirwa
Director General, Central Board of Health

ACRONYMS

BSC	biological safety cabinet
CO_2	carbon dioxide
EDTA	ethylenediaminetetraacetic acid
EIA	enzyme immunoassay
ESR	erythrocyte sedimentation rate
HEPA filter	high-efficiency particulate air filter
HIV	human immunodeficiency virus
I^{125}	iodine-125
MSH	Management Sciences for Health
PEP	postexposure prophylaxis
PPE	personal protective equipment
RPM Plus	Rational Pharmaceutical Management Plus Program
USAID	U.S. Agency for International Development

1.0 INTRODUCTION

Laboratory services provide essential diagnostic support for quality patient care and management and play an integral role in medical research and training. They perform the additional function of supporting preventive measures of public health importance.

Laboratory safety is the protection of the laboratory worker from hazards and risks associated with their work. The knowledge of these risks and hazards and how to avoid them will place laboratory workers in an occupationally safe environment that is conducive to their physical and mental well-being.

A number of hazards and risks are associated with laboratory functions and must be considered in laboratory design, policies, and standards. All accidents in the laboratory, regardless of severity, should be reported to the safety officer and investigated.

Laboratory workers need to promote and maintain safe and best practices while also protecting the community and the environment. Laboratory staff who fail to take adequate safety precautions endanger not only themselves but others as well.

2.0 OBJECTIVES

The overall objective of this manual is to promote health and safety in all medical laboratories in Zambia.

The manual is designed to help laboratory workers to—

- Identify hazards in the workplace and assess the risk to staff, patients, and others
- Observe the code of safe laboratory practice
- Promote and maintain safe practice
- Monitor adherence to health and safety regulations
- Report accidents informatively and investigate promptly
- Work safely and be able to carry out first aid.

3.0 CODE OF ETHICS AND PROFESSIONAL CONDUCT

Ethics are standards of right behavior and moral principles. A code of ethics is critical to safeguard the patient ad the laboratory worker. The Medical and Allied Professions Act 2001, including the Code of Professional Conduct , Medical Ethics, Zambia's Code of Ethics for Paramedical Professions, as well as the Medical Council of Zambia all provide general guidelines on medical ethics for laboratory personnel.

Laboratory personnel are obliged to follow the Code of Professional Conduct, which helps to remind laboratory staff of their responsibilities to patients, their duty to uphold standards, and their need to work with complete integrity.

3.1 Code of Ethics

Medical laboratory personnel shall—

- Be dedicated to the use of clinical laboratory science to benefit humankind irrespective of nationality, race, creed, social status, infirmity, or nature of health problems
- Exercise professional judgment, skill, and care and recognize their limitations while meeting established standards
- Provide expertise to advise and counsel other health professionals
- Maintain strict confidentiality of patient or client information and test results and safeguard the dignity and privacy of patients and clients
- Strive to improve their professional skills and knowledge and adopt scientific advances that benefit patients and improve the delivery of test results.
- Uphold and maintain the dignity and respect of our profession and strive to maintain a reputation of honesty, integrity, and reliability
- Promote health care and the prevention and control of disease
- Fulfill reliably and completely the terms and conditions for employment
- Follow safety procedures and strive to maintain the safety of the patient or client
- Ensure consent has been obtained from ethical committees whenever human specimens are used for research

3.2 Code of Professional Conduct

Medical laboratory personnel shall—

- Place the well-being of and service to the sick above their own interests
- Be loyal to their medical laboratory profession by maintaining high standards of work and striving to improve their professional skills and knowledge
- Work scientifically and with complete honesty
- Not misuse their professional skills or knowledge for personal gain
- Never take anything from place of work that does not belong to them
- Not disclose to a patient or any unauthorized person the results of their investigations
- Treat with strict confidentiality any personal information that they may learn about a patient
- Respect and work in harmony with the other members of their hospital staff or health center team
- Be at all times courteous, patient, and considerate to the sick and their relatives
- Promote health care and prevention and control of disease
- Follow safety procedures and know how to administer first aid
- Not drink alcohol during laboratory working hours or when on emergency standby
- Use equipment and laboratory ware correctly and with care
- Not waste reagents or other supplies
- Fulfill reliably and completely the terms and conditions of their employment

4.0 SAFETY OBLIGATIONS

4. 1 Employer

The employing authority, through the safety committee, is responsible for ensuring that the health of laboratory personnel (all technical and support staff) is adequately monitored. The objective is to monitor for occupational accidents and acquired diseases. The employer shall—

- Provide effective personal protective equipment (PPE) and procedures
- Exclude highly susceptible individuals from highly hazardous laboratory work
- Facilitate provision of active or passive immunization
- Monitor occurrence of laboratory-acquired infections
- Train staff in safety procedures on a regular basis

4.2 Employee

The employee shall—

- Take safety measures to protect both him- or herself and all others who may come in contact with the laboratory or its waste
- Notify the laboratory safety officer of all laboratory accidents
- Practice good personal hygiene
- Use provided personal protective equipment

4.3 Safety Committees

Safety committees must be formed and must give adequate representation to the employer, employee, and trade unions at all levels to monitor laboratory safety standards. The committee at the national level should be multidisciplinary and should always include a laboratory representative.

A safety committee should be established at each level of care, should include a representative from each of the laboratory sections, and should be chaired by a senior member of the staff.

4.3.1 Responsibilities

The safety committee shall be responsible for promoting, enforcing, and overseeing safety policies and regulations at the point of service.

4.3.2 Safety Officer

The laboratory safety officer shall be elected by and from the safety committee. The safety officer shall represent the laboratory services on the hospital infectious control and prevention committee. The officer must have appropriate technical background and be well versed in safety issues.

Functions of a safety officer will include—

- Providing regular reports on safety status to the laboratory in-charge
- Undertaking continuous review of the accident prevention program
- Investigating all laboratory accidents
- Maintaining accident records
- Developing the health surveillance program
- Conducting regular safety inspections
- Inspecting new equipment and facilities
- Ensuring compliance with regulations
- Assigning tasks to members of the committee
- Archiving all documentation related to safety (for example, accident report forms, the accident record book, and all safety manuals) (see Appendix 1)
- Completing the accident report form in case of an accident and submitting the form to relevant authorities
- Organizing staff training and keeping documentation and records of attendance of these training sessions

5.0 FIRST AID

First aid is the skilled application of accepted principles of basic treatment at the time and place of an accident. It is intended to give immediate basic treatment for injuries. *First aid should NOT be substituted for definitive medical management for serious cases.*

5.1 First Aid Requirements for Laboratories

- All laboratory staff should receive practical training in first aid.
- Each laboratory facility should have first-aid boxes.
- First-aid boxes should be constructed from materials (for example, wood or metal) that will keep the contents free from dust and moisture. The box should be kept in a prominent position and be easily recognized by international convention. A white cross on a green background identifies the first-aid box.
- All laboratory personnel should be familiar with the location and contents of the first-aid boxes.

5.2 Contents of a Laboratory First-Aid Box

A first-aid box, well stocked for emergencies (see Table 5-1), must be kept in the laboratory and checked regularly against an inventory kept inside. Each laboratory and other workplaces should display prominently the wall charts on “Laboratory First Aid” and “Spillages of Hazardous Chemicals.”

Table 5-1. Minimum Contents of a First-Aid Box

Item	Quantity
First-aid manual	
Elastic adhesive bandage, length 270 cm.	1
Sofra-tulle framycetin sulfate B.P. 1%	1 tin
Absorbent lint, 25 g	1
Safety pins	1 packet
Sal volatile	1
Bandages 2.5 cm × 500 cm	6
Pressure dressing, large	2
Pressure dressing, medium (75 mm × 100 mm)	4
Pressure dressing, small (50 mm × 75 mm)	6
Crepe bandage, 7.5 cm × 450 cm	2
Cotton wool, 125 g	1
Arm sling	1
Eye bath	1
Eye shield	
Resuscitation face mask with one-way valve	
Scissors	1 pair
Saline	1
Elastoplast	1 box
Methylated spirit	
Forceps (Spencer wells)	1 pair
Paracetamol	
Aspirin	
Mouthpiece for mouth-to-mouth resuscitation	
Sodium bicarbonate powder and boric acid powder	

6.0 PERSONAL HEALTH AND SAFETY

6.1 Practice of Personal Hygiene

6.1.1 Hand Washing with Soap

- A hand basin should be situated near the exit.
- Soap dispensers should be provided exclusively for hand washing.
- Paper towels or hand dryers must be provided.

6.1.2 Personal Protective Equipment

The following should be worn—

- Coats, gloves, mask. Coats should be hung on pegs or hooks in the laboratory near the exit.
- Goggles—if eye splashing is a risk.
- Protective clothing—in biohazard areas.

6.1.3 Storage

- Laboratory coats should be stored separately from personal items (for example, outer clothing, valuables, bags), preferably in a locker or cupboard in a separate room.
- Laboratory coats must not be worn in a staff canteen or dining room.

6.1.4 Washing Clothing

- Soiled protective clothing should be placed in a laundry bag, not in a locker.
- Coats should be soaked overnight in 1 percent domestic bleach before washing.

6.1.5 Work Area

- No eating, drinking, smoking, or chewing gum in the laboratory.
- No licking of labels or placing pens, pencils in the mouth or hair while in the laboratory.
- No application of cosmetics.
- No storage of foodstuffs in laboratory
- Cuts, bites, open wounds should be covered with waterproof adhesive dressing.

6.2 Safe Laboratory Techniques

6.2.1 Specimen Collection

- Gloves must be worn.
- Containers should be leakproof.
- A carrying tray should be used for blood collection outside the laboratory.
- Needles should be disposed of in the sharps disposal containers.

6.2.2 Handling of Leaking Specimens

- Disposable gloves must be worn.
- Leaking specimens should be discarded (exceptions include cerebrospinal fluid, histology specimens).
- Contaminated request forms must be rewritten and the contaminated form must be discarded in a plastic waste bag.
- Workers must wash their hands immediately after removing their gloves.

6.2.3 Transport

- To avoid accidental leakage or spillage, special secondary containers (metal or plastic) should be used during transportation. (See Figure 6-1.)
- Forms should not be wrapped around the container.
- Specimens sent through the post should be clearly labeled with a biohazard sticker and sent in a padded envelope or container with double or triple packages. (Postage regulations should be developed in association with the post office and the airlines.)
- Recommendations of the national reference centers should be followed.

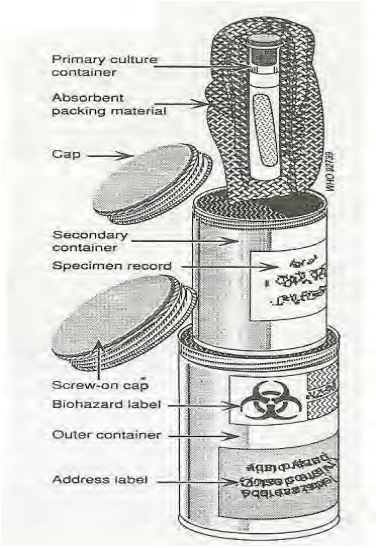


Figure 6-1. Packaging of infectious material

6.2.4 Specimen Processing

- Laboratories that receive large numbers of specimens should designate a particular room or area for this purpose.
- Personnel who receive and unpack specimens should be aware of the potential health hazards involved and should be trained to adopt universal precautions, particularly when dealing with broken or leaking containers. Disinfectants should be available.
- Mouth pipetting is *strictly* forbidden.
- Protective wear must be worn at all times in the laboratory.
- Glass ampoules should be held in a pad of tissue when being opened.
- Non-disposable glassware should be autoclaved before cleaning. (See Appendix 3.)
- Wire loops should be completely closed to avoid aerosols.
- Wire loops should not be more than 6 centimeters in length to avoid producing aerosols.
- Petri dishes should not be piled so high that they are liable to fall over or be easily knocked over.
- Bunsen burners should not be placed inside safety cabinets.

6.2.5 Handling of Spills

An effective disinfectant (according to the standard operating procedures) should be used and applied to spills in a manner that minimizes the generation of aerosols. Follow this procedure—

- Remove all uncontaminated objects from the immediate vicinity to prevent their contact with the spilled material.
- Gently pour an appropriate disinfectant around the area where the spills have occurred to limit the area of contamination.
- Use absorbent material to wipe the disinfectant from the periphery inward toward the spilled material.
- Wipe the contaminated area again with clean absorbent material soaked in a disinfectant, and allow the area to dry by evaporation.
- Discard the used absorbent material in a separate plastic bag.
- Wipe nearby objects with absorbent material soaked in a disinfectant if they were splashed during the spillage.
- Remove and discard the used disposable gloves in the plastic bag.
- Wash hands with disinfectant and rinse with water.

6.3 Medical Examinations

All laboratory workers are required to undergo a comprehensive preemployment medical examination conducted by a recognized medical officer appointed by the employer. The preemployment medical examination and report should include the following—

- A full medical history
- Chest X-ray
- Vaccinations

Laboratory workers may require the following vaccinations—

- Hepatitis B
- Bacillus Calmette-Guérin
- Typhoid
- Rabies

All laboratory personnel should have a regular examination every six months.

Women of childbearing age who work in the laboratory should recognize the risk to an unborn child of occupational exposure to certain microorganisms and substances (for example, methanol, sodium biselenite).

6.4 Postexposure Prophylaxis

Postexposure prophylaxis (PEP) for HIV should generally be given if—

- The source of exposure is known to be HIV-infected
- Information indicates that the source of exposure is likely to be HIV-infected
- Status of the source of exposure is not known

The recipient of PEP must be HIV-negative.

The following steps should be taken immediately upon possible exposure to HIV:

STEP 1: Treat the exposure site.

a. Wounds and skin sites—

- Flush site with running water and wash with soap and water.
- Where there is bleeding, allow the site to bleed freely.
- *Do not squeeze.*

b. Mucous membrane sites—

- Flush with plenty of water.

STEP 2: Report the incident.

- Laboratory personnel report the incident without delay to the immediate supervisor.
- The supervisor reports to the infection control officer.
- After working hours and weekends, the supervisor reports to supervising officer on duty.
- Infection control officer records the incident and informs the counselor.
- The exposed individual receives pre-test counseling.
- Soon after injury the exposed individual is tested for HIV serology.

STEP 3: Provide PEP.

- If therapy is necessary, prophylaxis should be initiated within 2–72 hours.
- Duration of the therapy will depend on drug used.

STEP 4: Ensure that the exposed individual receives counseling.

- The infection control officer in liaison with psychosocial counselors will arrange for tests to be repeated at six weeks and three months after initial exposure.

7.0 SAFE LABORATORY WORK ENVIRONMENT

A well-designed laboratory should provide a safe physical environment and facilitate safe work practices. The safety of a work environment must take into consideration the type of work to be performed, climatic conditions, local availability of building materials, laboratory location, number of staff, work practices, and security of the premises.

7.1 Laboratory Location

Laboratories should be sited away from patient, residential and public areas. They may be a stand-alone building on a hospital or similar site or be a separate building complex for research, and teaching activities as in a university, medical school or public health laboratory.

7.2 Laboratory Building

The laboratory building should be designed and constructed according to the national laboratory standard designs available at each level of care (relevant local or national building codes), particularly with regard to fire safety, the provision of resistant structural elements and adequate means of escape. There must also be an adequate water supply.

Other requirements for the laboratory building include the following—

- The building should provide protection against prevailing and anticipated weather conditions, including extremes of temperature, rainfall, and flooding.
- All laboratory equipment should be positioned to allow smooth workflow to avoid criss-crossing and unnecessary accidents.
- Laboratory furniture should be capable of supporting anticipated loads and uses. Bench tops should be impervious to water and resistant to moderate heat and organic solvents, acids, alkalis, and chemicals used to decontaminate the work surface and equipment.
- The surfaces of walls, floors, and ceilings should be water-resistant and easy to clean.
- Biological safety cabinets (BSCs) (see Appendix 2) should be sited away from walk areas and out of crosscurrents from doors and ventilation systems.
- Laboratories should have easily accessible specimen reception rooms that should be separate from the offices.
- Safety signs and symbols should be suitably displayed on entrances as one way of promoting awareness.
- All exits and escape routes should be clearly marked.

In addition to the special requirements for the laboratory activities, the internal environment must provide for the comfort of the laboratory staff by meeting the following criteria—

- Extremes of temperature and humidity must be avoided.
- Air-conditioning systems may be required for the building as a whole or for selected rooms or areas.
- Roofing materials should be heat-reflective and have low thermal capacity and conductivity.
- The building must have adequate lighting.
- The laboratory should be maintained in a clean, orderly, and sanitary condition.
- The laboratory should have clean and adequate ablution amenities provided separately for male and female staff.

7.3 Staff Facilities

- The laboratory should provide space for lockable cabinets for personal items for individual members of staff.
- The laboratory department should have a staff common room.

7.4 Storage Facilities

Storage facilities should be adequate to hold supplies for immediate use within the laboratory to prevent clutter. Long-term storage facilities should be located outside the laboratory working areas.

8.0 HAZARDS AND RISKS

A hazard is any condition in the workplace that can cause illness or injury or in any way impair the mental, physical, or social well-being of workers.

8.1 Types of Hazards

The main hazards are subdivided into physical, mechanical, biological, ergonomic, chemical psychosocial, and work organization and include the following—

- Physical—heat, humidity or cold, noise, vibration, illumination, electrical, radiation, ventilation, fire, and overcrowding.
- Mechanical—manual and power-driven equipment, falling objects, accessways and floors
- Biological—infectious materials and diseases such as tuberculosis, animal bites and wounds.
- Ergonomic—standing all day, extreme movements, positioning of a worker.
- Chemical—inhalation, absorption, or ingestion
- Psychosocial, such as—
    - Contractual hazards—low pay, shift work, flextime abuse, unsociable hours, excessive hours, and job insecurity
    - Job design hazards—an excess or lack of work; lack of stimulation, pace, and flow of work; job isolation; lack of direction and decision making; lack of control; underutilization of skills
    - Relationships—bad relations with supervisors or colleagues; sexism, racism, or ageism; customer or client complaints; lack of communication
- Poor work organization—lack of opportunity for continuing education, monotony and boredom, isolation, limited career options, hazardous conditions, high demand, piecework, and task work

8.2 Addressing Hazards

8.2.1 Fire Hazards

Fire hazards in the laboratory arise mainly from the presence of materials that are inflammable or combustible and the availability of a number of ignition sources. Fire may also be caused by overheating of faulty, poorly maintained electrical equipment, overloading of electrical circuits, the use of adapters, overheating of electrical motors due to inadequate ventilation.

8.2.1.1 Causes of Fire

8.2.1.1.1 Bunsen Burners and Gas Fires

Causes—

- Open flames
- Flexing gas tubing
- Unclosed gas taps
- Gas leaks

Prevention—

- Bunsen burner tubing must be made of reinforced plastic and fixed with clamps at both ends to prevent the escape of gas. Soft rubber tubing must *NOT* be used.
- Gas taps should be *turned off* when not in use.
- Leaking gas tubing must be replaced immediately.
- Gas should be supplied from main service by fixed pipework and outlets or from a liquefied gas bottle or tank located outside the laboratory building.

8.2.1.1.2 Heaters

Causes—

Use of open heating elements in presence of volatile chemicals

Prevention—

- Electric heating mantles should be used instead of open heating elements.
- Use of electric heaters with open elements is prohibited.

8.2.1.1.3 Chemicals

Causes—

- Improper handling and storage of flammable or explosive materials
- Improper segregation of combustible chemicals
- Sparking equipment near flammable substances and vapors
- Improper or inadequate ventilation

Prevention—

- Flammable liquids should be stored in clearly labeled, well-ventilated, metal safety storage containers on a concrete or metal base with appropriate drainage facilities.
- To guard against the vapor hazard, the containers of all flammable chemicals must be tightly closed when not in use.

- Only a minimum of flammable chemicals may be kept in the laboratory.
- When flammable chemicals are used, all open flames in the vicinity must first be extinguished.
- Smoking in all laboratories, and in areas where flammable chemicals are handled, is *strictly forbidden*. Cigarette butts should not be discarded in the laboratory.
- Separate waste bottles must be kept in all laboratories for the purpose of discarding flammable chemicals.

8.2.1.2 Fire Prevention

Fire warnings, instructions, and escape routes should be displayed prominently in each room and in corridors. “Switch Off” notices should be displayed in areas where Bunsen burners and electrical appliances are used. In addition, the following should be taken into account—

- Extinguishers and blankets should be readily available throughout work areas.
- Automatic fire detection and alarm systems and sprinklers (to extinguish fire) should form part of necessary installations.
- Fire exits should be available.
- Laboratory doors should be self-closing.
- Electrical outlets should be grounded.

8.2.1.3 Fire Drills

The safety officer must ensure that employees familiarize themselves with and practice the fire precautions and procedures established by the hospital and laboratory. Fire drills and evacuation exercises must be conducted at least twice a year. Firefighting equipment must be placed in strategic locations within the laboratory. Each staff member should be proficient in the use of this equipment.

8.2.1.4 Firefighting Equipment

Table 8-1 shows various firefighting equipment and uses.

Table 8-1. Types of Fire Extinguishers

Type	Color Code	Used For	Not Used For
Water	Red	Paper Wood Fabric	Electrical fires Flammable liquids Burning metals
Carbon dioxide (CO_2)	Black	Flammable liquids and gases Electrical fires	Alkali metals Paper
Dry powder	Blue	Flammable liquids and gases Alkali metals Electrical fires	Reusable equipment and instruments (because residues are very difficult to remove)
Foam	Yellow	Flammable liquids	Electrical fires
Sand bucket	—	Flammable liquids	—
Fire blankets	—	Clothing Small fire on floor or bench	—

The fire extinguishers should be serviced twice a year or as directed by the manufacturer.

8.2.1.5 Emergency Action

Should a fire break out in the workplace, the following steps should be taken immediately—

- Sound the fire alarm promptly.
- Report the fire to the telephone switchboard operator, who will summon the necessary technical assistance.
- Until assistance arrives at the scene of the fire, control the fire if it is safe to do so by—
    - Closing all the doors and windows to prevent a draft (wind) fanning the fire
    - Turning off all gas taps, electrical appliances, and the power sources
    - Using the appropriate firefighting equipment installed in the building

8.2.2 Equipment and Glassware Hazards

Equipment and glassware hazards are common in the laboratory. A list of such hazards and approriate prevention techniques is provided in Table 8-2.

The safe use of equipment is dependent on—

- Equipment being installed and positioned correctly
- Equipment being used as instructed by the manufacturer
- Equipment being cleaned, inspected, serviced, and repaired correctly
- Staff being well instructed in the correct use, cleaning, and maintenance of equipment

- Not using the equipment prior to proper installation and commissioning by a qualified engineer

- Accessible edges and corners of metallic equipment being smoothed with a file or padded with suitable material

- The supervisor ensuring standard operating procedures and maintenance schedules exist and are implemented

The safe use of glassware is dependent on—

- Use of glassware with fine polished edges whenever possible
- Pipette fillers fitted with care to avoid breakage of glass pipettes

Care is needed when handling broken glass. Strong rubber or leather gloves should be available for use all the time.

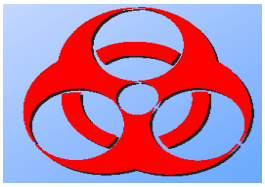
Table 8-2. Equipment and Glassware Hazards and Their Prevention

Equipment	Hazard	Prevention
Sharps— • Hypodermic needles • Microtome blades • Surgical blades • Broken glassware	Accidental inoculation	• Use disposable needles and syringes. • Do not recap or clip needles. • Use plasticware. • Dispose of sharps in puncture-resistant sharps containers. • Use safe laboratory practice.
Syringes Pipettes Capillary tubes	Aerosol or spillage	• Use BSC for all procedures with infectious materials. • Do not pipette by mouth. • Handle with care.
Centrifuges	Aerosols, splashing	• Use sealable buckets (safety cups) or sealed rotors. • Open buckets or rotors after aerosols have settled (30 minutes) or in a BSC.
Ultracentrifuges	Aerosols, splashing, and tube breakage	• Install a HEPA filter between centrifuge and vacuum pump. • Load and unload buckets in a BSC. • Maintain a logbook of operating hours for each rotor. • Establish a preventive maintenance program to reduce risk of mechanical failure.
Anaerobic jars	Explosion—dispersing infectious materials	• Ensure the integrity of wire capsule around catalyst.

Equipment	Hazard	Prevention
Desiccators	Implosion—dispersing glass fragments and infectious materials	• Place in a stout wire cage.
Homogenizer issue grinders	Aerosols, leakage, and container breakage	• Operate and open equipment in a BSC. Wait for 30 minutes if safety cabinet is not available. • Use specially designed models that prevent leakage. • If manual tissue grinders are used, hold tube in wad of absorbent material.
Sonicators ultrasonic cleaners	Aerosols, impaired hearing, dermatitis	• Operate and open equipment in BSC or sealed unit. • Ensure insulation to protect against subharmonics. • Wear gloves to protect against high-frequency plus detergent action on skin.
Culture stirrer, shakers, agitators	Aerosols, splashing, and spillage.	• Operate in a BSC or specially designed primary containment. • Use heavy-duty screw-capped culture flasks, fitted with filter-protected outlets, if necessary, and secure well.
Freeze dryers (lyophilizers)	Aerosols and direct contact contamination	• Use O-ring connectors to seal the unit throughout. • Use air filters to protect vacuum lines. • Use a satisfactory method of decontamination (e.g., chemical). • Provide an all-metal moisture trap and a vapor condenser. • Carefully inspect all vacuum vessels for surface scratches. • Use only glassware designed for vacuum work.
Water baths	Growth of microorganisms and use of sodium azide to prevent microbial growth	• Ensure regular cleaning and disinfection. • Do not use sodium azide.
Automated analyzers	Injury from moving parts and probes	• Guard moving parts properly. • Loose hair, ties and other clothing must be secured.

Equipment	Hazard	Prevention
Gas cylinders	Explosion, fire, leakage of toxic gases	• Gas must be stored outside the building and piped in. • Trolleys must be used for transportation. • Nonreturn valves must be used. • Gas tubing must be leakproof.
Visual display units	Eyestrain, headache, back- and neckache.	• Work in well laid-out area with good lighting, good quality screens, and keyboards. • Avoid spending excessive continuous time working at the visual display unit.
Heat sealers	Burns, electric shock	• Ensure that the blood tubing is wiped dry prior to sealing.
Refrigerators, deep freezers	Sparking, cold burns	• Use sparkproof refrigerators to store flammable chemicals. • Wear protective gloves when handling materials from ultra-freezers.
Biological safety cabinets (BSCs)	Contamination from filters, air backflow and work surfaces	• Decontaminate the cabinet before changing the filters. • Avoid use of Bunsen burners inside the cabinets because they may disturb the direction of air flow. • Promptly decontaminate the cabinet in the event of any spillages. • Leave ultraviolet lights on overnight.
Horizontal laminar flow, fume cupboards	Contamination	Do not use for handling infectious materials.

8.2.3 Microbial Hazards



Infections by microorganisms may be acquired through the following avenues during specimen handling—

- Skin—through cuts and scratches
- Eyes—through transfer from contaminated fingers
- Mouth—through such practices as mouth pipetting and putting contaminated materials into the mouth
- Respiratory tract—through inhalation of aerosols.

8.2.3.1 Prevention of Microbial Hazards

- Use appropriate personal protective equipment (PPE)
- Handle biological specimens in the safety cabinet

8.2.3.2 Classification of Infectious Microorganisms

Risk Group 1—The organisms in this group present a low risk to the laboratory worker and to members of the community. They are unlikely to cause human disease. Examples include food spoilage bacteria and common molds and fungi.

Risk Group 2—These organisms offer a moderate risk to the laboratory worker and a limited risk to members of the community. They can cause serious human disease but are not a serious hazard. Effective preventive measures and treatment are available and the risk of spread in the community is not great. Examples include staphylococci, streptococci, and enterobacteria (except *Salmonella typhi*).

Risk Group 3—This group contains organisms that present a high risk to the laboratory worker but a low risk to the community should they escape from the laboratory. They do not ordinarily spread very quickly from one individual to another. Again, effective vaccines and therapeutic materials are available for most pathogens in this group. Examples include *Vibrio cholerae, Brucella, Microbacterium tuberculosis,* and *Salmonella typhi.*

Risk Group 4—The agents in this group are all viruses. They present a high risk to the laboratory worker and the community should they escape from the laboratory. They can cause serious disease and are readily transmitted from one individual to another. At present, no vaccines or therapeutic materials are available to counteract these viruses. Examples include viruses causing hemorrhagic fevers such as Marburg, Lassa, and Ebola.

8.2.4 Chemical Hazards

In the laboratory, the risks associated with the use of chemicals can be minimized by the staff knowing which chemicals are hazardous and how to handle and store them correctly.

8.2.4.1 Types of Hazardous Chemicals

Hazardous chemicals encountered in the laboratory include flammable, oxidizing, toxic, harmful, irritating, corrosive, and explosive chemicals. Each type requires special handling. (See Appendix 4.)

8.2.4.1.1 Flammable Chemicals

A flammable substance is one that readily ignites (catches fire) and burns. Some flammable chemicals (such as acetone, diethyl ether, absolute alcohol, and glacial acetic acid) pose a more serious fire risk than others because they ignite more easily.

8.2.4.1.2 Oxidizing Chemicals

An oxidizing substance is one that produces heat or involves oxygen in contact with other substances causing them to burn strongly, become explosive, or spontaneously combust. Oxidizing chemicals include peroxides, nitric acid, ammonium nitrate, chromic acid, calcium hypochlorite, and potassium permanganate.

8.2.4.1.3 Toxic Chemicals

A toxic substance is one that can cause serious acute or chronic effects, even death, when inhaled, swallowed, or absorbed through the skin. Toxic chemicals include potassium cyanide, mercury and mercury compounds, sodium azide, formaldehyde, and methanol.

8.2.4.1.4 Harmful Chemicals

A harmful substance is one that can cause limited effects on health if inhaled, swallowed, or absorbed through the skin. Harmful chemicals include barium chloride, benzoic acid, potassium oxalate, saponin, xylene, iodine, and sulfuric acid.

8.2.4.1.5 Irritating Chemicals

An irritating chemical is one that can cause inflammation and irritation of the skin, mucous membranes, and respiratory tract following immediate, prolonged, or frequent contact. Irritants include ammonia solution, acetic acid, sulfasalicylic acid, potassium dichromate, and formaldehyde vapor.

8.2.4.1.6 Corrosive Chemicals

A corrosive chemical is one that when ingested, inhaled, or allowed to come in contact with skin can destroy living tissue and is capable of damaging inanimate substance. Examples of corrosive substances include phenol, sulfuric acid, nitric acid, and sodium hydroxide.

8.2.4.1.7 Explosive Chemicals

Any substance that may explode when heated or when subjected to shock or friction is considered to be an explosive chemical. Examples of explosive chemicals include sodium azide, perchloric acid, picric acid and picrates, diethyl ether, and other ethers.

8.2.4.2 Safe Storage of Chemicals

- Chemicals must be stored according to their compatibility classes, meaning that flammable chemicals *must not* be stored next to oxidizing and explosive chemicals. For example, sulfuric acid and sodium hydroxide (both corrosives) should be stored in the same area.
- Flammables should be stored in special fire-resistant cabinets located in an outside storeroom away from main laboratory.
- Alkaline, oxidizers. and carcinogens should be stored separately.
- Volatile noxious chemicals or those with high vapor pressures should be stored in a ventilated cabinet that has an exhaust to the outside. They should not be stored in fume cupboards.

8.2.4.3 Chemical Spills and Leakages

Chemical spillages can contaminate laboratory furniture and equipment. Staff may be contaminated directly or indirectly by contact with contaminated surfaces.

- If nonflammable liquid chemicals are spilled, place sufficient dry sand or absorbent paper around the spillage to prevent its spread and to soak up the chemical.
- Wearing chemical-resistant gloves and using a plastic dustpan, collect the material.
- If the spill is a strong acid or alkali, neutralize it (see instructions below) and dispose of it safely.
- If leakages from flammable gas occur, extinguish all flames and remove or switch off all sources of ignition.
- If personal injury has occurred or a hazardous chemical has been spilled on clothing, remove the clothing and immediately wash and immerse the affected part of the body in water.
- If the injury is serious, apply appropriate first-aid measures and seek medical advice.

8.2.4.4 Neutralization

- Use 50 g/L (5% weight/volume) sodium bicarbonate or sodium carbonate to neutralize acid spills.
- Use 10 g/L (1% volume/volume) acetic acid to neutralize strong alkaline spills.
- Clean the spillage area with water and detergent.

8.2.5 Electrical Hazards

All laboratory electrical equipment should be grounded, preferably using three-prong plugs. Double-insulated devices, requiring only two-prong plugs, are rare in laboratories, but if present may require separate grounding. A ground-free supply may become live as a result of an undetected fault. Install circuit breakers, power surge protectors, and ground-fault interrupters.

Sparkproof laboratory equipment is recommended for use in laboratories in the presence of flammable solvents. For electrical fires, always use either carbon dioxide (CO_2)or dry-powder fire extinguishers rather than water or foam fire extinguishers.

Table 8-3 lists electrical hazards and means of prevention.

Table 8-3. Electrical Hazards and Prevention

Hazard	Prevention
Wet or moist surfaces near electrical equipment	Avoid use of electrical equipment near wet surfaces. Avoid spillages.
Broken plug tops or sockets	Have broken plugs and sockets replaced without delay.
Frayed or damaged insulation of **MAINS** cables.	Do not attempt to repair mains cables. Leave this for trained electricians.
Equipment with **HIGH VOLTAGE** power supplies.	Proper installation and extra care should be exercised when handling equipment with high-voltage power supplies. Place **"HIGH VOLTAGE"** notices or symbols near such equipment and power supplies.
Static electricity	Install humidity controller in laboratories to reduce static formation. Equipment must be grounded. Personnel must wear static collectors when handling electronic components such as solid-state circuitry.
Overloading of circuits by use of adapters	Do not use extension cables or multisocket adapters because their use often leads to overloading of electric circuits.
Fuses of wrong rating	Always install fuses of the correct rating. Failure to do so can lead to equipment damage and fire.
Tripping over electric cables	Excessively long cords should be avoided.

8.2.6 Radiation Hazards

Radiation can cause two types of harmful effects: *somatic*, those that are clinically observable in irradiated individuals, and *hereditary*, those that are observable in descendants of irradiated individuals.

To ensure radiation protection, the entrance to radiation area must be signposted with the international radiation symbol. In addition, take the following precautions—

- Avoid skin contamination, inhalation, and deposition of radionuclides in the body.
- All workers *must* wear suitable personal protective equipment (PPE) when handling radioactive materials.
- Avoid the spread of contamination.
- When working with radioactive materials, use drip trays with absorbent paper.
- Always work in a fume cupboard when handling radioisotopes such as iodine-125 (I^{125}). Whenever possible, use disposable containers and instruments.
- Follow guidelines given by the radiation protection unit for the disposal of radioactive waste. Nondisposable items must be rinsed thoroughly before decontamination.
- Avoid external beta and gamma radiation.
- When working with high emitters, always carry them in lead pots and use great care.
- All workers who come into contact with radiation sources need to carry with them dosimeter films to monitor the levels of exposure.

9.0 DECONTAMINATION

Decontamination is the process of rendering ineffective infectious, deleterious, and radioactive materials on work benches or equipment and on any waste, before an item is reused or disposed of, as the case may be.

9.1 Types of Decontamination

Decontamination is accomplished by disinfecting or sterilizing a contaminated item.

9.1.1 Disinfection

Disinfection kills or renders pathogenic microorganisms inactive. Most disinfection procedures or methods employ chemicals. Treatment with chemical disinfectants is not suitable for all kinds of infectious waste and should be restricted to reusable pipettes and glassware.

9.1.2 Sterilization

Sterilization kills all classes of vegetative organisms and spores and is usually accomplished by heat, for example, in an autoclave or hot-air oven. (See Appendix 3.)

9.2 Decontamination Procedures

Procedures differ depending on what is to be decontaminated. Follow the instructions below to decontaminate surfaces, equipment, reusable items, and disposable materials.

9.2.1 Surfaces

Use 0.5 percent sodium hypochlorite to disinfect “clean” surfaces such as bench tops—

- Soak an appropriate absorbent in working chlorine or hypochlorite solution.
- Wipe the surfaces and leave the disifectant to act for 10 minutes.
- Rinse in profuse amounts of clean water to remove all traces of the disinfectant.

9.2.2 Equipment

Disinfectants are used in bench discard jars as an immediate “make safe” procedure, but the contents must be autoclaved (see Appendix 3) before disposal or recycling. Disinfect as follows—

- Place instruments in 0.5 percent chlorine solution after use.
- Soak for 10 minutes and rinse immediately.
- Wipe surfaces with chlorine solution.
- Use a recommended disinfectant—

    - Glutaraldehyde (“Cidex”), 1–2 percent for 1 hour (must be fresh)
    - Ethanol, 70 percent for 1 hour

***Warning*: Sodium hypochlorite, especially in high concentration, is an oxidant and very damaging to metal instruments and metal parts of any equipment.**

9.2.3 Reusable Equipment

Decontamination procedure of equipment such as centrifuges, cell counters, and enzyme immunoassay (EIA) equipment, must conform to manufacturer's recommendations.

Equipment such as BSCs (Appendix 2) can be decontaminated by fumigation using formalin with potassium permanganate. Use the following procedure—

- Remove all material and equipment from the BSC and from the immediate environment.
- Ensure that the BSC is switched on.
- Seal all air intakes and exhaust grills in the laboratory by taping large plastic garbage bags over the grills. Tape around door frames or other openings through which the formaldehyde vapor may leak.
- Use 25 mLof formalin and 15 g of potassium permanganate for each cubic meter capacity that has to be decontaminated.
- Place the potassium permanganate crystals in a deep metal container in the BSC.
- Pour the formalin over the crystals of potassium permanganate and leave the laboratory immediately, because the reaction rapidly produces the release of heat and formaldehyde gas.
- Close and seal the laboratory door.
- Allow the formaldehyde vapor to act overnight or preferably over a weekend with the BSC switched on.
- At the end of that period, remove the covers from air intakes and exhaust grills as well as the tape around doors and other openings.
- Allow the room to air out until no more formaldehyde is detectable, then mop all residue from floors, walls, and benches. If a white powder residue is obvious, remove it by wiping with 10 percent ammonium hydroxide solution. (Wear gloves.)
- Switch the BSC off and proceed with replacement of filters or repair.

9.2.4 Disposable Materials

To decontaminate used, disposable gloves, use this procedure—

- Immerse both gloved hands in 0.5 percent chlorine solution.
- Remove gloves from hands by turning them inside out. Dispose of the gloves in heavy-duty plastic bags.

Reusable Gloves

To decontaminate reusable gloves, use this procedure—

- Submerge contaminated gloves in 0.5 percent sodium hypochlorite solution for 10 minutes.
- Thoroughly rinse in water to remove all traces of the disinfectant.
- Drip dry by hanging.

9.2.5 Radioactive Spills

Follow guidelines given by the radiation protection unit for the management of radioactive spills.

10.0 SAFE WASTE DISPOSAL

Laboratory wastes and contaminated materials represent hazards both to laboratory staff and to the community. The uncontrolled dumping of solid, liquid, chemical and biological laboratory waste can threaten the environment. The safe disposal of laboratory waste is therefore of prime importance.

10.1 Types of Waste

Laboratory-generated waste includes—

- Sharps
- Chemical waste
- Human anatomical waste
- Blood and body fluids
- Solid waste such as cotton wool, tissue paper, culture plates with used media, used blood-giving sets, empty blood packs, used test tubes, used glass slides, and erythrocyte sedimentation rate (ESR) tubes.
- Laboratory specimens
- Equipment effluent
- Radioactive waste

10.2 Waste Segregation

Infectious waste should be carefully segregated from other kinds of waste by placing it in color-coded bags, which should be sealed when three-quarters filled. These bags should be supported in metal or autoclavable plastic boxes to minimize damage and retain spillages.

Bulk (24-hour) urine specimens are a special case. They may be safely disposed of by directly emptying them into a sluice or pit latrine.

The recommended way of identifying health care waste categories is by sorting the waste into color-coded and well-labeled bags or containers. Table 10-1 shows the color-coding system.

Table 10-1. Color Coding System

Color	Type of Waste
Black	Risk-free waste
Yellow	Infectious waste
Brown	Chemical waste

10.3 Treatment before Disposal

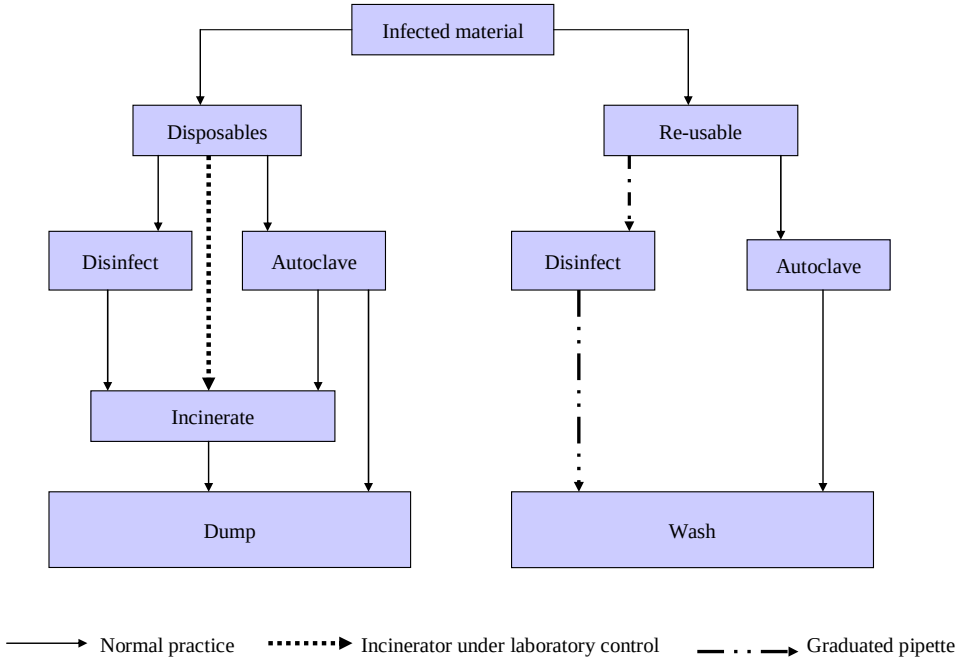


Figure 10-1. Flowchart for the Treatment of Infected Material

10.3.1 Serological Reactive and Expired Units of Blood

Units of blood to be discarded should be decontaminated and denatured before incineration using the following method—

- Raise the temperature in the water bath to 56 ^{o}C and allow to stabilize at this temperature.
- Place the units of blood in a porous metal bucket and place the bucket in the water bath.
- Allow to heat for 30 minutes.
- Remove units from buckets and place them in autoclavable biohazard plastic bags.
- Take the sealed plastic bags for incineration.

10.3.2 Infectious Waste

Contaminated and used culture plates and media, used cotton wool, blood specimen containers, and urine and stool specimen containers should be autoclaved at 121^{o}C at 15 pounds per square inch for 15 minutes before disposal. (See Appendix 3.)

10.4 Transportation of Waste Material for Incineration

- All materials for incineration must be documented in a log book.
- The log book must bear at least the following information—
    - Porter's name and signature
    - Supervisor's name and signature
    - Date of collection
    - Source of waste
    - Weight of the waste
    - Signature of recipient officer at the incinerator
- The porter's supervisor must make sure the material for incineration is properly packaged, labeled as BIOHAZARDOUS material, and that the package is leakproof.
- The porter must wear necessary PPE.
- The material must be transported as quickly as possible using a route less exposed to the public.

10.5 Methods of Disposal

Waste may be safely disposed of using incineration or burial or both.

10.5.1 Incineration

Incineration provides high temperatures and destroys microorganisms; therefore, it is the best method for disposal of contaminated wastes. Incineration also reduces the bulk size of wastes to be buried.

Simple incinerators can be built from locally available materials such as bricks, concrete blocks, used fuel or oil drums, and so forth.

10.5.2 Burial

- If incineration is not possible, all contaminated wastes must be buried in a rubbish pit and covered with soil to prevent scattering of the waste materials.
- Rubbish pits should be at least 4 to 5 meters deep, 1 to 2 meters wide, and protected to prevent scavenging.
- Rubbish in pits should be covered regularly with soil to prevent scavenging or accidental contamination of the environment.

APPENDIX 1. ACCIDENT REPORT FORM

Full names of injured:……..

Ward/Department:……...

Present Post:……

Date of Injury:…….

Site of injury:……

Cause of injury:……

Full description of how
injury occurred:……
…….
…….
…….
…….
…….
…….

Nature of injury (doctor's diagnosis if available)

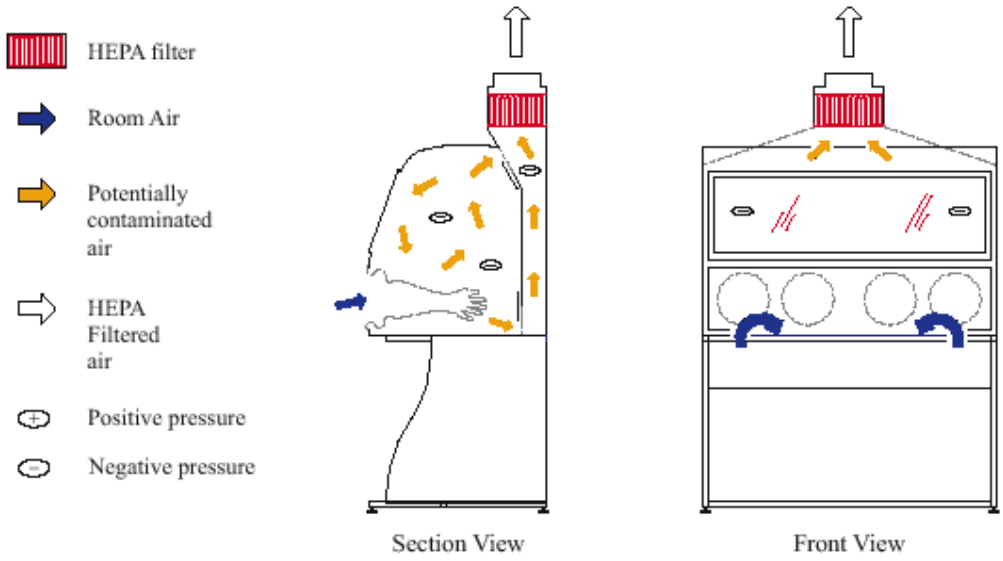
…….
…….
…….
…….
…….

Signature of injured (if possible):……

APPENDIX 2. BIOLOGICAL SAFETY CABINETS

Class I Biological Safety Cabinet

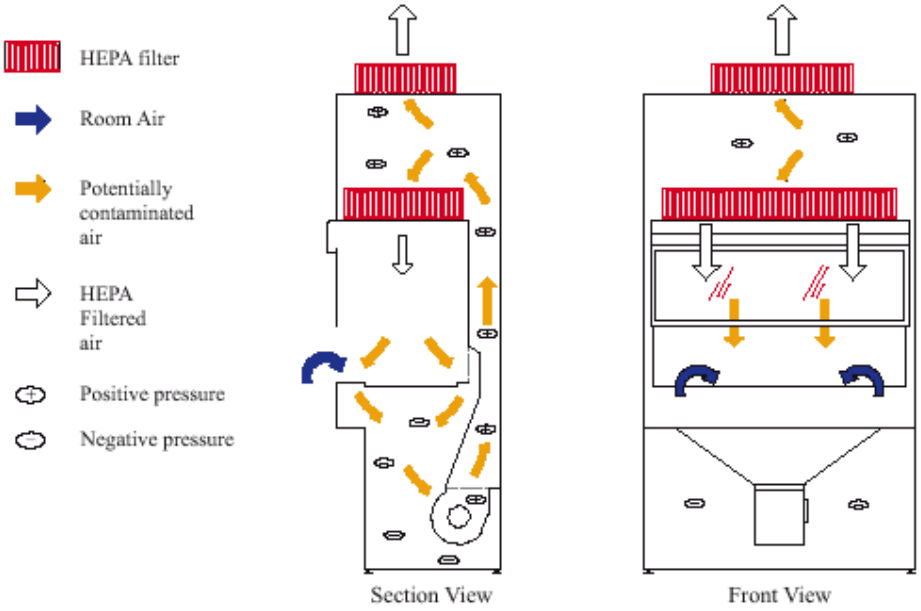
This BSC was designed to work with Risk Group 1 infectious microorganisms, but it may also be used for work with radioactive materials and volatile toxic chemicals. Unsterilized room air is drawn over the work surface and through the front opening; therefore, to the Class I BSC does not provide consistently reliable product protection.



Class II Biological Safety Cabinet

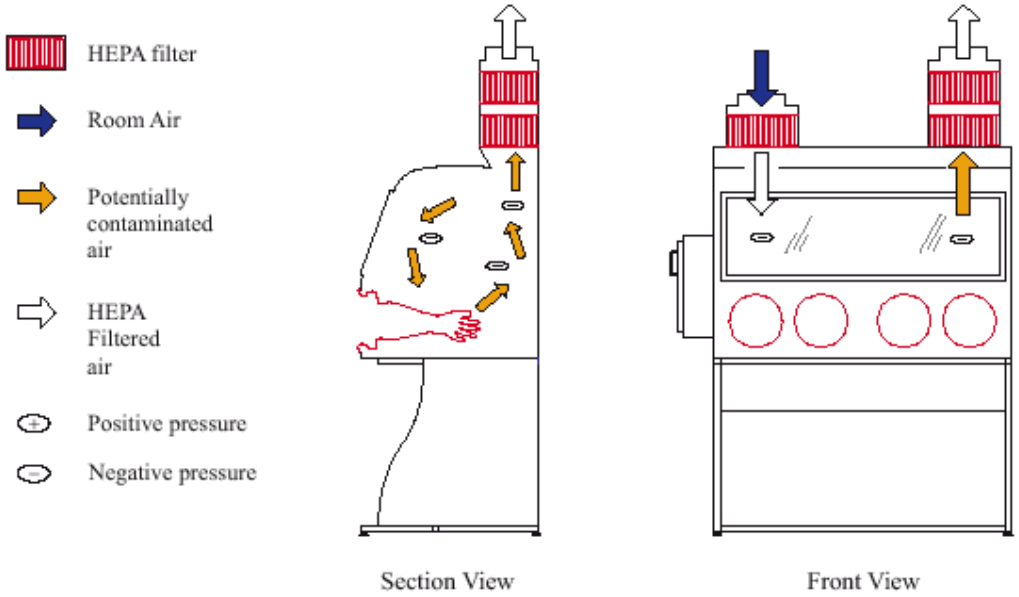
The Class II BSC is designed not only to provide personnel protection but also to protect work surface materials from contaminated room air. Class II BSCs, of which there are four types (A1, A2, B1, and B2), differ from Class I BSCs by allowing only HEPA-filtered (sterile) supply air to flow over the work surface. The Class IIB1 and IIB2 BSCs are variations of the Class IIA1.

The Class II BSC can be used for working with infectious agents in Risk Group 2, Risk Group 3, and Risk Group 4 infectious microorganisms when positive pressure suits are used.



Class III Biological Safety Cabinet

Designed to provides the highest level of personnel protection and is used for Risk Group 4 agents. All penetrations are sealed "gas tight." Supply air is HEPA-filtered and exhaust air passes through two HEPA filters. Airflow is maintained by a dedicated exhaust system exterior to the cabinet, which keeps the cabinet interior under negative pressure.



Types of Biohazard Safety Cabinets

Type of Protection	BSC Selection
Personnel protection, microorganisms in Risk Groups 1–3	Class I, Class II, Class III
Personnel protection, microorganisms in Risk Group 4, glove box laboratory	Class III
Personnel protection, microorganisms in Risk Group 4, suit laboratory	Class I, Class II
Product protection	Class II, Class III only if laminar flow is included
Volatile radionuclide and chemical protection, minute amounts	Class IIB1, Class IIA2 vented to the outside
Volatile radionuclide and chemical protection	Class I, Class IIB2, Class III

APPENDIX 3. AUTOCLAVING

Saturated steam under pressure (autoclaving) is the most effective and reliable means of sterilizing laboratory materials. For most purposes, the following cycles will ensure sterilization of correctly loaded autoclaves—

1. 3 minutes holding time at 134˚C
2. 10 minutes holding time at 126˚C
3. 15 minutes holding time at 121˚C
4. 25 minutes holding time at 115˚C

Examples of Autoclaves

Gravity-Displacement Autoclaves

Steam enters the chamber under pressure and displaces the heavier air downward and through the valve in the chamber drain, fitted with a HEPA filter.

Pre-vacuum Autoclaves

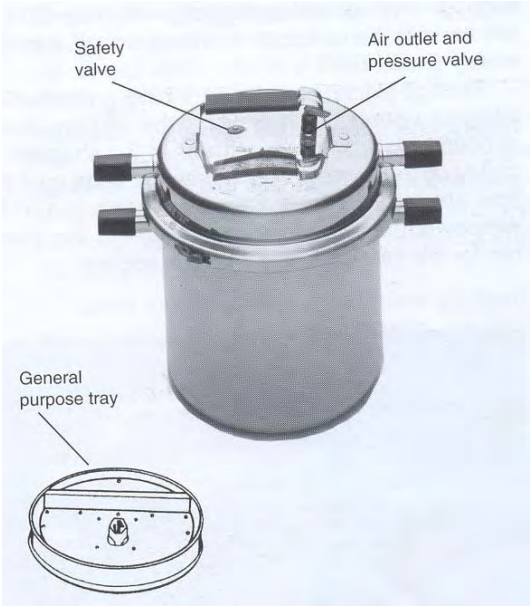
These machines allow the removal of air from the chamber before steam is admitted. The exhaust air is evacuated through a valve fitted with a HEPA filter. At the end of the cycle, the steam is automatically exhausted. These autoclaves can operate at 134˚C and the sterilization cycle can therefore be reduced to 3 minutes. They are ideal for porous loads, but cannot be used to process liquids because of the vacuum.

Fuel-Heated Pressure Cooker Autoclaves

This type of autoclave should be used only if a gravity-displacement autoclave is not available. They are loaded from the top and heated by gas, electricity, or other fuel. Heating

water in the base of the vessel generates steam, and air is displaced upward through a relief vent. When all the air has been removed, the valve on the relief vent is closed and the heat

Reduced. The pressure and temperature rise until the safety valve operates at a present level; this is the start of the holding time. At the end of the cycle the heat is turned off and the temperature allowed to fall to 80 C or below before the lid is opened.



Loading an Autoclave

Materials should be loosely packed in the chamber for easy steam penetration and air removal. Bags should allow the steam to reach their contents.

Precautions in the Use of Autoclaves

The following rules can minimize the hazards inherent in operating pressurized vessels—

1. Responsibility for operation and routine care should be assigned to trained individuals.

2. A preventive maintenance program should include regular inspection of the chamber, door seals, and all gauges and controls by qualified personnel.

3. The steam should be saturated and free from chemicals (for example, corrosion inhibitors) that could contaminate the items being sterilized.

4. All materials to be autoclaved should be in containers that allow ready removal of air and permit good heat penetration; the chamber should be loosely packed so that steam will reach the load evenly.

5. For autoclaves without an interlocking safety device, which prevents the door being opened when the chamber is pressurized, the main steam valve should be closed and the temperature allowed to fall below 80˚C before the door is opened.

6. Slow exhaust settings should be used when autoclaving liquids, because they may boil over when removed due to superheating.

7. Operators should wear suitable gloves and visors for protection when opening the autoclave, even when the temperature has fallen below 80˚C.

8. In any routine monitoring of autoclave performance, biological indicators, or thermocouples should be placed at the center of each load. Regular monitoring with thermocouples and recording devices in a “worst case” load is highly desirable to determine proper operating cycles.

9. The drain screen filter of the chamber (if available) should be removed and cleaned daily.

10. Care should be taken to ensure that the relief valves of pressure cooker autoclaves do not become blocked by paper or any other substance in the load.

APPENDIX 4. CHEMICALS AND REAGENTS LISTED BY HAZARDS

Extremely Flammable

- Acetone
- Diethylamine
- Diethyl ether

Highly Flammable

- Acetone alcohol
- Acid alcohol
- Ethanol and alcohol reagents
- Methanol
- Methylated spirit
- Toluene
- Oxidizing (fire-promoting)
- Calcium hypochlorite
- Chromic acid
- Hydrogen peroxide (strong)
- Nitric acid
- Perchlorates
- Potassium permanganate
- Sodium nitrite

Toxic

- Cadmium sulfate
- Diphenylamine
- Formaldehyde solution
- Lactophenol
- Mercury
- Mercury II chloride (Mercuric chloride)
- Methanol
- Phenol
- Picric acid
- Potassium cyanide
- Sodium azide
- Sodium fluoride
- Sodium nitrite
- Sodium nitroprusside
- Thiomersal
- Thiosemicarbazide
- o-Tolidine
- o-Toluidine

Harmful

- Aminophenazone
- Ammonium oxalate
- Auramine phenol stain
- Barium chloride
- Benedicts reagent
- Benzoic acid
- Carbol fuchsin stain
- Cetylpyridinium chloride
- Chloroform
- Copper II sulphate
- Dobell's iodine
- Ethylenediaminetetraacetic acid (EDTA)
- Ethylene glycol (ethanonediol)
- Formol saline
- Glycerol jelly
- Glutaraldehyde
- Iodine
- Iron III chloride (ferric chloride)
- Lugl's iodine
- Methylated spirit
- Naphthylamine
- ρ-Nitrophenyl
- Oxalic acid
- Potassium oxalate
- Potassium permanganate
- Salicyclic acid
- Saponin
- Sodium deoxycholate
- Sodium dithionite
- Sodium dodecyl sulphate
- Sodium tetraborate
- Sodium tungstate
- Stains (powder form)
    - Acridine orange
    - Auramine O
    - Brilliant cresyl blue
    - Crystal violet
    - Giemsa
    - Harris's hematoxylin
    - Malachite green
    - May Grunwald
    - Methylene blue
    - Neutral red
    - Toluidine blue
- Sulphanilic acid
- Thiourea
- Toluene
- Xylene

Irritant

- Acetic acid, glacial
- Ammonia solution
- Calcium chloride formaldehyde solution
- Hydrogen peroxide
- Lactic acid
- Naphthlethylenediamine
- dihydrochloride
- Potassium dichromate
- Sodium carbonate
- Sulfasalicylic acid
- Zinc sulfate

Corrosive

- Acetic acid, glacial
- Ammonia solution
- Calcium hypochlorite
- Chromic acid
- Fouchet's reagent
- Hydrochloric acid
- Nitric acid
- Phenol
- o-Phosphoric acid
- Potassium hydroxide
- Silver nitrate
- Sodium hydroxide
- Sulfuric acid
- Thymol
- Trichloroacetic acid

Explosive

- Picric acid (when dry)
- Sodium azide

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