FEDERAL MINISTRY OF HEALTH & SOCIAL WELFARE

DEPARTMENT OF HOSPITAL SERVICES

MEDICAL LABORATORY SERVICES DIVISION

NATIONAL GUIDELINE FOR MEDICAL LABORATORY ON BIOSAFETY AND BIOSECURITY

First Edition

March 2026

FEDERAL REPUBLIC OF NIGERIA

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Foreword

The health and well-being of our nation depend on the strength, safety, and reliability of our healthcare systems. At the heart of these systems are medical laboratories, which provide diagnostics and critical data that guide clinical decisions, inform public health surveillance, and enable rapid responses to emerging threats.

The National Guideline for Medical Laboratory on Biosafety and Biosecurity has been developed to provide a comprehensive framework for protecting laboratory personnel, the public, and the environment from biological risks. It outlines clear standards and procedures for safe laboratory practices, the secure handling of pathogens, and the responsible management of biological materials. By aligning with global health security, this guideline strengthens Nigeria's capacity to prevent, detect, and respond to public health emergencies while fostering a culture of safety and accountability across all tiers of the health system.

The COVID-19 pandemic revealed vulnerabilities in laboratory systems worldwide and highlighted the need for coordinated protocols that ensure resilience in times of crisis underscored the urgency of robust biosafety and biosecurity measures. This guideline responds to that call by promoting risk-based approaches, strengthening governance structures, and advancing digital and operational innovations that enhance laboratory safety and security.

Further anchored in President Bola Ahmed Tinubu's Renewed Hope Agenda and the Nigeria Health Sector Reform Blueprint, this document supports the four strategic pillars of the reform: effective governance and equity, improved population health outcomes, unlocking the health sector value chain, and bolstering health sector security. Laboratory biosafety and biosecurity are cross-cutting enablers of these pillars, ensuring that our laboratories remain safe, reliable, and responsive to the needs of all Nigerians.

The development of this guideline reflects extensive collaboration among government agencies, laboratory professionals, academia, and relevant stakeholders. It embodies a shared commitment to building a resilient health system that is transparent, accountable, and prepared for the challenges of today and tomorrow.

I call upon all stakeholders, public and private, national and sub-national, to adopt and implement this guideline with urgency and fidelity. By doing so, we will not only protect the integrity of our laboratory systems but also strengthen Nigeria's capacity to achieve Universal Health Coverage, health security, and sustainable development.

Prof. Muhammad Ali Pate *CON*
Coordinating Minister of Health and Social Welfare
Federal Ministry of Health

Preface

Medical laboratories are indispensable to the delivery of quality healthcare, public health surveillance, and disease control. They provide evidence that guides clinical decisions, informs policy, and enables timely interventions during health emergencies. However, the benefits of laboratory services can only be fully realized when biosafety and biosecurity are upheld as fundamental principles. Protecting laboratory personnel, communities, and the environment from biological risks is not only a professional obligation but also a national priority.

The National Guideline for Medical Laboratory on Biosafety and Biosecurity has been developed to provide a unified framework for ensuring safe laboratory practices nationwide in Nigeria. It outlines standards for risk assessment, containment, safe handling of pathogens, and secure management of biological materials. By harmonizing these practices across primary, secondary, and tertiary levels of care, the guideline strengthens our collective capacity to prevent accidental exposures, mitigate risks, and ensure the responsible use of biological resources.

This document builds on lessons learnt from past public health challenges, including the COVID-19 pandemic, which underscored the importance of resilient laboratory systems. It aligns with international best practices while reflecting Nigeria's unique health system realities. Importantly, it complements other national policies and strategies aimed at strengthening laboratory services, thereby contributing to the broader goal of health security and sustainable development.

The development of this guideline was informed by extensive consultation with key stakeholders, government agencies, laboratory professionals, and academia. Their contributions reflect a shared vision: to build a medical laboratory system that is safe, secure, and responsive to the needs of all Nigerians.

I commend this effort and urge all stakeholders to embrace and implement the guidelines with diligence and commitment. The adoption will not only safeguard laboratory workers and the public but also reinforce Nigeria's capacity to achieve Universal Health Coverage, health security, and the continuous implementation of the Renewed Hope Agenda.

Daju Kachollom S. mni
Permanent Secretary
Federal Ministry of Health and Social Welfare

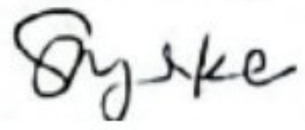
Acknowledgements

The development of the National Guideline for Laboratory Biosafety and Biosecurity is the result of an intensive, collaborative process. It reflects the shared vision and technical expertise of a diverse group of organizations and individuals committed to transforming healthcare delivery in Nigeria.

We extend our profound gratitude to our international partners for their steadfast support and technical guidance. Specifically, we thank the UK Health Security Agency, the Medical Laboratory Science Council of Nigeria and The Global Fund COVID-19 Response Mechanism grant through the National Agency for the Control of AIDS (NACA). Their partnership and global perspectives were instrumental in ensuring these guidelines meet international benchmarks while remaining contextually relevant to our national needs.

We also wish to recognize the invaluable contributions of the various government agencies, healthcare professionals, and technical experts who participated in the drafting and review processes. This document is a testament to your collective dedication and hard work.

Finally, we acknowledge every stakeholder whose insights and feedback helped refine this framework. Your commitment to excellence is the foundation upon which this guideline stands, ensuring a more integrated and resilient laboratory system for all Nigerians.



Dr. Abisola S. Adegoke *mni*
Director, Department of Hospital Services
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Executive Summary

The National Guideline for Medical Laboratory on Biosafety and Biosecurity is designed to strengthen Nigeria's health security, laboratory systems, and emergency preparedness. It provides practical, evidence-informed guidance to support the safe, secure, and reliable operation of medical laboratories across all tiers of the health system. The Guideline addresses the growing complexity of biological threats, emerging and re-emerging infectious diseases, rising diagnostic demand, and the need for harmonized laboratory practices nationwide.

Medical laboratories form the backbone of effective healthcare delivery and public health surveillance, providing critical evidence for clinical diagnosis, treatment decisions, disease monitoring, outbreak investigation, antimicrobial resistance tracking, and research. Laboratory operations, however, inherently involve biological, chemical, and radiological risks. Without robust biosafety and biosecurity measures, these risks can lead to laboratory-acquired infections, environmental contamination, occupational hazards, and broader threats to public and national health security. The Guideline establishes a unified national framework to mitigate such risks while enhancing laboratory performance, resilience, and reliability. It aligns with Nigeria Health Sector Reform Blueprint, the Renewed Hope Agenda, International Health Regulations (IHR 2005), World Health Organization (WHO) laboratory standards, and global health security priorities. Lessons from recent public health emergencies, including the COVID-19 pandemic, emphasize the importance of preparedness, coordination, and sustainable investment in laboratory systems.

The Guideline applies to all public and private medical laboratories, diagnostic facilities, research institutions, and related entities handling biological agents, toxins, and valuable biological materials in Nigeria. This includes laboratories at primary, secondary, and tertiary healthcare levels, as well as specialized public health, private health, research, and reference laboratories. Its scope covers the full laboratory value chain, including specimen collection, testing, storage, transportation, waste management, and disposal. By providing consistent national standards, the Guideline reduces fragmentation, promotes equity in safety practices, and ensures effective risk management across diverse settings. It supports decentralized operations while maintaining accountability and quality assurance at all levels.

The overarching goal of the Guideline is to protect laboratory personnel, patients, communities, and the environment while strengthening national health security. It aims to establish a comprehensive biorisk management system integrating biosafety and biosecurity, strengthen governance and accountability for laboratory safety, enhance infrastructure and engineering controls based on risk assessment, build a competent and protected workforce, ensure environmentally sound laboratory waste management, prevent loss, theft, or misuse of biological materials, and strengthen emergency preparedness, surveillance, and response capacity.

Effective governance is central to the Guideline. It recommends the establishment of Institutional Biosafety Committees (IBCs) and the designation of trained Biorisk Officers to

provide oversight, technical guidance, and coordination of biosafety and biosecurity activities. Senior leadership commitment is essential, requiring integration of biosafety and biosecurity into institutional policies, operational plans, and budgets, including allocation of resources for infrastructure, equipment maintenance, training, occupational health, and emergency preparedness. The Guideline promotes a culture of safety, transparency, and continuous improvement, moving beyond compliance to institutional ownership.

The Guideline provides detailed technical guidance on laboratory design, biosafety levels (BSL 1–4), engineering controls, and operational practices. Laboratories are classified based on risk assessment, ensuring containment measures are proportionate and cost-effective. Operational guidance covers biological safety cabinets, ventilation, autoclaves, personal protective equipment, standard operating procedures, access control, incident reporting, and routine audits. These measures reduce occupational exposure, prevent laboratory-acquired infections, and protect surrounding communities. Biosecurity is emphasized as a critical component of national and global health security. The Guideline outlines systematic approaches to asset management, threat and vulnerability assessments, access control, inventory management, secure transport, and information security. These measures reduce the risk of deliberate misuse or accidental loss of biological materials, strengthen preparedness against biological threats, and reinforce trust in Nigeria's diagnostic and research institutions.

Environmentally responsible waste management is an important focus of the Guideline. It provides a framework for segregation, treatment, transport, and disposal aligned with national regulations and international best practices, highlighting waste minimization, safe treatment technologies, and ecosystem protection. A competent and protected workforce is essential for effective laboratory systems. The Guideline prioritizes continuous training, competency assessment, mentorship, certification, and occupational health programs including medical surveillance, vaccination, and post-exposure management. These measures enhance staff retention, morale, and productivity while minimizing occupational risks and associated costs.

The Guideline incorporates robust monitoring and evaluation mechanisms, including performance indicators, audit systems, and review processes aligned with international standards such as ISO 35001 and Strengthening Laboratory Biosafety Programs (SLBP). Routine assessments support data-driven decision-making, continuous improvement, and transparent reporting to government and development partners. Successful implementation of the Guideline is expected to result in safer, more resilient laboratory systems nationwide, reduced occupational and environmental risks, improved outbreak detection and response capacity, strengthened national and global health security, and enhanced donor confidence through measurable impact and accountability.

The National Guideline for Medical Laboratory on Biosafety and Biosecurity provides a comprehensive, practical, and scalable roadmap to strengthen Nigeria's laboratory systems. It serves as an authoritative reference for laboratories, government institutions, donors, and partners, promoting safe, secure, and responsible laboratory practices. Its implementation will

contribute to public health protection, emergency preparedness, Universal Health Coverage, and sustainable development in Nigeria.

Elom Emeka

Director/Head Medical Laboratory Services Division
Federal Ministry of Health and Social Welfare

Acronyms

Abbreviations	Meaning
BRM	Biorisk Management
BSL	Biosafety level
CDC	Center for Disease Control
CHP	Chemical Hygiene Plan
EIA	Environmental Impact Assessment
GMO	Genetically Modified Organism
HAI	Hospital Acquired Infections
IBC	Institutional Biosafety Committee
IHR	International Health Regulations
ISO	International Organization for Standardization
LAI	Laboratory Acquired Infections
MLSCN	Medical Laboratory Science Council of Nigeria
NBMA	National Biosafety Management Agency
NCDC	Nigeria Centre for Disease Control and Prevention
NEMA	National Emergency Management Agency
NNRA	Nigerian Nuclear Regulatory Authority
OHS	Occupational Health and Safety
POC	Point of Care
SDS	Safety Data Sheet
SLBP	Strengthening Laboratory Biosafety Program
SOP	Standard Operating Procedure
VBM	Valuable Biological Materials
VLM	Valuable Laboratory Materials
WHO	World Health Organization
UKHSA	United Kingdom Health Security Agency

Definition of Terms

For this guideline, the following terms and definitions apply.

1. **Audit**: Systematic, independent, and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled.
2. **Biohazard**: Potential source of harm caused by biological materials.
3. **Biological agent:** Any microbiological entity, cellular or non-cellular, naturally occurring or engineered, capable of replication or of transferring genetic material that may be able to provoke infection, allergy, toxicity or other adverse effects in humans, animals, plants and the environment.
4. **Biological materials**: Any material comprised of, containing, or that may contain biological agents and/or their harmful products, such as toxins and allergens.
5. **Biorisk**: Effect of uncertainty expressed by the combination of the consequences of an event (including changes in circumstances) and the associated "likelihood" (as defined in ISO Guide 73) of occurrence, where biological material is the source of harm.
6. **Biorisk management system**: Management system or part of a management system used to establish biorisk management policies, objectives, and processes to achieve those objectives.
7. **Biorisk management**: Coordinated activities to direct and control an organization with regard to biorisk.
8. **Biosafety**: Practices and controls that reduce the risk of unintentional exposure or release of biological materials.
9. **Biosecurity**: Practices and controls that reduce the risk of loss, theft, misuse, diversion of, or intentional unauthorized release of biological materials.
10. **Competence**: Ability to apply knowledge and skills to achieve intended results.
11. **Conformity**: Fulfilment of a requirement.
12. **Continual improvement**: Recurring activity to enhance performance.
13. **Corrective action**: Action to eliminate the cause of nonconformity and to prevent recurrence.
14. **Decontamination**: Procedure that eliminates or reduces biological agents and toxins to a safe level with respect to the transmission of infection or other adverse effects modified.
15. **Documented information**: Information required to be controlled and maintained by an organization and the medium on which it is contained.
16. **Effectiveness**: Extent to which planned activities are realized and planned results achieved

17. **Environment**: Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelationships.

18. **Facility**: Operational unit and associated buildings and equipment used to manage biological materials.

19. **Harm**: Adverse effect on the health of people, animals, or plants, on the environment, or on property.

20. **Hazard**: Source or situation with a potential for causing harm.

21. **Incident**: Occurrence arising out of, or during, work that could or does result in harm.

22. **Information security**: Preservation of confidentiality, integrity, and availability of information.

23. **Inspection conformity**: Evaluation by observation and judgment accompanied as appropriate by measurement, testing, or gauging.

24. **Laboratory**: Room or clearly defined area within a facility designated for work on biological materials.

25. **Management system**: Set of interrelated or interacting elements of an organization.

26. **Measurement**: Process to determine a value.

27. **Monitoring**: Determining the status of a system, a process, or an activity

28. **Nonconformity**: Non-fulfilment of a requirement.

29. **Objective**: Result to be achieved.

30. **Organization**: person or group of people that has its own functions with responsibilities, authorities, and relationships to achieve its objectives.

31. **Outsource (verb)**: Arrange where an external organization performs part of an organization's function or process.

32. **Performance**: Measurable result.

33. **Personal protective equipment (PPE)**: material used to prevent exposure to or contamination of a person by biological materials.

34. **Physical security**: Combination of physical measures to reduce the risk of unauthorized access, to safeguard assets and people, and to protect them from a potential security incident.

35. **Policy**: Intentions and direction of an organization as formally expressed by its top management.

36. **Process**: Set of interrelated or interacting activities which transform inputs into outputs.

37. **Reliability**: Property of consistent intended behavior and results.

38. **Requirement**: Need or expectation that is stated, generally implied, or obligatory.

39. **Risk**: effect of uncertainty.

40. **Stakeholder**: Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity.

41. **Threat**: Potential cause of an incident, which may result in harm to individuals, assets, a system, an organization, or the environment.

42. **Top management**: Person or group of people who directs and controls an organization at the highest level.

43. **Toxin**: Substance, produced by plants, animals, protists, fungi, bacteria, or viruses, which in small or moderate amounts produce an adverse effect on humans, animals, or plants.

44. **Validation**: Establishment of the performance characteristics of a method and provision of objective evidence that the performance requirements for a specified intended use are fulfilled

45. Valuable Laboratory Materials- Material of value to the laboratory due to its replacement cost and its necessity for the laboratory operational purposes.

46. **Verification**: Demonstration that a validated method functions in the user's hands according to the method's specifications determined in the validation study and is fit for purpose.

47. **Worker**: Person performing work or work-related activities under the control of the organization.

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Scope

The document applies to public and private medical laboratories, medical research institutions, and other medical laboratories in the country that work with biological agents, materials, and toxins. This could be in the form of testing, storage, transport, and disposal of hazardous biological materials at primary, secondary, and tertiary institutions.

1.0 INTRODUCTION

Laboratory biosafety is the safe working practice associated with handling of biological materials, particularly infectious agents. It addresses containment principles, technologies and practices that are implemented to prevent unintentional exposure to pathogens and toxins, or their accidental release (WHO 2009). On the other hand, biosecurity is the protection, control, accountability for Valuable Biological Materials (VBM) to prevent the loss, theft, unauthorized access, misuse, diversion or intentional release of biological agents being handled in the facility (WHO 2009). Working with infectious agents require adherence to safety regulations that cover handling, storage and transportation of infectious agents and materials. There is a growing realization among policy makers that adequate training, information sharing, infrastructure development, provision of equipment and regulatory framework are crucial to achieving a safe work environment. The World Health Organization Laboratory Biosafety and Biosecurity program is designed to assist member states understand, adopt and implement biosafety and biosecurity-risk management strategies to minimize the risk of infections through safe and secure practices in laboratories, specimen transportation and environments, and accomplish these goals in a cost-effective manner. The perceptions of biosafety and biosecurity vary across different tiers of medical, research institutions, and public health laboratories in Nigeria as they deal with different biological agents. We are living in an era of uncertainty, where emerging and re-emerging infectious agents and diseases have become the order of the day, which may result in widespread epidemics or even pandemics. The handling of pathogens or their toxins cannot be done without the knowledge and application of special procedures for safety. The release of human and animal pathogens and toxins from laboratories or other containment facilities poses risks to public health, animal health, plant health, and environmental health. These risks can be minimized through the application of appropriate biosafety and biosecurity principles and practices.

This document is important for both routine and unexpected work situations in the laboratory. It is the responsibility of all laboratories that work with Valuable Biological Materials (VBM) and other Valuable Laboratory Materials (VLM) to operate safely and securely. This document will provide guidance for compliance with Government regulations in Medical Laboratory practice, in the identification of training needs and supervision, effective allocation of resources to mitigate risks in our laboratories and evaluation of emergency plans.

It is meant to identify, assess, control, and monitor the risks and threats associated with hazardous biological materials. Emphasis is placed on the importance of a “safety culture” that incorporates risk assessment, good microbiological practice and procedure (GMPP) and Standard Operating Procedures (SOPs), training and mentoring of personnel, and prompt reporting of incidents and accidents followed by investigative and corrective actions. It is intended to complement existing International Standards and guidelines for biological risk management.

1.2 Biorisk Management Policy

This policy promotes and sustains safe laboratory practices to protect personnel, clients, visitors, and the environment. and should be made available as documented information, communicated within the organization, appropriate to the nature and scale of the risks associated with the facility and its activities.

The policy should commit the organization to protect personnel, clients, visitors, and the environment from exposure to and/or contamination by the biological materials that are stored or handled at the facility. It should assess and prioritize the risks associated with specific activities that involve biological materials, reduce the risks of unintentional or deliberate release, theft, loss, or exposure to biological materials through the implementation of specific control measures. The policy should design and implement processes to continually evaluate and improve the effectiveness of the biosafety management system, ensure that the need for effective biosafety management should take precedence over all non "health and safety" operational requirements; effectively informing all employees and relevant third parties, and communicating individual obligations about biosafety management to those groups.

1.3.1 Policy Trust

a The safety of the laboratory personnel shall be the collective responsibility of the employer and employee

b Occupational health and safety services shall be available for all health personnel

c Laboratory safety committees shall be established at each level of health care delivery.

d Institutional safety committees shall be established and shall have adequate laboratory representation.

e Laboratory safety code of practice shall be implemented at each level of health care delivery.

f There shall be access control to laboratories by non-laboratory personnel.

g Disposal of laboratory waste shall be in accordance with National healthcare waste management policy.

h Appropriate International health regulations should be implemented as applicable.

i All laboratories shall have documented procedures to protect personnel, clients, documents, and the environment

j Knowledge and skills of designated Biosafety Officers shall be strengthened by regular training to enable appropriate response to incidents.

1.1 Management Responsibility

Management support is required to ensure the success of a biosafety and biosecurity management system in the organization. Management should provide the directions, empowerment, and resources needed for the establishment, implementation, maintenance, and continual improvement of the biosafety and biosecurity systems. Effective implementations of this guideline require proper coordination across all tiers. At each tier, an Institutional Biosafety Committee (IBC) should be established to drive the implementation of the guideline. Additionally, the committee should be involved in planning, advocacy, resource mobilization, coordination of training, capacity building and provision of oversight in the implementation and support of biorisk assessment. Within the context of biorisk management, biosafety and

biosecurity are complementary disciplines; it is important to align the mitigation of safety and security risks. This alignment can be enhanced through unity of oversight.

1.2 Top Management

Top management should take ultimate responsibility for the organization's biorisk management system. Its ultimate responsibility should not be delegated but may delegate authority. The management should establish a biosafety and biosecurity program and enforce its implementation. It should define the consequences of failure or non-conformance in the requirements and guidelines.

Management should demonstrate leadership and commitment with respect to the biorisk management system by ensuring the following:

a The biorisk policy is developed with clearly defined objectives to implement and measure the performance of biorisk management systems in the organization

b The integration of the biorisk management system requirements into the organization's business processes

c Demonstrate its commitment by ensuring the availability of resources (human resources with specialized skills, infrastructure, equipment, technology, safety commodities and finance) to establish, implement, maintain, and improve the biorisk management system.

d Communicate the importance of effective biorisk management implementation and the conformance to the biorisk management system requirements.

e Promotion of continual improvement and support other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility.

f Ensure the development and adoption of a biorisk manual and operational plan.

g Ensure that regular training in laboratory biosafety and biosecurity is provided.

h Provide an arthropod and rodent control program.

i Appropriate medical evaluation, vaccination, surveillance and treatment should be provided for all personnel in case of need, and adequate medical records should be maintained.

j Determine the staffing and funding requirement for bio risk management based on the outcome of a robust risk assessment

k Ensure the biosafety and biosecurity activities are captured in the annual operational plan and budget.

l Ensure that the responsibilities and authorities for relevant roles are assigned and communicated within the organization, including those who manage, perform, and verify work associated with the control of biological materials.

1.4 Senior management

Senior management should be designated with operational responsibility for overseeing the biorisk management system and ensure the implementation of the operational function of the system.

These functions include:

a Liaise with top management to ensure the provision of appropriate and adequate number of trained and qualified personnel, facilities, and other resources required for the safe and secure operation of the facility

b Reporting to top management on the performance and promotion of the biorisk management system throughout the organization

c Institute review, audit, and reporting measures to provide assurance that the requirements of this document are being implemented and maintained effectively.

d Ensure communication of safety manual and other safety documents to all staff who shall adhere to prescribed safety practices with documented evidence.

1.5 Biorisk Administrative Programs

Biosafety and biosecurity are important areas of focus for organizations working with biological materials, including laboratories, healthcare facilities, and research institutions. Implementing Biosafety and biosecurity programs can help to prevent accidents, theft, intentional and unintentional release of pathogens to protect workers, the public and environment, and ensure compliance with regulations and best practices. It can also prevent unnecessary waste of resources, litigation and compensation that may arise in cases of breaches and occupational accidents.

There is need to integrate an increasingly adaptive risk management approach and support laboratory accreditation program.

1.6 Institutional Biosafety Committee (IBC)

An Institutional Biosafety Committee (IBC) should be established to support the biorisk management system. Where applicable, based on the nature of the organization and its activities, the committee should consist of members who are independent of activities being reviewed for biorisk issues.

- The committee should establish a mechanism by which committee members should exempt themselves from participation in decision-making procedures (e.g. vote) on issues where real or perceived conflicts of interest exist. The committee should have documented terms of reference and report to senior management. Issues addressed should be formally documented, including the assignment, tracking, and completion of all actions. The IBC should meet at a defined and appropriate frequency (at least twice a year), and when otherwise required

Membership of this committee should include but not limited to:

i. Member of senior management
ii. Institutional biosafety officer(s)
iii. Technical experts (clinicians, scientists, etc.)
iv. Security officers
v. Facility manager/engineer
vi. Other members appropriate to the nature and scale of the activities undertaken

1.7 Biorisk Officer

An individual responsible for all or part of the biorisk program at the facility should be designated with specific responsibilities which include but not limited to:

a Work with the institutional biorisk committee (IBC) to implement safety programs and serve as a resource person to the organization.

b Ensure written biorisk manuals, policies, SOPs are in place

c Conduct risk assessment(s) to identify and mitigate hazards and exposures in the facility.

d Liaise with the IBC to review biorisk related documents (Biorisk Manual, SOPs, templates and forms) and ensure copies are available at designated locations.

e Ensure that biorisk assessments are performed, reports reviewed, and recommendations implemented.

f Communicate biorisk assessment reports to all personnel and ensure compliance with mitigation measures and recommended interventions.

g monitor and evaluate the effectiveness of the intervention measures and to change the intervention as appropriate to improve biorisk management performance.

h Develop an annual safety audit plan.

1.8 Laboratory Biorisk Program Review

The Laboratory biorisk program should be reviewed at least once a year, to identify safety gaps, and standardize biosafety practices and procedures.

1.9 Laboratory Biorisk audit program

Establishing a formal audit process to review and evaluate compliance and effectiveness of organization's biorisk programs will guide identification and mitigation of gaps. The audit will help biosafety officers to promptly follow up on deficiencies, agree on target date on corrective action, and verify the implementation of the corrective measures.

The laboratory should have a biorisk audit program which should include objectives, scope, criteria and plan/schedule.

The audit schedule related to biorisk programs should include:

a Regular audits of the entire biorisk program elements

b Audits should be conducted using appropriate checklist at least once a year

c Audit findings should be documented, reviewed and utilized to improve the biorisk program.

2.0 BIOSAFETY LEVELS (1-4)

Biosafety level designations are based on a composite of the laboratory design features, construction, containment facilities, equipment, practices and operational procedures required for working with agents from the various risk groups. Laboratory facilities are designated as basic – Biosafety Level 1, Biosafety Level 2, Containment – Biosafety Level 3, and Maximum Containment – Biosafety Level 4.

The assignment of a laboratory to a biosafety level must be based on a risk assessment. Such an assessment will take the risk group as well as other factors into consideration in establishing the appropriate biosafety level. An agent that is assigned to Risk Group 2 should generally require Biosafety Level 2 facilities, equipment, practices and procedures for safe conduct of work. However, if experiments require the generation of high-concentration infectious aerosols, then Biosafety Level 3 may be more appropriate to provide the necessary degree of safety, since it ensures superior containment of infectious aerosols in the laboratory workplace. The biosafety level assigned for the specific work to be done is therefore driven by professional judgement based on a risk assessment, rather than by automatic assignment of a laboratory biosafety level according to the particular risk group designation of the pathogenic agent to be used.

2.1.BSL-1 Laboratory

Biosafety Level 1 (BSL-1) represents the basic level of containment suitable for handling agents not known to cause disease and present minimal hazard to the lab personnel and the environment; work relies entirely on standard microbiological practices appropriate for general instructional laboratories. Agents not known to cause disease and present minimal hazard to the lab personnel and the environment

2.2. BSL-2 Laboratories

BSL-2 is designed for moderate-risk agents causing human disease of varying severity, commonly found in most clinical diagnostic laboratories; it builds on BSL-1 by introducing primary barriers like lab coats and gloves and recommending enhanced containment for certain procedures using Biological Safety Cabinets (BSCs).

2.3. BSL-3 Laboratories

BSL-3 is an enhanced containment level for agents that pose a potential for aerosol transmission and can cause serious, potentially fatal infections (e.g., *Mycobacterium tuberculosis*); this level mandates strictly controlled access, sustained negative laboratory pressure with unidirectional airflow, HEPA filtration of exhausted air, and mandatory respiratory protection.

2.4. BSL-4 Laboratories

BSL-4 is the maximum containment level for exotic, high-consequence agents that pose a high risk of aerosol transmission and life-threatening diseases with no available treatment or vaccines (e.g., Ebola); facilities are physically isolated with highly specialized ventilation and waste management, requiring personnel to work within Class III BSCs or wear full-body, air-supplied positive-pressure suits.

2.5. BSL2 and BSL 3 Laboratory design and facilities

In addition to the core requirements for laboratory design, the special requirements for BSL 2 and BSL 3 laboratory design are as follows:

i. The laboratory work area should be separated from the areas that are open to unrestricted traffic flow within the building. Additional separation should be achieved by placing the laboratory at the blind end of a corridor or constructing a partition and door.

ii. For BSL3, laboratory should have an anteroom (e.g. a double-door entry) and make adequate provision to maintain the pressure differential within the laboratory. The anteroom should have facilities for separating clean and dirty clothing and an emergency shower.

iii. Anteroom doors of BSL3 laboratory should be self-closing and interlocking so that only one door is open at a time. A break-through panel may be provided for emergency exit use.

iv. Surfaces of walls, floors and ceilings should be water-resistant and easy to clean. Openings through these surfaces (e.g. for service pipes) should be sealed to facilitate decontamination of the room(s).

v. The laboratory room should be sealable for decontamination. Air-ducting systems must be constructed to permit gaseous decontamination.

vi. Windows should be closed, sealed and break resistant.

vii. A hand-washing station with hand-free controls should be provided near each exit door.

viii. There must be a controlled ventilation system that maintains directional airflow into the laboratory room.

ix. A visual monitoring device with or without alarm(s) should be installed so that staff can always ensure that proper directional airflow into the laboratory room is maintained.

x. The building ventilation system should be so constructed that air from the containment laboratory – Biosafety Level 3 is not recirculated to other areas within the building. Air may be high-efficiency particulate air (HEPA) filtered, reconditioned and recirculated within that laboratory. When exhaust air from the laboratory (other than from biological safety cabinets) is discharged to the outside of the building, it must be dispersed away from occupied buildings and air intakes. Depending on the agents in use, this air may be discharged through HEPA filters. A heating, ventilation and air-conditioning (HVAC) control system may be installed to prevent sustained positive pressurization of the laboratory. Consideration should be given to the installation of audible or clearly visible alarms to notify personnel of HVAC system failure.

xi. All HEPA filters must be installed in a manner that permits gaseous decontamination and testing.

xii. Biological safety cabinets should be sited away from walking areas and out of crosscurrents from doors and ventilation systems.

xiii. The exhaust air from Class II biological safety cabinets which will have been passed through HEPA filters, must be discharged in such a way as to avoid interference with the air balance of the cabinet or the building exhaust system.

xiv. Autoclave facilities for the decontamination of contaminated waste material should be available in the containment laboratory.

xv. Backflow-precaution devices should be fitted to the water supply system. Vacuum lines should be protected with liquid disinfectant traps or their equivalent. Alternative vacuum pumps should also be properly protected with traps and filters.

xvi. The containment laboratory– Biosafety Level 3 facility design and operational procedures should be documented.

2.6. BSL 4 Laboratory design and facilities

The microbes handled in BSL4 laboratories are dangerous and exotic, posing a high risk of aerosol-transmitted infections. Infections caused by theses microbes are frequently fatal and without treatment or vaccines. BSL-4 laboratories must have primary barriers such as Biological Safety cabinet, fume hood, glove box, animal housing, centrifuge, fermenter etc.

In addition to the BSL 3 requirements, Biosafety Level 4 should have the following: ***Primary containment***. An efficient primary containment system should be in place, consisting of one or a combination of the following.

Class III biosafety cabinet provides the primary containment. Passage through an anteroom with a minimum of two doors prior to entering the rooms containing the Class III biological safety cabinet(s) (cabinet room) should be provided. A personnel shower with inner and outer changing rooms is a requirement. The anteroom should have provision for passing supplies and materials into the BSC III room.

The doors of the autoclave or fumigation chamber should be interlocked in such a way that the outer door cannot open once decontamination is ongoing.

Suit laboratory. The rooms in the protective suit laboratory should be designed to direct personnel through the changing and decontamination areas prior to entering areas where infectious materials are manipulated. A suit decontamination shower should be provided and used by personnel leaving the containment laboratory area. A separate personnel shower with inner and outer changing rooms should also be provided. Air to the suite should be provided by a system that has a 100% redundant capability with an independent source of air for use in the event of an emergency. Entry into the suit laboratory should be through an air lock fitted with airtight doors. An appropriate warning system for personnel working in the suit laboratory should be provided for use in the event of mechanical system or air failure.

1. ***Controlled access***. The maximum containment laboratory – Biosafety Level 4 should be in a separate building or in a clearly delineated zone within a secure building. Entry and exit of personnel and supplies should be through an airlock or pass-through system.

2. ***Controlled air system***. Negative pressure should be maintained in the facility. Both supply and exhaust air should be HEPA-filtered. The appropriate ventilating systems for the Class III cabinet laboratory and suit laboratory are as follows:

3. ***Class III cabinet laboratory***. The air supply to the Class III biological safety cabinet(s) should be drawn from within the room through a HEPA filter mounted on the cabinet or supplied directly through the supply air system as applicable. Exhaust air from the Class III biological safety cabinet should pass through two HEPA filters prior to being released outdoors. A dedicated non-recirculating ventilating system for the cabinet laboratory should be provided.

4. ***Suit laboratory.*** Dedicated air supply and exhaust systems are required. The supply and exhaust components of the ventilating system should be balanced to provide unidirectional airflow within the suit area from the area of least hazard to the area(s) of greatest potential hazard. Redundant exhaust fans should be provided to ensure that the facility always remains under negative pressure. Devices should be provided to monitor the differential pressures within the suit laboratory and between the suit laboratory and adjacent areas, as well as airflow in the supply and exhaust components of the ventilating system. HEPA-filtered air supply should be provided to the suit area, decontamination shower and decontamination airlocks or chambers. Exhaust air from the suit laboratory should be passed through a series of two HEPA filters prior to release outdoors. Alternatively, after double HEPA filtration, exhaust air may be recirculated, but only within the suit laboratory. Under no circumstances should the exhaust air from the Biosafety Level 4 suit laboratory be recirculated to other areas. The HEPA filter housing should be designed to allow for in situ decontamination of the filter prior to removal.

5. ***Decontamination of effluents***. Facilities should be provided where all effluents from the suit area, decontamination chamber, decontamination shower, or Class III biological safety cabinet should be decontaminated before final discharge.

6. ***Sterilization of waste and materials***. Space should be provided for a double-door, pass-through autoclave in the laboratory area as well as other methods of decontamination for equipment and items that cannot withstand steam sterilization.

7. ***Airlock entry ports*** for specimens, materials and animals should be provided.

8. ***A dedicated power supply and an alternative power source*** should be provided to ensure uninterrupted supply

9. ***Containment drain(s)*** must be installed.

2.7. Code of practice

The laboratory shall adopt a safety or operations manual that identifies known and potential hazards, and specify practices and procedures to eliminate or minimize exposure to such hazards. Some important concepts are:

2.7.1 Access control

i. The international biohazard warning symbol and sign shall be displayed on the doors of the rooms where microorganisms of Risk Group 2 or higher risk groups are handled.

ii. Only authorized persons should be allowed to enter the laboratory working areas.

iii. Laboratory doors should be kept closed.

iv. Access to animal houses should be specially authorized.

v. No animal should be admitted other than those involved in the work of the laboratory.

2.7.2 Laboratory working areas

i. The laboratory should be kept neat, clean and free of materials that are not pertinent to the work.

ii. Work surfaces shall be decontaminated before and at the end of working day

iii. Manage spills in line with the SOP on spill management.

iv. All contaminated materials, specimens and cultures shall be decontaminated before disposal.

v. Packaging and transportation of biological materials shall follow applicable national and/or international regulations.

vi. When windows can be opened, they shall be fitted with arthropod-proof screens.

vii. Regular fumigation of laboratory and its environment shall be done at least twice a year

3.0 LABORATORY SAFETY EQUIPMENT

Laboratory equipment, when used effectively together with good procedures and practices will help minimize the likelihood of exposure of personnel to hazards when handling or manipulating biological agents. Appropriate budget must be available for equipment's operation and maintenance. Equipment should be incorporated into the facility design and accompanied by specifications that outline its safety features. Training to demonstrate proficiency of all personnel in operating or maintaining a piece of equipment must be properly performed. Adequate records / inventory must be kept detailing equipment use, maintenance performed, functionality status, validation/calibration procedures undertaken, and their results.

The following records should be kept:

- Equipment inventories (to include details on age, condition, functioning, location, serial number, model number etc.)
- Equipment purchases requests and contact information of people authorized to purchase, install, calibrate, validate, certify, operate and maintain equipment.
- Scheduled maintenance or incidents.
- Training and proficiency of personnel authorized for equipment use

Equipment management should follow a process of selection, procurement, installation / placement, calibration and verification, training of personnel, maintenance, storage, archiving and disposal (when obsolete). Selected equipment should be installed so that it facilitates operation and allows for cleaning, decontamination, maintenance and certification to be performed.

A detailed equipment management system should be implemented. This includes but is not limited to:

- All manufacturers' equipment instruction manuals shall be made available in the laboratories.
- Routine preventive maintenance and corrective actions.
- Performance verification must be done at regular intervals, in between scheduled preventive maintenance and servicing, and other applicable instances to ensure the equipment is functioning as expected.
- Maintenance of all equipment records.

Manipulation of all potentially infectious material must be conducted within a biological safety cabinet or other primary containment device in Biosafety level 2 (BSL2) and Biosafety level 3 (BSL3) laboratories. Consideration should be given to equipment such as centrifuges, which will need additional containment accessories, for example, safety buckets or containment rotors. Some centrifuges and other equipment, such as cell-sorting instruments for use with infected cells, may need additional local exhaust ventilation with High Efficiency Particulate Air (HEPA) filtration for efficient containment.

3.1 Essential Biosafety Equipment

i. **Pipettes:** The use of mouth pipetting is prohibited. Automatic pipettes or pipettes with blowers are permitted for use. To prevent the aerosols generation, pipettes should not be used to blow air or forcibly expel liquids/solutions that contain biological agents. All personnel should be adequately trained in the accurate use of pipettes to reduce risks of contamination caused by aerosolization and splashing. Any pipetting activity that will generate aerosols should be carried out in a biosafety class II minimum.

ii. Biological safety cabinets (BSC): BSCs are to be used whenever high risk airborne infectious materials are handled. These may include centrifugation, grinding, blending, vigorous shaking or mixing, sonic disruption, opening of containers of infectious materials whose internal pressure may be different from the ambient pressure, intranasal inoculation of animals, and harvesting of infectious tissues from animals and eggs. Such materials may be centrifuged in the open laboratory if sealed centrifuge with safety cups are used and if they are loaded and unloaded in a biological safety cabinet. All BSCs should be operated and routinely maintained according to manufacturers' instructions and serviced and certified by appropriately qualified personnel.

iii. **Centrifuges**: All centrifuges should be operated and serviced according to manufacturers' instructions and serviced by appropriately qualified and certified personnel. Centrifuges should be cleaned and disinfected regularly, or immediately decontaminated after a spill, with an appropriate disinfectant. When centrifuging high risk infectious materials, safety cups should be used. Where centrifuges with safety cups are not available, centrifuge lids should be opened in the BSC after centrifugation. Where safety buckets are available for a centrifuge, these should be used. Sealing rings for buckets should be checked regularly for integrity and replaced if cracks appear.

iv. Refrigerators and freezers: Refrigerators and freezers should be spark-proof and certified if they are to store flammable solutions with appropriate signages placed on the outside of the doors. Appropriate Personal Protective Equipment should be worn when handling specimens from cryogenic storage, for example, thermal protective apron and gloves, as well as face and eye protection when placing specimens in or removing them from liquid nitrogen. All containers stored inside refrigerators and freezers should be clearly labelled so that they can be easily identified. An inventory of their contents must be maintained and controlled periodically. Unlabeled materials must be assumed as infectious, should be decontaminated, and discarded using appropriate waste channels.

v. **Personal protective equipment (PPE)**; refers to a set of wearable equipment and/or clothing worn (for example, gloves) by personnel to provide an additional barrier between them and the biological agents being handled, which effectively controls risk by reducing the likelihood of exposure to the agents. Any PPE used in the laboratory must be correctly fitted, and personnel must be given adequate training to ensure it is used properly and effectively. Incorrect use of PPE, for example, unfastened laboratory coats, will not give the protection they are designed to provide. When combinations of PPE are worn together, they must complement one another and continue to fit properly. It is important to note that

there is not one size, type and/or brand that is appropriate for all personnel. Laboratory personnel should be consulted and a selection of items tested in order to procure the most effective items. Compliance with wearing PPE will generally be improved when users have input on comfort and fit.

vi. **Laboratory coats/Gowns;** Laboratory coats/gowns should be used in laboratories to prevent personal clothing from getting splashed or contaminated by biological agents. Laboratory coats/gowns should have long sleeves, preferably with fitted cuffs, and should be worn closed. Sleeves should never be rolled up. Coats should be long enough to cover the knees but not trail on the floor. Where possible, the fabric of the laboratory coat should be splash-resistant and overlap at the front. Laboratory coats/gowns can be reusable or disposable. Where reusable, laundering of the coats/gowns should be done by the laboratory or specialist contractor. Laundering should be done regularly, and consideration should be given to autoclaving any visibly contaminated coats before laundering. Laboratory coats/gowns should only be worn in designated areas. When not in use, they should be stored appropriately; they should not be hung on top of other laboratory coats/gowns, or in lockers or hooks with personal items. Laboratory coats/gowns should not be taken home by personnel.

vii. **Footwear**: Footwear should be worn in the laboratory and should be of a design that minimizes slips and trips and can reduce the likelihood of injury from falling objects and exposure to biological agents. Footwear should cover the top of the foot and should be well-fitting and comfortable to allow personnel to perform their tasks without fatigue or distraction.

viii. **Gloves:** Appropriate disposable gloves should be worn for all procedures that may involve planned or inadvertent contact with blood, body fluids and other potentially infectious materials. They should not be disinfected or reused as exposure to disinfectants and prolonged wear will reduce the integrity of the glove and decrease protection to the user. Gloves should always be inspected before use to check they are intact. Different types of gloves may be needed for different applications or other occupational hazards, such as thermal protection (Industrial gloves), or protection from sharps or against chemicals (Industrial gloves). Various sizes should be available to ensure that gloves properly fit the user to allow adequate movement and dexterity for the procedures being performed. Nitrile, vinyl and latex gloves should often be used for protection against biological agents. It should be noted that latex protein could cause allergies over time; low protein and powder-free options are available to minimize the occurrence of an allergy.

ix. **Eye protection**: Safety glasses, safety goggles, face shields (visors) or other protective devices should be worn whenever it is necessary to protect the eyes and face from splashes, impacting objects and artificial ultraviolet radiation. Eye protection should be cleaned after every use. If splashed, it should be decontaminated with an appropriate disinfectant. Personal prescription glasses (spectacles) should not be used as a form of eye protection as they do not cover enough of the face around the eyes, particularly around the side of the head. Specialized prescription safety glasses should be purchased for personnel with such

needs. Some goggles are available that have recesses that enable the user to wear glasses underneath them.

x. **Respiratory protection**: Respiratory protection is generally not required for protection against biological agents as a part of the core requirements. Where a risk assessment indicates that the use of respiratory protection is needed, this is considered a heightened control measure. However, there may be circumstances where respiratory protection is required for other reasons based on assessments of non-biological hazards such as chemicals or allergens

4.0 BUILDING AND FACILITY SAFETY

The facility design requirements for laboratories should be based on the scope of the activities, services and the risk assessment of the services to be provided by the laboratory. Facility design must follow a process which begins with a site assessment. Site assessment should be conducted on a location using standard checklist to ascertain the space available, biosafety and biosecurity implications of location. In addition to this, Environmental Impact Assessment (EIA) should be conducted to guide facility design required to meet laboratory best practices and biosafety requirements. Each state/FCT should consult and comply with their respective environmental protection board or agency regulations.

In designing a laboratory and assigning certain types of work to be performed, special attention should be paid to conditions that are known to pose safety problems.

These include:

i. Formation of aerosols

ii. Work with large volumes and/or high concentrations of microorganisms.

iii. Overcrowding and too much equipment

iv. Infestation with rodents and arthropods

v. Unauthorized entrance

vi. Use of specific samples and reagents.

vii. Radiation

viii. Waste management

5.0 GENERAL FACILITY DESIGN REQUIREMENTS

The facility design features listed below are core requirements for biosafety and biosecurity, and for all laboratories handling biological agents and toxins.

i. Sufficient space must be provided for the safe conduct of laboratory work and for cleaning and maintenance.

ii. Designated hand-washing basins operated by a hand-free mechanism must be provided in each laboratory room, preferably close to the exit door.

iii. The laboratory should be a restricted-access area. Laboratory work area entrance doors should have vision panels (to avoid accidents during opening), appropriate fire ratings and preferably be self-closing.

iv. Doors should be appropriately labelled with the international biohazard warning symbols wherever biohazardous materials are handled and stored.

v. Laboratory walls, floors and furniture should be smooth, easy to clean, impermeable to liquids and resistant to the chemicals and disinfectants normally used in the laboratory.

vi. Laboratory bench tops should be impervious to water and resistant to disinfectants, acids, alkalis, organic solvents and moderate heat.

vii. Fans are prohibited in the medical laboratory because they circulate aerosols.

viii. Laboratory furniture should be fit for purposes (Ergonomics). Open spaces between and under benches, cabinets and equipment must be accessible for cleaning.

ix. Laboratory lighting (illumination) must be adequate for all activities. Undesirable reflections and glare should be minimized where applicable. Emergency lighting must be sufficient to permit safe stopping of work as well as safe exit from the laboratory.

x. Laboratory ventilation (including heating/cooling systems, local cooling split-system air conditioning units – specifically when retrofitted) should ensure airflows do not compromise safe working. Consideration must be given to resultant airflow speeds and directions, and turbulent airflows should be avoided; this applies also to natural ventilation.

xi. Laboratory storage space must be adequate to hold supplies for immediate use to prevent cluttering on bench tops and in aisles. Additional long-term storage space, conveniently located outside of the laboratory room/space, should be considered.

xii. Space and facilities should be provided for the safe handling and storage of chemicals and solvents, radioactive materials, compressed and liquefied gases if used.

xiii. Facilities for eating, drinking and storage of food and drink, personal items, jackets and outerwear should be provided outside the laboratory work area.

xiv. First-aid facilities should be readily accessible and adequately equipped/stocked.

xv. The management of waste should be considered in design. Appropriate methods for decontamination of waste, for example, disinfectants and autoclaves, should be available in proximity to the laboratory.

xvi. Safety systems should cover all the emergencies based on risk assessment, fire, electrical, chemical and radiological emergencies.

xvii. There should be a reliable and adequate power supply with backup to permit safe shutdown of devices.

xviii. Emergency situations should be considered in the design as indicated in the local risk assessment and should include the geographical/meteorological context.

xix. The power rating of all equipment and electrical installations to be used in the laboratory should be incorporated into the facility design.

6.0 WASTE MANAGEMENT AND ENVIRONMENTAL SAFETY PROGRAM

Waste is anything that is not in use and to be discarded. Laboratory waste and contaminated materials present hazards to laboratory staff, clients, and the environment if not well managed.

Each laboratory should have a waste management program that involves generation, segregation, collection/packaging, storage, treatment, transportation, and disposal of wastes. The program shall outline the appropriate management of hazardous and non-hazardous waste from health facilities and especially laboratories.

Laboratory generated waste includes but not limited to:

i. General/non-infectious waste
ii. Sharps
iii. Chemical waste
iv. Pathological/anatomical waste.
v. Blood and body fluids
vi. Radioactive waste
vii. Animal waste
viii. Pharmaceutical waste

Waste management program shall include training that covers but not limited to the following:

i. Overview of the waste management program.
ii. Assigned roles and responsibilities for implementation of the program.
iii. Modes of transmission and prevention of pathogens.
iv. Location and proper use of personal protective equipment.
v. Proper waste segregation with appropriate color coding, the biohazards symbol, and precautions to follow in handling regulated waste and handling of sharps.
vi. Post exposure management.
vii. Hierarchy of control principle

Waste disposal should be in accordance with existing national and state regulatory framework.

6.1 Waste Minimization

To minimize the amount of hazardous waste presented for disposal, it is important to follow the underlisted principles:

i. Avoid overstocking supplies, either by purchase or donations
ii. Substitute hazardous experimental materials for non-hazardous ones in line with hierarchy of control principle.

iii. Dispose waste in line with the facility's SOP.

iv. Proper commodity management practices should be implemented.

6.2 Waste Management Process

Waste management process should include the following:

i. Segregation

ii. Collection

iii. Packaging

iv. Treatment

v. Storage

vi. Transport

vii. Disposal

6.2.1 Waste Segregation

Waste segregation is the separation of different types of wastes based on risks levels. It is the initial and crucial point in waste handling process that will help determine the amount and type of waste for treatment and disposal. Designate waste at the point of origin and separate hazardous waste from non-hazardous waste. Separate sharp and broken contaminated glass and put in rigid, puncture resistant containers. Lock/seal sharps containers when ¾ full. Health care waste should be segregated by placing it in color-coded bags supported in bins of matching colors to minimize damage and retain spillage.

6.2.2 Waste Collection

Appropriate waste collection materials should be provided at all points of waste generation to eliminate the possibility of interaction with humans, animals or the environment, hence minimizing exposure.

During waste collection, ensure that:

a. Waste does not accumulate at the production and storage points.

b. Waste bags should be tightly closed or sealed when they are about three-quarters full before transportation and should *not* be closed by stapling.

c. Sharps containers are puncture resistant, closable, leak proof and should be sealed and disposed when about three-quarters full

d. Designate a central holding site/ waste transfer stations.

e. Specific routes should be planned to prevent exposure of staff and patients to potential risks and to minimize the passage of waste through patient care and other clean areas.

f. No bags should be removed unless they are labeled with their point of production and contents.

g. A supply of fresh collection bags or containers should be readily available at all locations where waste is produced.

h. The Laboratory management should ensure that adequate supplies are available, and that procurement is timely to ensure the facility does not run out of the bags.

i. Waste transportation trolleys for infectious waste and sharps should be marked with the international bio-hazard sign and only be used for infectious waste and sharps.

j. The logistics staff should be specially trained in the transportation of hazardous substances.

k. Procedures for the handling of accidents and spillages should be readily available

l. Biological, chemical and radiological spill kits should be available.

6.2.3 Packaging

Packaging of waste can be described as containment of waste and is used to ensure the safety and protection of personnel and the environment.

This can be achieved by:

a. Ensuring all hazardous waste is sealed properly with tape.

b. Placing bags in upright position to prevent spillage of liquid.

c. Storing hazardous waste including sharps in appropriate waste receptacles that are impervious to moisture, puncture resistant, and display the distinctive biohazard signage.

d. Using durable reusable waste bins for storage of hazardous waste and ensure waste bins are cleaned and decontaminated with approved disinfectant each time they are emptied.

e. Using packaging that maintains its integrity during storage and transport.

6.2.4 Treatment and Decontamination of Infectious Waste

Infectious waste should be decontaminated and treated by applicable methods described below to render it noninfectious before disposal.

i. Autoclaving

- Autoclaves must be operated at a minimum temperature of 121°C for a minimum of 20 minutes. Holding period should be increased to 30 minutes when autoclaving blood.
- Each package of waste in a load should have autoclave tape and chemical indicator to indicate the attainment of adequate temperature and pressure conditions.
- All autoclaves must be evaluated monthly under full-load conditions for effectiveness against biological indicators that is quality controlled. Those that fail to achieve satisfactory results should be removed for repair or replacement.
- The autoclave should be certified at least annually and evidence kept.

- Treatment by autoclaving should be done on cultures, blood, and blood products before disposal.

ii. Chemical Treatment of Cultures

- Sodium and potassium hypochlorite of 10 percent v/v concentration should be used as approved chemicals solution for treating surface colonies and colonies in suspensions.
- All cultures should be submerged for a minimum of 20 minutes to ensure that waste is rendered noninfectious.
- Cultures can be incinerated after treatment.

6.2.5 **Storage of Hazardous/treated Waste**

When hazardous/treated waste is not to be disposed immediately, then it needs to be stored in a holding area.

This place should at the minimum have the following:

a. Designated location with limited access.

b. Floors impervious to liquid and room with good ventilation to control odors.

c. Clean barricaded area to keep vermin and other vectors away.

d. Universal biohazard signage.

Storage of hazardous waste should be at a minimum amount of time and should be specified in the institution waste management plan.

6.2.6 Transportation of Hazardous Waste

Hazardous waste must be transported from the laboratory to the disposal location in appropriately labelled container. The universal biohazard symbol should be displayed prominently on transporting containers. Keep personnel protective equipment and disinfectant available in case of spillage.

Records should be kept when hazardous waste is transported and should contain at the minimum the following:

a. Name of generating site

b. Name of individual transporting waste

c. Phone number and contact person at generating site.

d. Weight/volume of the generated waste (Kg /litres)

e. Number of bags and/or boxes or containers transported.

f. Time of departure from generating site and time of arrival at disposal site.

6.2.7 Waste Disposal

Waste(s) should be disposed of through a final process of incineration after treatment.

Incineration is the controlled burning of solid, liquid, or gaseous combustible wastes to unrecognized form. Incineration is one of the recommended methods for disposing of hazardous waste because it provides high temperatures and destroys microorganisms. It also reduces the volume of waste to be buried, and Simple incinerators can be built from locally available materials e.g. bricks, concrete blocks, or used fuel or oil drums. In general, such an incinerator is useful only for small health care facilities that do not have large quantities of infectious waste. If the health care facility is large, it is more efficient to build or install an incinerator large enough to accommodate all the facility's waste-disposal needs. The facility should have a schedule for incineration to avoid accumulation of waste at the incinerator.

For efficient burning:

i. Ensure the incinerator is not overloaded

ii. Both the chambers are functioning

iii. The venturi is in place, and the temperature gauge is functioning.

iv. Ensure the incinerator is quality controlled and serviced annually.

v. Accumulated ash shall be removed from the incinerator and deposited in a land fill.

The following waste should not be incinerated:

i. Pressurized gas containers (aerosol cans)

ii. Large amounts of reactive chemical waste

iii. Silver salts and photographic or radiographic waste

iv. Plastic containing polyvinyl chloride

v. Waste containing high mercury or cadmium content, for example, broken thermometers, used batteries, and lead-line wooden panels

6.2.8 General Tips for Waste Disposal

i. Do not push or pack hazardous waste with feet or hands.

ii. Use clearly marked containers for each type of waste to ensure optimal segregation

iii. Containers should be in the immediate area of use

iv. Use heavy-duty utility gloves and appropriate PPE when handling waste.

v. Decontaminate and clean heavy-duty utility gloves between uses.

vi. Handle wastes carefully to avoid spills or splashes.

vii. Always wash your hands after removing gloves and handling contaminated waste.

viii. Avoid transferring contaminated waste from one container to another.

ix. Dispose of used toxic chemicals or medicine containers according to approved SOPs

x. Rinse glass containers thoroughly water. Glass containers may be washed with detergent, rinsed, dried, and reused.

xi. For plastic containers that contain toxic substances, such as glutaraldehyde, rinse three times with water and dispose of by incineration, burial, or both. These containers may be used for sharp disposal containers, but do not reuse them for any other purpose.

xii. Equipment that is used to hold and transport waste must not be used for any other purpose in the laboratory or health care facility.

xiii. Contaminated waste containers should be cleaned each time they are emptied and non-contaminated ones whenever they are visibly soiled. Contaminated waste containers should be labeled clearly.

NOTE: If incineration is not possible, then careful burial following approved SOPs, is the next best alternative

6.2.9 Contingency and Emergency Plan for waste management

If spills or damage of container are encountered during storage, handling or transporting hazardous waste the following should be done:

i. Put on gloves, goggles and protective outer garments.

ii. Use copious amount of disinfectant to clean up spills.

iii. Place waste in new biohazard bags or containers and seal properly.

iv. Contact safety officer and write and submit an incident report in the safety folder.

v. When transporting hazardous waste, gloves, disinfectant and adsorbent material shall be carried to address any emergency spills

vi. Disposal of all solid and liquid waste should comply with approved national and state regulations.

7.0 BIOSECURITY

Biosecurity refers to protection, control and accountability for valuable biological materials to prevent the loss, theft, unauthorized access, misuse, diversion or intentional release of biological agents being handled in the facility. Effective biosafety practices are recommended and biosecurity risk control measures should be performed as an integral part of facility biosafety program management.

As with biosafety, the biosecurity risk assessment process also includes the development of a strategy to manage the biosecurity risk by selecting and implementing biosecurity risk control measures. A laboratory biosecurity program is required to prepare, implement, oversee and review these processes in facilities. In many cases, this can be combined with biosafety program management, although it may need to be a stand-alone program when the biosecurity risks identified are severe and/or numerous. The key elements of laboratory biosecurity program include risk assessment framework, biosecurity plan based on a site-specific risk assessment, maintenance, repairs, reporting, access control, loss, theft, or release of agents/toxins, misuse, and inventory discrepancies.

7.1 Biosecurity risk assessment

Risk Assessment is an evaluation of the likelihood and consequences of undesirable events caused by an adversary that could affect the defined assets. The goal is to determine which events the security system must be designed to protect against. A proper Risk Assessment is mandatory to determine security needs. This will include Asset assessment, Threat assessment and Vulnerability assessment.

7.1.1 Asset Assessment

Biosecurity asset assessment is a process that involves identifying, evaluating, and managing the assets and resources within an organization or facility that are critical to maintaining biosecurity. These assets can include physical infrastructure, personnel, information, technology, and biological materials. The goal of biosecurity asset assessment is to enhance the protection of valuable assets from threats and vulnerabilities, whether they are natural or intentional in nature. Biosecurity asset assessment is crucial for organizations and facilities involved in biotechnology, healthcare, research, and critical infrastructure. It helps protect valuable assets from potential harm, ensuring the safety and security of the organization and the broader community.

7.1.2 Threat Assessment

Biosecurity threat assessment is a specialized process that focuses on identifying and evaluating threats that could compromise the security of Valuable Biological Materials (VBM), facilities, or systems. Threat assessment requires vigilance, adaptability, and a multi-disciplinary approach. It involves analyzing the sources, motives, capabilities, and intentions of potential adversaries and the vulnerabilities and consequences of a breach. It is essential for maintaining the safety, security, and integrity of biological research, laboratories, healthcare facilities, and the broader community. Biosecurity threat assessment is critical for preventing accidental releases, minimizing the risk of intentional misuse of biological materials, and ensuring the safe and responsible handling of hazardous biological agents. It requires collaboration among scientists, healthcare professionals, security experts, and policymakers to protect public health and safety.

7.1.3 Vulnerability Assessment

This is a systematic evaluation process in which qualitative and quantitative techniques are applied to arrive at an effective level for a security system to protect biological laboratories and operations from specifically defined acts that can harm a person's interest. Biorisk assessment is meant to mitigate the risk to staff, environment, public, facility and agency.

Each facility should ensure that suitable technological innovations in assessing and prioritizing biorisks are identified, implemented, maintained and documented. Biorisk assessments should consider activity and protocol specific information. This should be based on the unique context of those activities and protocols, including factors related to facility, environment and personnel periodically, at least annually.

The steps for risk assessment include identification of biological agents, materials, equipment, personnel, potential and consequences of misuse and weaponization.

i. **Risk Identification:** Identifying risks is a crucial step in evaluating and managing the risks associated with biological agents. It is the first step in the overall risk management process. Each facility should collate information on type of biological agents, their physical location, personnel required to access the laboratory premises either to handle the agents or for other reasons such as service and maintenance, and those responsible for the biological agents.

ii. **Evaluate the risks:** Risk Evaluation is the process of determining, subjectively, whether a risk is high or low, and whether it's acceptable or not. It is a crucial intermediary step between Risk Characterization and taking active steps towards mitigating risk. Facility should ensure confidentiality of the information gathered, as related to the likelihood of someone gaining access to the identified biological agents and the consequences of a deliberate release of those agents.

a. The facilities should follow the five Steps to Evaluate Risk:

- Identify and prioritize assets
- Identify agents, materials, equipment, personnel
- Evaluate potential misuse or weaponization
- Evaluate consequence of misuse
- Prioritize assets based on consequence of misuse

b. Assess potential threats and vulnerabilities:

- Identify types of outside threats
- Identify types of inside threats
- Evaluate motive, means, opportunity for potential adversaries

c. Analyze the risk of specific security scenarios:

- Develop list of possible security scenarios

- Evaluate probability of each scenario materializing and its consequences
- Prioritize or rank scenarios by risk for management to review

d. Design and develop an overall risk management program

e. Re-evaluate institution's risk posture and protective objectives

iii. **Develop a risk control strategy:** Facility should determine the minimum-security standards required for work to be allowed to proceed with the identified biological agents (that is the acceptable risk).

iv. **Implementing risk control measures:** Facility biosecurity risk control measures should include both procedural physical security systems and a clear definition of the threats. Facilities should consider the five pillars of Biosecurity Risk Mitigation (Physical Security, Personnel Management, Material Control & Accountability, Transport Security, and Information Security) when implementing risk control measures.

v. **Reviewing risks and risk control measures:** The operation of the biosecurity program should be verified through periodic exercises and drills. Facility biosecurity protocol should be established to identify reports, investigate and remedy breaches. The involvement, roles and responsibilities of public health and relevant authorities in the event of a security breach should be clearly defined. There should be regular review and updating of procedures. Ensure compliance with these procedures, with clear instructions on roles, responsibilities and remedial actions for appropriate integration into a biosecurity program.

7.4 Transport of Biological Agents

Transport of biological materials refers to the movement of materials outside of restricted areas. This can occur across international border, within the country, or facility.

7.4.1 Internal Transport

This is the movement of materials from one restricted area to another within a facility. It may involve personnel from the facility, shipping area, receiving areas and disposal areas. In order to move material safely and securely, there should be a pre-approval process.

7.4.2 External Transport

This is the movement of material from one facility to another; this may involve commercial carriers and occur within a wide array of national and international regulations. The facility should establish plans to address safety and security incidents that might occur during internal and external transportation. The facility should address all applicable national and international transportation requirements and ensure that a system is in place to maintain appropriate controls on shipping packages and transport containers that contain biological materials in accordance with the facility risk assessments.

7.5 Packaging of Biological Materials

The packaging of biological materials should follow applicable national or international regulations to ensure safety. Personnel who package, handle, and ship this agent (including import

and export) should be subjected to all relevant training. A responsible facility official should notify accordingly. All activities relating to the packaging of biological materials, storage, and cold chain management, should be covered by regulatory control. These ranges from planning, risk estimation, labelling, documentation, training, and incident reporting. The facility should ensure a good working relationship between the sender, the carrier and the receiver, so that biological materials and infectious substances are packaged and transported in a safe and timely manner.

8.0 BIORISK MANAGEMENT TRAINING

Training and retraining are core elements of biorisk management and is essential to the success of biorisk management program. It is critical that personnel should be knowledgeable on the hazards and threats associated with the pathogens and toxins present in the work environment and the practices and tools that can protect them. The training program should encompass both didactic and hands-on, with the following considerations:

i. Facilities should have a training plan that covers the entire Biorisk Management Training Program.

ii. Personnel involved in the implementation of Biorisk Management Program should be provided with suitable awareness training on the risks and how to safely mitigate them.

iii. There should be appropriate mentorship and supportive supervision until personnels are considered suitably competent and proficient in any new processes and procedures.

iv. Training should include scenario-based emergency response and periodic refresher training, at least annually.

v. Competency Assessment should be conducted and documented.

9.0 RADIATION SAFETY PROGRAM

The purpose of radiation protection is to provide an appropriate level of protection for humans without unduly limiting the beneficial actions giving rise to radiation exposure.

9.1 Personnel radiation

Personnel exposure to radiation should be monitored at regular intervals. The radiation protection officer should ensure compliance, and adherence to radiation manual by all personnel. Radiation protection protocol should be in accordance with national and international standards, including provision of dosimeters.

Radionuclide-based materials should not be used when other techniques are available. If substitution is not possible, then the radionuclide with the least penetrating power or energy should be used.

Laboratories where radio nuclides are used should be designed to simplify containment, cleaning and decontamination. The radionuclide work area should be in a small room adjoining the main laboratory, or in a dedicated area within the laboratory away from other activities. Signages displaying the international radiation hazard symbol should be pasted at the entrance to the radiation area.

10.0 MONITORING AND EVALUATION

10.1 Introduction

Implementation of the entire bio risk management including evaluating and ensuring that the system is working the way it is designed is a critical component of achieving the goals of this guideline. Monitoring performance measures actual progress and it involves targeting a goal, establishing measurements to track progress, collecting and reporting results, acting on the findings and having periodic reviews, and all this is geared towards continual system improvement.

10.2 Key Performance Indicators (KPIs)

The KPIs will provide measurable benchmarks for biosafety and biosecurity performance. The Specific, Measurable, Achievable, Relevant and Timebound (SMART) performance metrics will cover cardinal areas such as governance, training, equipment, operational practices, and occupational health. Outlined below are the SMART KPIs:

i. Institutional Biosafety Committee functionality
ii. Availability of updated bio-risk manual and SOPs
iii. Annual biosafety/biosecurity audit coverage using SLBP/ISO 35001-aligned checklist
iv. Staff competency and annual training completion
v. Emergency preparedness drills conducted
vi. Biological Safety Cabinet certification within last 12 months
vii. Autoclave performance (monthly BI tests and annual certification)
viii. Incident reporting timeliness (within specified timeline)
ix. Waste management compliance (segregation, treatment)
x. Biosecurity controls (inventory and access logs)
xi. Occupational health surveillance records
xii. Radiation safety compliance

10.3 Measuring performance

i. **Audits and inspections:** This should be performed using the Strengthening Laboratory Biosafety Programs (SLBP) Checklist, which was developed in-line with ISO 35001 Standard for assessing laboratory biosafety and biosecurity. The Biosafety and Biosecurity Laboratory Assessment Tool assess the status of all laboratory biosafety core requirements across different modules. It consists of a standardized scoring system. It is designed to support national, regional, and global efforts to strengthen biosafety in clinical, public health, and veterinary laboratories.

ii. **Supportive Monitoring & Supervision**: Quarterly on-site visits using supervision checklist, monthly remote coaching, peer learning sessions, and action planning. Standardized data tools such as audit and supervision checklist, incident investigation template, and equipment tracker will be deployed.

10.4 Data Quality Assurance (DQA) Plans

For effective data audit, three-layer DQA (routine desk review, semi-annual verification, and periodic independent review) will be implemented quarterly or annually (as the case may be). To achieve this, tools such as RDQA and WHO DQR metrics will be deployed. Risk-based or cluster sampling will be deployed to achieve objective data coverage.

10.5 Indicator Reference Table

Domain	Indicator	Definition	Frequency	Data Source	Responsible/Risk owner
Governance	Institutional Biosafety Committee (IBC) functionality	% labs with IBC meeting ≥2 times/yr	Quarterly	IBC meeting minutes/report with pictures and attendance	Lab Manager
Documentation	Bio-risk manual currency	% labs with updated manual	Quarterly	Document registry	Biosafety Officer
Training	Staff competency	% staff trained annually	Quarterly	Training register	HR/Biosafety Officer
Equipment	BSC certification	% BSCs certified	Monthly	BSC log	Engineering/Biosafety Officer
Equipment	Autoclave performance	% autoclaves passing BI test	Monthly	Autoclave log	Engineering/Biosafety Officer

11.0 OCCUPATIONAL HEALTH AND SAFETY PROGRAM (OHS)

This is a multidisciplinary area of work aiming at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health; and the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities (WHO).

Occupational health and safety programs at the facility level should be specific in context and risks in individual settings, in line with national legislation, policies and subnational programs. These programs should be based on establishing an occupational health and safety management system that envisages continuous improvement of working conditions for workers in health facilities and other persons under the control of the health facilities,

11.1 Health and medical surveillance

All medical laboratory workers should undergo a pre-employment health check at which their medical history is recorded and a targeted occupational health assessment performed.

12.0 EMERGENCY PREPAREDNESS AND RESPONSE PROGRAM

12.1 Introduction

Emergency situations are bound to occur in workplaces. Medical, public health and research laboratories are not exceptions. To minimize the impact of these situations each facility should develop an emergency preparedness and response plan to suit the level and scope of concerned laboratory.

12.2 Emergency Management Elements

This section of the program briefly describes the required facility's approach to the core elements of emergency management, which include: Prevention, Direction and control, Communications systems, Life safety, Identification of an emergency response center, Property protection, Community outreach, Recovery and restoration, Administration and logistics.

12.3 Emergency Preparedness and Response Plan: which will cover the following

i. The facility's emergency management policy and action plan

ii. The purpose of the plan

iii. Authorities and responsibilities of key personnel

iv. The types of emergencies that may occur

v. Training personnel

vi. Where response operations will be managed.

vii. How simulations will be conducted.

viii. Logistics management

ix. Monitoring

12.4 Emergency Preparedness and Response Training

After the preparation of the plan all staff should be trained as part of the implementation and thereafter staff should be trained periodically (preferably annually) as an institutional requirement. The training should cover the following: Emergency response plan, Emergency drills, Employee safety, Documentation, Review of the plan, among others.

13.0 CHEMICAL MANAGEMENT AND HYGIENE PROGRAM

13.1 Introduction

Laboratory personnel are exposed to chemical hazards among others. It is, therefore, vital that they have proper knowledge of the hazardous effects of these chemicals, the routes of exposure, and the hazards that may be associated with their handling and storage. Safety Data Sheets (SDS), which describe the hazards associated with the use of a given chemical, are available from the manufacturer, and should be made available in laboratories where these chemicals are used, e.g. as part of a safety or operations manual. All laboratories should have in place a chemical hygiene plan.

13.2 Definitions and classifications

Hazardous chemicals are often defined and classified according to the hazards and degrees of danger they present, or regulations written for the transport of dangerous goods. They should be listed by their degree of reactivity or instability, flammability, health hazard or by toxic effects.

13.3 Disposal

Chemicals should be disposed of safely based on the institutional guidelines or policies and in accordance with the prescription of the SDS. Specific disposal procedures shall be defined in the chemical hygiene plan.

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Appendix I

Employee Exposure Reporting Form

To be completed by staff within 12 hours of incident/accident

Last Name _____First Name: _____Middle Initial_____

Lab/Section Job Title: _____ ID/Personal No._____

Date/Time of Exposures: _____/_____

Hazard(s): _____

Type of Exposure (e.g. inhalation, ingestion, contact, fall):_____ _____

Cause of Exposure _____

Was personal protective equipment available? Yes No

Was personal protective equipment used? Yes No

What type of personal protective equipment was used?_____

Severity of Exposure: (Minor, Moderate or Major)_____

Describe: _____

_____

Attention requir e d : 1. First Aid 2. Medical Treatment (admission, outpatient)

3. Not necessary

Did employee lose time from work ? Yes No Estimate of lost time: _____

Were other employees exposed? List Names_____

_____

How would you prevent recurrence?_____

_____

_____

_____

_____

Exposed employee's signature_____ Date_____

Supervisor's Name: _____ Signature: _____ _____ Date_____ ___

APPENDIX II

Examples of incompatible combinations of some commonly used chemicals.

CHEMICAL	Keep from contact with
Acetic Acid	chromic acid, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganate
Acetylene	chlorine, bromine, copper, fluorine, silver, mercury
Alkali Metals (e.g.Sodium)	water, chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia, Anhydrous	mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium Nitrate	acids, metal powders, flammable liquids, chlorates, nitrites, sulphur, finely divided combustible materials
Aniline	nitric acid, hydrogen peroxide
Bromine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Carbon, Activated	calcium hypochlorite, all oxidizing agents
Chlorates	ammonium salts, acids, metal powders, sulphur, finely divided combustible materials
Chromic Acid	acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids
Chlorine	ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Copper	acetylene, hydrogen peroxide
Flammable Liquids	ammonium nitrate, inorganic acids, hydrogen peroxide, sodium peroxide, halogens
Hydrocarbons	fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrofluoric Acid	anhydrous ammonia, ammonium hydroxide
Hydrogen Peroxide	copper, chromium, iron, most metals or their salts, alcohols, acetone, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen Sulphide	fuming nitric acid, oxidizing gases
Iodine	acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	acetylene, fulminic acid, ammonia
Nitric Acid	acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases
Oxalic Acid	silver, mercury

Perchloric Acid	acetic anhydride, bismuth and its alloys, organic materials
Potassium	carbon tetrachloride, carbon dioxide, water
Potassium Chlorate	sulphuric and other acids
Potassium Permanganate	glycerin, ethylene glycol, benzaldehyde, sulphuric acid
Silver	acetylene, oxalic acid, tartaric acid, ammonia compounds
Sodium Peroxide	alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulphide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulphuric Acid	potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)

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