UNIVERSITI MALAYA

LABORATORY SAFETY GUIDELINES

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PREFACE

This *Laboratory Safety Guidelines* publication is another step forward towards a safer work place in the University, especially in the laboratories. This book serves as a guide and provide guidelines on working safely in laboratories. There are many hazards and hazardous materials in the laboratories, but it does not mean it is a dangerous place to work. On the contrary, it is relatively safe when all the staff and laboratory users are trained, know the safety requirements and follow them diligently. Therefore, this document is aimed at preparing our staff, students and all laboratory users to understand and know the safe methods of work and other safety requirements when working in the laboratories.

It is everyone's responsibility to ensure a safe workplace. It is important that all users observe and follow all the safety regulations which is designed to reduce the risk and to prevent unnecessary accidents and occupational diseases. I hope that every staff and laboratory user will assimilate the safety work culture, and that you are committed to do it right from here on.

Always be alert as safety is a state of mindfulness, and accidents will happen when safety awareness ends.

Last but not least, I take this opportunity to thank all the writers who have contributed much of their time and effort for making this publication possible.

Professor Dr. Noorsaadah Abd Rahman
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Acknowledgement

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(http://www.merckmillipore.com/Web-SG-Site/en_US/-/SGD/ShowDocument-Pronet?id=201510.400)
List of toxic substances by the United States Center for Disease Control: https://www.atsdr.cdc.gov/substances/index.asp.

List of chemicals which are carcinogenic and reproductive hazards by the United States Center for Disease Control: (https://www.atsdr.cdc.gov/substances/ToxOrganSystems.asp **Malaysia MOH Guidelines on Chemical Management for the classification of hazardous drugs** (https://bit.ly/2moB5uQ) **UM IBBC** (https://umcms.um.edu.my/sites/um-research/institutional-biosafety-and-biosecurity-committee-ibbc) and **UM IBC** (https://umcms.um.edu.my/sites/um-research/biosafety-committee).

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GLOSSARY OF TERMS

ACCRONYMS & ABBREVIATIONS

AEL	Accessible Emission Limit
AELB	Atomic Energy Licensing Board
ALARA	As Low As Reasonably Achievable
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc.
BSS	Basic Standard Safety
CM	Continuous wave
DOE	Department of Environment
DOSH	Department of Safety and Health
EM	Electromagnetic
GLP	Good Laboratory Practices
GMO	Genetically Modified Organisms
GMPP	Good Microbiological Practices and Procedures
GMT	Good Microbiological Technique
IEC	International Electrotechnical Commission
JKKPI	Steering Safety and Health Committee (*Jawatankuasa Keselamatan dan Kesihatan Pekerjaan Induk*)
JKKPP	Central Safety and Health Committee (*Jawatankuasa Keselamatan dan Kesihatan Pekerjaan Pusat*)
JKKPK	Safety and Health Sub-Committee (*Jawatankuasa Keselamatan dan Kesihatan Pekerjaan Kecil*)
LASER	Light Amplification by Stimulated Emission of Radiation
LC	Laboratory Coordinator
LMO	Living Modified Organisms
LSO	Laser Safety Officer
LU	Laser User
MOH	Ministry of Health Malaysia
MTA	Material Transfer Agreement
NFPA	United States National of Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
JPPHB	Department of Development and Asset Maintenance
OSH	Occupational Safety and Health
OSHE	Occupational Safety & Health and Environment
OSL	Optically Stimulated Luminescence
OSHEM	Occupational Safety & Health and Environment Manual
OSHMS	Occupational Safety and Health Management System
PTj	Responsibility Centre (*Pusat Tanggungjawab*); Department; Faculty
PIC	Person In Charge
PPE	Personal Protective Equipment
RPP	Radiation Protection Program
RPO	Radiation Protection Officer
RPS	Radiation Protection Supervisor
RW	Radiation Worker
SDS / MSDS	Safety Data Sheet / Material Safety Data Sheet
Sv	Sieverts
SOP	Standard Operating Procedures
SCH	Special Chemical Hazards
UM	Universiti Malaya
UPPS	Radiation Protection Services Unit
USCDC	United States Center for Disease Control

DEFINITIONS

Acid	Chemical that dissociates in water and forms hydrogen ions. Acid has a sour taste and can cause serious skin burns. Its pH values ranging from 0 to 6 and it makes litmus paper turns red.
Aerosol	1) A compressed substance which is released as a fine spray by means of a propellant gas. 2) A mixture of solid or liquid small particles suspended in air. The particles may have diameters ranging from 100 microns to 0.01 micron or less, such as dust, mist, and smoke.
Air cleaner	A device designed for the purpose of removing atmospheric airborne impurities such as dusts, gases, vapors, fume and smokes. (Air cleaners include air washers, air filters, electrostatic precipitators and charcoal filters).
Air Filter	An Air cleaner to remove light particulate loadings from normal atmospheric air before introduction into the building. Usual range: Loadings up to 3 grains per thousand cubic feet (0.003 grains per cubic foot). Note: Atmospheric air in heavy industrial areas and in plant air in many industries has higher loadings than this and dust collectors are then indicated for proper air cleaning. Air, Standard mean dry air at 70 o F and 229.92 in (Hg) barometer. This is substantially equivalent to 0.075 Ib/cu ft. Specific heat of dry air - 0.24 BTU/ lb /F.
Alkali	Any chemical substances that forms soluble soaps with fatty acids. Alkalis are also referred to as bases. They may cause severe burns to skin. Alkalis turn litmus paper blue and pH values range from 8 to 14
Atomic Energy	All energy of whatever type derived from or created by the transmutation of atoms
Atomization	A process of breaking up bulk liquids into droplets or fine particles.
Aqueous	A water-based solution.
Bases	See “alkali
Biohazardous	A risk to human or the environment caused by something biological such as a poisonous chemical or an infectious disease
Biohazard Bag	A specially designed plastic bag that is used to collect and transport evidence from an accident scene to another site, such as the laboratory
Biological Agents	Contagious and potentially contagious agents/substances and biological toxins, including recombinant DNA molecules, genetically modified organisms (GMOs) and living modified organisms (LMOs).
Biohazardous Materials	Biological agents that cause, or are a probable cause of infection that can pose significant health risk to laboratory personnel.
Bio Risk	Risk associated with biological agents and biohazardous materials.
Boiling Point	The temperature at which a liquid changes to a vapor state, at a given pressure. Flammable materials with low boiling points (below 37.78 °C) generally present special fire hazards.
Bulge	A rounded swelling which distorts an otherwise flat surface.
Centrifugal Gravitational Force	The force that is necessary to keep an object moving in a curved path and that is directed inward toward the center of rotation.
Centrifugation	A technique which involves the application of centrifugal force to separate particles from a solution according to their size, shape, density, viscosity of the medium and rotor speed.

Chamber	An enclosed space or cavity
Combustible	A term used to classify certain liquids that will burn, on the basis of flash points. Non-liquid substances such as wood and paper are classified as ordinary combustibles. Also, see "flammable."
Competency	The ability or capability to do something successfully or efficiently.
Concentration	The relative amount of a substance when combined or mixed with other substances. Examples: 2 ppm hydrogen sulfide in air, or a 50 percent caustic solution.
Condensed	Is made denser or more concise; compressed or concentrated where it changed from a gas or vapour to a liquid.
Containment	1) System surrounding chemical bottles or cans in storage or use, and able to hold the contents of the largest container of chemical if it were to break open or spill. 2) The combination of physical features and operational practices that protect laboratory personnel, the community and the environment from exposure to biological agents. 3) The action of keeping something harmful under control or within limits.
Corrosive	A chemical that causes visible damage of or permanent changes in living tissue by chemical action at the point of contact; or in the case of leakage from its packaging, a substance with a high corrosion rate on steel. Any waste that shows a "characteristic of corrosivity," may be regulated as a hazardous waste.
CO2	Carbon dioxide. Heavy, colorless gas released by the combustion and decomposition of organic materials and as a by-product of many chemical reactions. CO2 is non-combustible and comparatively low in toxic but when in high concentrations and in confined spaces, it may cause hazardous atmospheres and breathing difficulties).
Cyanides	Any of various salts or esters of hydrogen cyanide containing a CN group, including the extremely poisonous compounds potassium cyanide and sodium cyanide. Segregate from acids and oxidizers.
Damper	A person or thing that has a subduing or inhibiting effect.
Decontamination	The neutralization or elimination of hazardous substances, radioactivity, or bacteria from a place, object, or individual.
Disinfect	An act of cleaning something to destroy bacteria, usually with chemicals
Drive Shaft	A rotating shaft which transmits torque in an engine
Drum	A cylindrical container or receptacle.
Designated Area	Area that is used for work with "select carcinogens", reproductive toxins, extremely toxic or dangerous chemicals. A designated area may be the whole laboratory, area part of the laboratory or a device such as a fume hood.
Depressurizes	The release of the pressure of the gas inside (a pressurized vehicle or container).
Disintegration	A process in which a nucleus or other subatomic particle emits a smaller particle or divides into smaller particles.
Dust	A small solid particles created by the breaking up of larger particles by processes such as crushing, grinding, drilling, explosions, etc. Dust particles already in existence in a mixture of materials may escape into the air through such operations as shoveling, conveying, screening, sweeping, etc.

Dust Collector	An Air cleaner to remove heavy particulate loadings from exhaust systems before discharge to outdoors. Usual range: Loadings 0.003 grains per cubic foot and higher
Economizer	A device designed to make a machine or system more energy efficient.
Gases	Formless fluids which occupies an entire space evenly at normal temperatures and pressures
Gaskets	A shaped sheet or ring of rubber or other material sealing the junction between two surfaces in an engine or other device.
Gauge	An instrument that measures and gives a visual display of the amount, level, or contents of something.
Employee	An individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.
Explosive	Material that causes a rapid, almost instantaneous release of pressure, gas, and heat when exposed to sudden shock, pressure, or high temperature.
Flammable	Any solid, liquid, vapour, or gas that can easily combust and burn quickly.
Firebox	A chamber of a steam engine or boiler in which the fuel is burnt.
Flanges	A projecting flat rim, collar, or rib on an object, serving for strengthening or attachment for maintaining position on a rail
Fume Hood	A device enclosed on five sides and has a moveable or fixed partial sash enclosing on the remaining side. Constructed and maintained to remove air from the laboratory and to avoid or reduce the escape of air pollutants into the laboratory, allowing chemical manipulations to be carried out without the use of any part of the employee's body other than hands and arms.
Hazard	Any substance that has the potential to hurt or damage people, property, or the environment.
Hazardous	Dangerous
Hazardous Chemical	A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.
Hazardous Waste	Any substance that (a) has a characteristic of hazardous waste (i.e., ignitability, corrosivity, etc.), or (b) is included by name in hazardous waste regulations.
Hood	A shaped inlet for collecting polluted air and transporting it to the exhaust duct system.
Ionizing Radiation	Electromagnetic radiation or corpuscular radiation capable of producing ionization in its passage through matter.
Irradiating Apparatus	Apparatus capable of producing ionizing radiation includes X-ray machine, electron microscope and irradiator
Incompatible	A mixture of chemicals that, when in direct contact with one another, may cause harmful reactions.
Ingestion	The act of taking something in through the mouth, swallowing it, and passing it through the digestive system.

Inhalation	The drawing in of a substance in the form of a gas, vapour, fume, mist, or dust into the body.
Interlock	When two or more things engage with each other by overlapping or by the fitting together of projections and recesses.
Inter-Molecular Force	The forces which mediate interaction between molecules, including forces of attraction or repulsion which act between molecules and other types of neighboring particles
Irritant	Chemicals that, through chemical action at the point of contact, cause a reversible inflammatory effect on living tissue.
Laboratory	A place where chemical modifications and analysis are performed for either research, academic, or clinical purposes
Laboratory Operator	A person who operates a chemical laboratory and he or she holds a management position (Appointed by the management of the respective schools)
Laboratory Personnel	Staff, visiting researchers/scholars and students performing work activities in laboratories in and outside of UM (including field work).
Lasers	1) Lasers are energy instruments that produce monochromatic, directional and coherent light. 2) The laser is a form of electromagnetic (EM) wave with excellent directivity and high power densities. 3) Accessible Emission Limit (AEL) is the maximum accessible emission level permitted with particular laser hazard class.
Latch	A circuit which retains whatever output state results from a momentary input signal until reset by another signal or a metal bar with a catch and lever used for fastening a door or gate.
Laboratory Chemical Wastes (LCW)	Any obsolete, abandoned, discarded, expired and off-specification laboratory chemicals in the form of liquid, solid, or gaseous material including samples resulting from laboratory operations that are no longer in use and intended for disposal
Local Exhaust	A mechanical ventilation system for capturing and exhausting contaminants from the air at the point where the contaminants are produced (welding, grinding, sanding, other processes or operations), as opposed to “general exhaust.” The work area is often partially enclosed to improve the capture of the contaminants.
Malfunction	A piece of equipment or machinery that fail to function normally.
Modern Biotechnology	The application of in vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of the nucleic acid into cells or organelles, or fusion of cells beyond the taxonomic family, that overcome natural physiology reproductive or recombination barriers and that are not techniques used in traditional breeding and selection.
Material Safety Data Sheet	Information on a chemical’s known hazards, which is generated by the manufacturer and issued to the user but now being replaced by Safety Data Sheets (SDSs).
Nanoparticle	Nanoparticle is a class of substances with, at least, having one dimension less than 100 nm

Non-Ionizing Radiation	Described as a series of energy waves composed of oscillating electric and magnetic fields traveling at the speed of light
Overhaul	Taking apart a piece of machinery or equipment to examine it and repair it if necessary.
Oxidizers	Chemicals, other than explosives, that initiate or facilitate combustion in other materials, thereby causing fire either on its own or through the release of oxygen or other gases
O-Rings	A gasket or seal in the form of a ring with a circular cross section, typically made of rubber and used especially in swiveling joints.
Particularly Hazardous Substances	Chemicals that are “highly toxic,” “highly dangerous,” “select carcinogens,” “reproductive toxins,” or “select toxins.”
Peephole	A small hole that may be looked through.
Pilot	A light orifice will look much like an upturned piece of metal tubing and the pilot light burns at the tip of this tubing
Principal Investigator	A senior researcher who has authority over the spaces and procedures in a laboratory.
Positive Pressure	An environmental condition when the air pressure inside a containment device or a room is higher than the outside air pressure. Air contaminants outside the glove box or room will be less likely to enter and contaminate the device or room, because air leaks and currents will tend to blow them out. Also, see “negative pressure.”
PPE	Personal Protective Equipment. Items worn by a person to prevent illness or injury.
ppm	Parts per million. A concentration unit.
Pyrophoric	A chemical that naturally combust in air below 130 °F (54 °C).
Radial	of or arranged like rays or the radii of a circle; diverging in lines from a common center.
Radioactive	Emission of ionizing radiation or particles
Radiation	A form of energy emission as electromagnetic waves or as moving subatomic particles, especially high-energy particles which cause ionization.
Radiation Sources	Refer to radioactive materials, irradiating apparatus and nuclear materials.
RPP	A legal requirement document that includes the protection of both radiation workers and public. It reflects the application of the management responsibility for radiation protection and safety through the adoption of management structures, policies and procedures.
RPO	A technically qualified as a competent person appointed by UM and approved by authority AELB or MOH.
RPS	A technically competent person appointed by UM and verified by authority AELB or MOH
RA	Trained and verified staffs by AELB or MOH to work under the instruction of the RPO in the handling or use of, or who will come into contact with radiation sources.
Risk	The likelihood of being exposed to a hazard would result in a negative outcome.

Recycling	A universal term for the reuse of wastes that includes reclamation and recovery.
Rotor	The rotating assembly in a turbine.
Smoke	An air suspension (aerosol) of particles, usually but not necessarily solid, often originating in a solid nucleus, form combustion or sublimation
Solvent	A substance that can dissolve other substances to form a homogeneous mixture
SOP	Standard Operating Procedure. A list of specific work practises for a process or operation.
Special Chemical Hazards	Also known as SCH. Are natural/synthetic compounds that embody a high risk to employees/workers in the work environment.
Steam	The vapor into which water is converted when heated, forming a white mist of minute water droplets in the air.
Sterilizer	A device used to destroy microorganisms in or on, usually by bringing to a high temperature with steam, dry heat, or boiling liquid.
Stress Test	The process of determining the ability of an equipment to maintain a certain level of effectiveness under unfavorable conditions. The process can involve quantitative tests done in a lab, such as measuring the frequency of errors or system crashes.
Spindle	A rod or pin serving as an axis that revolves or on which the machine revolves
Toxic	Relating to poisonous materials and having poisonous effects.
Toxicity	The sum of adverse effects arising from contact with a substance, usually through the mouth, skin, or respiratory tract.
USECHH	Use and Standard of Exposure Chemical Hazardous to Health Regulations 2000
Valve	A device for controlling the flow of fluid or air through a pipe, duct, or other conduit, especially one that is automatic and only allows movement in one direction.
Vent	An opening in a closed space that allows air, gas, or liquid to escape or enter.
Ventilation	Circulation of air.
Water Reactive Chemicals	A chemical that, when combined with water, produces a gas that is either flammable or hazardous to one's health.
Winchester Bottle	Strong and heavy bottle with relatively narrow neck, commonly used in the drug and chemical industries for liquid storage.
Work Activities	Research (including field work), services and teaching that include handling, manipulating, working, utilizing, storing, moving and disposing of biological agents.
Work Area	Place and area where work activities (including field work) involving biological agents and/or biohazardous materials are performed.

AIM

1. The laboratory environment can be a hazardous place to work and can be exposed to various potential hazards including chemical, biological, physical, radioactive and ergonomic hazards. UM aims to provide and ensure a safe and healthy working environment in the laboratories for the staff, researchers and students. With proper safe work system and risk management system, these hazards can be reduced and mitigated to safe and acceptable levels.

OBJECTIVES

2. The objectives of this laboratory safety guidelines are:

   a. To establish a common guide and standardize all laboratories practices and procedures in terms of safety and good lab practices.
   b. To communicate to all levels of staff, researchers, students and interested parties on the laboratory rules, regulations and requirements campus wide.
   c. To ensure and enhance compliance to federal and local regulations and requirements.

SCOPE AND APPLICATION

3. This document applies to all staff, researchers, students and all parties who are working in both research and teaching laboratories in University Malaya and its other premises (including Bachok Marine Research Station, Glemi Lami Biotechnology Research Centre (PPBGL) and Ulu Gombak Field Studies Centre). This published guideline is intended for lab managers, principal investigators, supervisors and person in-charge (PIC) to have the primary responsibility for maintaining laboratories under their supervision as safe, healthy places to work and for ensuring that all applicable occupational safety, health and environmental (OSHE) regulations are followed.

4. The Head of Responsibility Centre (RC / *PTj (Pusat Tanggungjawab)*, Head of Department (HOD) and Head of Centre/Unit/Programme are responsible to ensure this guideline is effectively implemented, practiced and enforced in the laboratories and its activities.

LEGISLATIONS

5. The principal OSHA and other regulations that apply to all laboratories are listed here for reference and compliance requirements. Although, it is not a comprehensive list, it covers the major hazards that staff and students are most likely to encounter in their work. The related parties need to be aware that these requirements must be implemented in all aspects which applies to laboratory work conditions in their facilities.

a. **Occupational Safety and Health Act (OSHA) 1994 (Act 514).** OSHA 1994 was formulated to ensure safety, health and welfare of all persons at all places of work, and it based on the self-regulation concept with the primary responsibility of ensuring safety and health at the workplace lying with those who create the risks and work with the risks. In the general duties (Section 15, 17 and 18) requires the employers / PIC to ensure safety, health and welfare at work of all employees/staff and people at work (including students) and to maintain plant and system of work that is safe and without risks to health. It also requires to provide information, instruction, training and supervision to ensure the safety and health of his staff, students and people at workplace. The duties of employees (Section 24) including students are require to be responsible and take care for the safety and health of him/herself and other persons who may be affected by his/her activities. They are to cooperate, work with and comply any instruction(s) on safety and operations in the laboratories as requested by PIC or the university, and to use PPE when required. All staff, students and other people at laboratories shall complied with all regulations and rules

b. **Use and Standards of Exposures of Chemicals Hazardous to Health (USECHH) Regulation 2000.** The purpose of the USECHH Regulations is to provide a legal framework for the employer to control chemicals hazardous to health with respect to their usage and to set workplace exposure standards so as to protect the health of employees and other persons at the place of work. The Regulations clearly stipulates the responsibility of the employer (including self-employed person), in respect of his employees and any other person, so far as is practicable to protect their safety and health from being affected by chemicals hazardous to health. The duties of the employer stipulated in the Regulations are:

(1) Identifying chemicals hazardous to health.
(2) Complying with the permissible exposure limits.
(3) Carrying out chemical health risk assessment.
(4) Taking action to control hazardous exposure.
(5) Labelling and relabelling chemicals hazardous to health.
(6) Providing information, instruction and training.
(7) Monitoring employee exposure at the place of work.
(8) Conducting health surveillance.
(9) Posting of warning signs.
(10) Record keeping.

These Regulations shall apply to all places of work (which are within the jurisdiction of the OSHA 1994) where chemicals hazardous to health are used, except chemicals that are:

(1) Defined as radioactive materials in the Atomic Energy Licensing Act 1984;

(2) Foodstuffs;
(3) Hazardous to health solely by the virtue of their explosive or flammable
(4) properties, or low temperature or a high pressure; and
(5) Pharmaceutical products.

The chemical labelling and signage follows the requirements as stipulated in CLASS Regulation 2013.

c. **Classification, Labelling and Safety Data Sheet of Hazardous Chemicals (CLASS) Regulation 2013.** The CLASS Regulations, promulgated under the Occupational Safety and Health Act 1994 (Act 514), have replaced the Occupational Safety and Health (Classification, Packaging and Labelling of Hazardous Chemicals) Regulations 1997 (CPL Regulations) The main objective of the CLASS Regulations is to ensure suppliers of hazardous chemicals provide sufficient information on hazards of chemicals that they supply, so as to mitigate the risk of accidents happening in the workplace, thus providing a safe and healthy working environment and condition. The responsibilities of suppliers as stated in the CLASS Regulations are to do the classification, labelling, preparation of Safety Data Sheet, packaging and chemicals inventory information submission. In the regulations, suppliers are defined as persons who supply hazardous chemicals, and include principal suppliers (that is, suppliers who formulate, manufacture, import, recycle or reformulate hazardous chemical chemicals) and subsidiary suppliers (that is, suppliers who repack, distribute or retail hazardous chemicals). CLASS Regulations only apply to chemicals supplied for use at a place of work. The regulations do not apply to:
(1) Radio-active materials;
(2) Wastes;
(3) Cosmetics or pharmaceuticals;
(4) Pesticides;
(5) A chemical used for R&D (less than 5 kg);
(6) A chemical in transit prior to export;
(7) Articles not containing chemicals intended to be released

d. **Factories and Machinery Act (FMA) 1967 (Act 139).** The Factories and Machinery Act (FMA) provide the regulations for the control of machineries matters relating to the safety, health and welfare of persons, and the registration and inspection of machinery. Machinery such as boilers, unfired pressure vessels, hoisting machinery, etc, need to be registered with DOSH and has a valid certificate of fitness is required for its operation (Section 19, FMA 1967).

e. **Environmental Quality Act (EQA) 1974 (Act 127).** The Environmental Quality Act (EQA) makes provision for the prevention, abatement, control of pollution and enhancement of the environment. The staff and students are required to comply with the clinical and chemical lab waste management as stipulated in the Scheduled Waste Regulations 2005. Staff need to ensure that chemical fumes released/extracted, such as via the LEV (i.e., fume hood), from the laboratory to the environment, are in compliance to the **Clean Air Regulations 2014**.

(1) **Scheduled Waste Regulation (SWR) 2005.** This Regulation provides the basis for classification of scheduled wastes as in the First Schedule (specific list of scheduled wastes). Scheduled wastes are potential harmful, and it presents potential risks;

(a) To human health;
(b) To the environment; and
(c) Of accidents.

Scheduled should not be handled using normal disposal methods used for non-hazardous industrial wastes (typically land filling). These scheduled wastes must be handled with caution and appropriately using a good scheduled waste management approach to safe guard the human health and environment.

(2) **Clean Air Regulation (CAR) 2014.** The CAR 2014 replaces the Environmental Quality (Clean Air) Regulations 1978 and the Environmental Quality Regulations (Dioxin and Furan) 2004. It aims to regulate emissions of air pollutants from industrial activities including power plants, waste fuel plants and asphalt mixing plants. These Regulations shall apply to any other premises or process that discharges or is capable of discharging air pollutants into the open air. New Lab facility (non-industry) must submit written notification to relevant DOE state office prior installation of air pollution control and chimney. And, existing lab facility need to submit written notification except for:

(a) Expansion of facility that will emit source of air pollution;
(b) *Notis Arahan* from DOE to submit written notification or install pollution control incompliance issues, etc.

f. **Atomic Energy Licensing Act 1984 (Act 304).** Atomic Energy Licensing Act governs all activities that deal with ionizing radiation in medical and non-medical sectors. The authority to enforce the legal requirements of Act 304 is given to Atomic Energy Licensing Board (AELB) for dealing with ionizing radiation in non-medical applications and Ministry of Health (MOH) for the use of ionizing radiation in medical applications. Dealing in defined as any activity that involve manufacturing, trade in, produce, process, purchase, own, posses, use, transfer, handle, sell or store any radioactive materials, nuclear materials, prescribed substances or irradiating apparatus. There are subsidiary regulations under this Act known as:

(1) Radiation Protection (Licensing) Regulations 1986
(2) Atomic Energy Licensing (Basic Safety Radiation Protection) 2010
(3) Radiation Protection (Transport) Regulations 1989
(4) Atomic Energy Licensing (Radioactive Management) Regulations 2011

g. **Fire Services Act 1988.** The Fire Services Act is to provide requirements for the protection of persons and property from fire risks and all requirements in the labs shall comply to the requirement within this Act.

h. **Uniform Building By-Laws (UBBL) 1984.** Laboratories should be built in compliance to the UBBL 1984, which is a uniform building code applicable to all building types in local authorities' areas of jurisdiction. Building required by law as a guideline to ensure that the rules and laws of the construction of buildings or structure followed complied with.

i. **Biosafety Act 2007 (Act 678)**. The Biosafety Act (2007) has been established and came into force at the end of 2009, describes the framework for the Malaysian system of regulation for living modified organisms (LMOs) and products of such organisms. The objective of this act is to protect human, plant and animal health, the environment and biological diversity, by regulating the release, importation, exportation and contained use of LMOs, and the release of products of such organisms.

(1) **The Biosafety (Approval and Notification) Regulations 2010**. The Biosafety (Approval and Notification) Regulations 2010 facilitate the implementation of the Act. The Regulations describe the establishment of IBC, procedure on the application for approval, release or import activity, as well as the certificate of approval related, notification procedures for the export, contained use and import for contained use of LMOs and appeal procedures against the decision of the National Biosafety Board (NBB). The Department of Biosafety, the authorized body to oversee all activities related to biosafety/modern biotechnology and monitors all activities pertaining to the living modified organism (LMO) and products of such organisms.

j. **The Prevention and Control of Infectious Diseases Act 1988 (Act 342).** It prescribes the measures to be taken to control or prevent the spread of any infectious disease within or from an infected local area. The relevant officials are empowered to conduct inspection on any place, person or thing and take preventive or remedial measures. The law also requires that infectious diseases should be notified from time to time and kept under surveillance. Infectious diseases are specified in the First Schedule.

k. **Electricity Supply Act 1990 (Act 447).** Electrical Supply Act requires the staff to comply with the stipulated regulations for example, the electricity supply, the control of any electrical installation, plant and equipment with respect to matters relating to the safety of persons and the efficient use of electricity and for purposes connected herewith.

l. **Biosafety & Biosecurity Policy and Guidelines**

(1) **Malaysia Laboratory Biosafety and Biosecurity Policy and Guideline.** It was established in 2015 by Ministry of Health Malaysia, and it reflects Malaysia's obligation to comply with the International Health Regulation (IHR) 2005. It consists of basic concepts and approaches that govern all activities involving the handling, manipulation working, using, storing and disposing of infectious and potentially infectious agents/materials and microbial toxins in all forms and sizes of laboratories in Malaysia. These policies stated that institution must established an oversight committee and to provide proper facilities commensurable with the biosafety risk level of the infectious and potentially infectious agents/materials and microbial toxins handled. All personnel working with infectious agents must be trained and authorized and must comply with all the relevant national and international obligations and legal frameworks which govern such activities. These policies operate alongside with the Prevention and Control Disease Act 1988 and the Regulations, which regard to Importation and Exportation of Human Remains, Human Tissues and Pathogenic Organisms or Substances.

(2) Universiti Malaya Policy and Procedure on Laboratory Biosafety and Biosecurity. It governs all activities involving the handling, manipulating, working, using, storing, and disposing of infectious and potentially infectious agents/ materials and biological toxins in all forms and sizes of laboratories and containment zone in UM. The purpose of this document is to formalize the UM Institutional Biosafety and Biosecurity Committee (IBBC) obligation in relation to national and international Biosafety and Biosecurity requirements. All PIs that working with infectious and potentially infectious agents/materials and biological toxins shall notify and obtain approval from the IBBC before the initiation of such activities.

CATEGORY OF HAZARDS

Chemical Hazards

6. Hazardous chemicals present physical and/or health threats to workers in clinical, industrial, and laboratories. Laboratory chemicals include cancer-causing agents (carcinogens), toxins (e.g., those affecting the liver, kidney, and nervous system), irritants, corrosives, sensitizers, as well as agents that act on the blood system or damage the lungs, skin, eyes, or mucous membranes.

Biological Hazards

7. Many laboratory workers encounter daily exposure to biological hazards. These hazards are present in various sources throughout the laboratory such as blood and body fluids, culture specimens, body tissue and cadavers, and laboratory animals, as well as other workers. Biological agents (e.g., viruses, bacteria, fungi, and prions) and toxins have the potential to pose a severe threat to public health and safety, to animal or plant health, or to animal or plant products.

Physical Hazards

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

Ergonomic Hazards

9. Laboratory workers are at risk for repetitive motion injuries during routine laboratory procedures such as pipetting, working at microscopes, operating microtomes, using cell counters and keyboarding at computer workstations. Repetitive motion injuries develop over time and occur when muscles and joints are stressed, tendons are inflamed, nerves are pinched and the flow of blood is restricted. Standing and working in awkward positions in front of laboratory hoods/biological safety cabinets can also present ergonomic problems.

Safety Hazards

10. A safety hazard is any force strong enough to cause injury, or damage to property. An injury caused by a safety hazard is usually obvious. For example, a worker may be badly cut. Safety hazards cause harm when workplace controls are not adequate. Some examples of safety hazards include, but are not limited to:

- a. slipping/tripping hazards (such as wires run across floors);
- b. fire hazards (from flammable materials);
- c. moving parts of machinery, tools and equipment (such as pinch and nip points);
- d. work at height (such as work done on scaffolds);
- e. ejection of material (such as from molding);
- f. pressure systems (such as steam boilers and pipes);
- g. vehicles (such as forklifts and trucks);
- h. lifting and other manual handling operations; and
- i. working alone.

Psychological Hazard

11. A psychological hazard is any hazard that affects the mental well-being or mental health of the worker by overwhelming individual coping mechanisms and impacting the worker's ability to work in a healthy and safe manner. Some example of sources of psychological hazards are workplace violence and harassment, fatigue and hours of work. Some example of personal factors are depression, anxiety and other mental illness.

HIERARCHY OF CONTROL

12. **At The Source Of The Hazard**

a. **Elimination** – Remove or get rid of a hazardous job, process, machine, tool or substance/material is the best way of protecting staff and people at work. For example, the PI can decide not to use a highly hazardous and toxic chemical in their research to ensure the safety and health of the staff and lab users.

b. **Substitution** – Doing the same work activities but changing a process using a less hazardous process/method will make the workplace safer by reducing the exposure risk to the hazard. For example, by changing a hazardous chemical with a less hazardous one will can reduce the severity and exposure risk of the hazard. Controls must be still in place to protect staff and students from any new hazards that are created.

13. **Engineering Control**

a. **Redesign** – Relook at the job activities and processes to make them safer. For example, transporting chemicals in a safer manner using better designed trolleys.

b. **Isolation** – When a hazard cannot be removed, eliminated or replaced, the next best alternative is to isolate, contained or kept it away from staff and students. For example, keeping chemicals in ventilated (ducted) chemical cabinet to insulated toxic fumes and chemicals from the lab users.

c. **Automation** – Hazardous and dangerous processes can be mechanized or automated. For example, using computer-controlled robotics devices to handle and dispense toxic chemicals. Care must be taken to protect staff from other hazards associated with the use of robotic devices.

d. **Barriers** – To prevent or blocked a hazard before it reaches the staff or students. For example, install guarding rail for rotating moving parts/rotating cutting blade to protect from accidental cuts, and special curtains can prevent eye injuries from flying splinters.

e. **Absorption** – At times, we may need to absorb the hazard, such as vibration and noise. Install suitable dampening material to reduce the impact and hazard. Lockout systems can be used to isolate energy sources during repair and maintenance. Usually, the further a control can keeps a hazard away from workers, the more effective it will be.

f. **Dilution** - Some hazards can be dissipated or diluted. For example, general lab ventilation systems help to dilute and dissipate the toxic gases before they reach lab users.

14. **Administrative Controls**

a. **Standard operating procedures (SOP) /Safe work instructions** (SWI) – Standardized safety procedures helps to ensure the users work safety and protected. The PI and superviors are expected to ensure that users follow these procedures. SOP & SWI must be reviewed and updated periodically.

b. **Supervision and training** – Training on SOP and SWI and refresher training should be conducted. Appropriate supervision to assist users in identifying hazards and evaluating work activities is important.

c. **Job rotations** and other procedures can reduce the time that user are exposed to a hazard can be implemented where possible. For example, staff rotation for jobs requiring repetitive movements to prevent cumulative trauma injuries should be implemented. Noisy processes can be planned when no one is in the workplace.

d. **Housekeeping, repair and maintenance programs** – Housekeeping such as cleaning, waste disposal and spill cleanup is important. Tools, equipment and machinery that are kept clean and well maintained will be less likely to cause injury.

e. **Hygiene** – Hygiene practices helps to reduce the risk of toxic materials being absorbed by staff and students or accidentally carried to their homes and families. It is a good practice to keep street clothing in separate lockers to avoid being contaminated by work clothing, especially those working with hazardous materials. Eating areas must be segregated from toxic hazards. Eating should not be allowed in the lab areas. Some work processes will require staff to shower and change clothes at the end of the work day before going home.

15. **Personal Protective Equipment.** PPE and clothing are used when other controls measures are not feasible or sufficient, it is additional protection and used as last resort. Staff need to be trained to use and maintain equipment properly. Both the management and staff must understand the limitations of the PPE. The management (HoD, PI, supervisors) is expected to ensure the lab users to use their PPE properly whenever it is needed. Care must be taken to ensure that it is in good condition and working properly. If not, the PPE may endanger the user's health by providing an illusion of protection when it is not.

RESPONSIBILITIES AND AUTHORITY

16. **Responsibilities of University Management.** Under the law, the Vice-Chancellor is responsible on all matters pertaining to safety and health at the UM including considering and discussing on matters related to OSH at the JKKPI meeting. University management is committed, as practicable as possible to:

a. Provide and as frequently as appropriate, to review the written statement policy with respect to OSH.

b. Ensure that resources are available to develop, implement, maintain and improve safety and health in UM. The resources include the human resources, finance, training, infrastructure and technology facilities.

c. Determine the role, distribute responsibility and accountability and devolution of authority in facilitating effective safety and health management.

d. Consider any reports received from JKK PTj or audit reports prepared by the safety and health auditors or any other government agencies on OSH.

17. **Responsibilities of Head of Responsibility Centre (RC) / *Pusat Tanggungjawab* (PTj)**. The Head of *Pusat Tanggungjawab* (PTj) is responsible to:

a. Ensure workplace for staff and others are free from hazards that cause or may cause dangerous accidents or incidents.

b. Ensure that legal requirements and OSH procedures are communicated to all staff at PTj.

c. Ensure adequate resources are provided for the implementation of OSH at PTj.

d. Chair the JKKP meeting, or devolution of authority to the appointed representative after the inaugural meeting. The head of PTj is still fully responsible for matters related to OSH at the PTj.

e. Ensure that adequate Personal Protective Equipment (PPE) are provided where necessary and maintained so as to function properly.

f. Prepare and submit safety and health reports (including statistics on incidents, accidents and the number of sick days related to OSH) periodically to OSHE to be discussed in the JKKPP meeting with the Director of OSHE. Reporting data will be used as the basis for improvement.

g. Ensure that staff and students receive appropriate safety training and OSH information are communicated to them including visitors and contractors.

h. Use existing communication channels and methods for discussion between management and staff to enhance OSH at the workplace.

i. Ensure the membership of all related committees on OSH is displayed on the website and the PTj notice board.

18. **Responsibilities of Staff**. Staff are responsible to:

a. Read and understand the UM occupational safety and health policy.

b. Comply with UM legal requirements and work procedures at the workplace while on duty, including workplaces outside the main campus area.

c. Use appropriate PPE while performing duty at workplace.

d. Report any hazard, incident and accidents to JKK PTj.

e. Report any accident, hazardous incidents, occupational poisoning and occupational disease to JKK PTj.

f. Report sick leave related to OSHE (including poisoning and infectious diseases) to JKK PTj.

g. Take note and follow emergency procedures and comply with the instructions given by the ERT.

h. Cooperate with JKK PTj when needed.

i. Be responsible for own safety and health and others who may be affected/influenced by your actions.

19. **Responsibilities of Officer-in-charge.** Besides performing their duties, officers'-in-charge are responsible to:

a. Ensure that the staff, students and contractors who are working under his/her supervision have been given appropriate safety and health training related to their work.

b. Take action against any hazard, unsafe conditions, incidents, accidents and report to the JKK PTj.

c. Assist JKK PTj to carry out OSH assessment at the workplace.

d. Assist JKK PTj to conduct investigation on reported incident (including accidents) and hazard at workplace.

e. Ensure that the staff, students and contractors who are working under his/her supervision have complied with appropriate PPE when performing their duties at the workplace.

f. Ensure that the staff, students and contractors who are working under his/her supervision understood and complied with emergency procedures and instructions given by the ERT.

20. **Responsibilities of Student.** Students are responsible to:

a. Read and comply to the UM safety procedure while in the campus area.

b. Behave appropriately while conducting activities in the laboratory/clinic. Some laboratories/clinics have specific work procedures that need to be followed while handling special materials and equipment.

c. Use the PPE and safety equipment properly.

d. Read and comply to emergency procedures and instructions given by staff or ERT.

e. Report hazards, incidents and accidents (including injuries and sick leave due to work/research activities/teaching) to Officers-in-charge.

f. Attend briefings, trainings, courses and other OSHE activities directed from time to time.

21. **Responsibilities of Contractor.** Contractors are responsible to:

a. Comply with legal requirements and regulations of OSHE and UM while conducting work in UM.

b. Follow Permit to Work system for matters related to construction work.

c. Use a safe working method.

d. Use equipment and materials that do not bring risk to themselves nor the staff, students and visitors of UM.

e. Report all injuries, incidents and accidents immediately to the UM authorities, i.e. the UM Officer-in-charge at the PTj.

f. Report all hazards, injuries, incidents and accidents to JKKPI and JKKPK.

g. Ensure that all employees under their supervision are competent, have appropriate experience and qualifications to carry out duties.

h. Ensure complete instructions of work are given to employees and supervise them frequently.

i. Inform the UM authorities, i.e. the Officer-in-charge at PTj immediately in the event of issue related to occupational safety and health.

i. Take note and comply to emergency procedures and instructions given by the ERT.

j. Their own safety and health and other people at workplace that who may be impacted/affected by their actions.

22. **Responsibilities of Visitor.** Visitors are responsible to:

a. Comply with UM regulations appropriately while in the UM campus.

b. Comply with emergency procedures and instructions given by the ERT.

23. **Role and Responsibilities of JKKPK**

a. JKKPK is head by the Head of respective PTj. Experienced or Senior Officer in OSH at the PTj shall be appointed as Secretary.

b. The terms of reference of the Committee are as follows:

(1) To assist in the design of OSH methods and work safety systems.

(2) To review the effectiveness of safety and health programmes at PTj.

(3) To ensure the assessment of hazard and analysis of the such risks to be carried out to evaluate the identified hazard, as well as to provide a control measure to the such risks.

(4) To conduct investigation as soon after any accident, barely accident, hazardous incidents, occupational poisoning or occupational disease happening at workplace in PTj and to prepare a report with recommendation of action/improvement plan.

(5) To conduct studies on accident trends, barely accident, hazardous incidents, occupational poisoning or occupational disease happening at workplace in PTj and report any unsafe or unhealthy condition or practice with recommendation of action/improvement plan to OSHE.

(6) Always ensure and review the measures taken on occupational safety and health matters are sufficient for of staff working at workplace at the PTj.

(7) Conduct workplace assessment or inspection at least once in every three months to ensure and determine any hazards or conditions that are detrimental to the safety and health of the staff at the workplace.

(8) At the opinion of the Committee, if there is any condition that is detrimental to the safety and health of any staff at the PTj, the details shall be recorded and proposed remedial measures should be recommended in a report.

(9) To resolve any matter referred to in paragraph (7) and, if unable to do at PTj level, a report shall be submitted to OSHE to be brought to the attention of the management or Vice-Chancellor to carry out a workplace assessment.

(10) Investigate complaints on occupational safety and health received by the PTj.

(11) The Committee shall meet as frequently as necessary or every three months in accordance with the risks involved in the workplace.

(12) The Committee needs to call for immediate attention in the event of accident resulting in serious loss of life or bodily injury to anyone, a barely accident, a hazardous occurrence or any other situation to ensure the safety and health of staff and other people at the workplace.

BASIC LABORATORY SAFETY PRACTICES

Working Alone

24. Working alone in the laboratory is prohibited if the procedures conducted involve highly dangerous substances or processes. If you are working alone with lesser hazard chemicals, it is mandatory to record your attendance in the logbook and inform another personnel in other laboratories of your presence or design an accountability system with your supervisor or co-workers. Ensure that you are well aware of any lab-specific policies around working alone. It is also prohibited to sleep or dwell in the laboratory without having valid reasons related to your laboratory work.

Avoid Chemical Exposure

25. **Avoid skin contact with chemicals**: Always use appropriate PPE but keep in mind that it is "the last line of defense" and use other precautions, such as using appropriate container and checking regularly that all connections are tight. Clean up spills as soon as possible and avoid clutter at workspaces to prevent from inadvertent exposure. Good PPE helps to control exposure to chemicals hazardous to health. The approved PPE provided shall:

    a. be appropriate to the type of work in which they are used for;
    b. fit and comfortable for the users;
    c. not affect the health or medical condition of the users; and
    d. be in sufficient supply and readily available to users who require it.

26. **Avoid inhalation of chemicals**: Use a fume hood whenever using volatile or aerosolized chemicals, even if the toxicity level is relatively low. Cap chemicals immediately after using them. Minimize the smelling of chemicals; only smell a chemical if no other method of identifying a chemical is available and just waft the air at the container opening towards your nose. Investigate the source of unfamiliar odors to eliminate them.

27. **Avoid ingestion of chemicals**: Do not taste chemicals. Never use mouth suction to pipet chemicals or start a siphon; use a pipet bulb or an aspirator instead.

28. **Avoid injection of chemicals**: Dispose of needles as soon as the injection is complete. Use needles with inherent safety devices that prevent accidental needle sticks. Discard sharps into appropriate waste containers and do not overfill them. When operating a high-pressure system, never use your hands to check for a pressure leak.

Washing Hands

29. Wash your hands thoroughly with soap and water after removing gloves and before leaving the laboratory area. Never wash your hands with organic solvents.

Eating and Drinking

30. Eating and drinking in the laboratory increase the chance of chemicals exposure; consumables are prohibited from being stored, prepared, or consumed in laboratories that use chemicals.

a. Glassware/Utensils

Never use glassware or utensils in the laboratory works to prepare or consume food or beverages.

b. Storage of Food/Beverages

Laboratory refrigerators, ice boxes, and cold rooms are not allowed for food or beverage storage.

Access to Emergency Equipment and Emergency Exits

31. Emergency equipment, such as eyewashes, showers and fire extinguishers must be directly accessible. Doorways, corridors, aisles, and stairways must not be blocked at all time to assure unobstructed access to exits in the event of an emergency.

Laboratory Signs

32. Laboratory Caution signs must be displayed clearly. These signs may provide information, prohibit unsafe act, or require protective measures.

a. Magnetic warning signs may be used to designate a “temporary hazard”. Warning signs must be display at a visible place at every entrance of the area to warn people entering the area of the hazards. The warning shall:
   (1) Give warning of the hazards.
   (2) Be written in Malay language and English language;

   Warning signs should be removed once the hazard no longer exists.

Housekeeping

33. Laboratory bench and other work surfaces must be wide enough to safely execute procedures. Aisles and exit routes must be unobstructed to allow for quick evacuation in the event of emergency. Always maintain the following in the laboratory:

a. Keep away flammable materials from ignition sources
b. Separate incompatible materials and chemicals
c. Emergency equipment and supplies (eyewash, shower, spill kit, fire extinguisher) readily accessible
d. Fume hoods maintained and organized

34. Shelves, cabinets, refrigerators and other storage equipment must be properly organized. Ensure all chemicals and scheduled wastes have the correct labels. Label information should be clearly visible. Storage on the floor should be limited and avoided whenever possible. Sinks should be clear of dirty glassware. Surfaces, if contaminated with hazardous materials, must be cleaned promptly. Garbage, recyclables, and any surplus equipment or materials must be discarded from the lab regularly. Air and gas tubing, power, control, and data wiring, must be routed to protect them from physical damage. do not create a tripping hazard, and are properly secured to appropriate infrastructure.

Sharps Safety

35. Sharps are objects that are used to cut or puncture body parts. Other sharps items can still cause injuries, although they do not fit the regulatory definition of sharps. Safety measures are essential to prevent injury and exposure.

36. Identify sharps devices to be used in laboratory procedures. Whenever possible, substitute a non-sharp alternative consider using a safe sharps device. If a sharp must be used, training and practice are required to prevent injury. Avoid recapping needles; if a needle must be recapped, use a needle holder to do so. Never leave an uncapped needle exposed in the work area. Promptly place all sharps waste into a sharps bin. Store reusable sharps in a labelled storage container. Use a magnet to contain reusable metal sharps.

37. Avoid factors and conditions that can lead to a sharps injury, such as hurrying or working when you are tired. Keep work area neat and tidy so that sharp items are always visible.

CHEMICAL MANAGEMENT

Chemical Procurement

38. Procurement of chemicals should be done through UM eProcurement system. Observe the following guidelines and recommendations in the procurement of these chemicals:

a. **Hazardous chemicals.** Avoid stockpiling chemicals and order only the minimal amount needed. Expired hazardous chemicals which are no longer useful should be considered, and treated as hazardous waste. Hazardous chemicals should be received directly in the laboratory and not by office personnels. As a precautionary step, make sure the chemicals that you received are correctly labelled, the container is intact, and has the correct date of receipt.

b. **Radioactive materials.** Application to procure radioactive material has to be submitted to UM Radiation Protection Services Unit (UPPS) prior to procurement of the material. Prior to approval, inspection will be carried out to ensure that necessary engineering and environmental controls are in place to accommodate the radioactive materials. More details can be obtained at –
UMPortal > PTj Info > Pejabat Keselamatan dan Kesihatan (OSH) > Manual Keselamatan dan Kesihatan Pekerjaan > Pengurusan Keselamatan Radiasi.

c. **Highly dangerous chemicals/ materials.** Administrative, engineering and environmental controls need to be in place before any highly dangerous chemicals can be procured. Examples of such chemicals include, but not limited to:

(1) Highly toxic gases

(2) Ultra-environmental toxic compounds like polyhalogenated dibenzofuran, -dibenzodioxin, -bifenyles and hexachlorobenzene.

These materials are deemed extremely hazardous to users and surroundings, and must be stored and used in accordance to the regulations. Contact OSHE at 03-7967 7925 for more information.

d. **Compressed gas cylinder**. Preferably, gas cylinders should be purchased through a supplier with cylinder return authorization program. It is important to make sure an arrangement has been made for the manufacturer to take back both the cylinder and any unused gas. Only order the amount of gas that you need and avoid stockpiling of gas cylinders.

Chemical Inventory

39. Laboratories must maintain a chemical inventory to enable the identification of hazards for specific locations. Besides, the inventory is required to enable the University to keep track of chemicals on the campus and comply with legal requirements. In order to optimize resources and minimize hazards, the chemical inventory should be accessible for every laboratory user. While sharing of particularly hazardous chemicals is encouraged, it remains subject to the approval by the owner.

40. The inventory must list all chemicals, together with their respective location (building/room) and the contact of the responsible staff. The data should be regularly updated and annually checked on consistency. During the physical inventory all containers should be checked on deterioration and integrity. Chemicals not matching safety requirements must be disposed following the respective regulation for scheduled waste.

41. The University aims for a central chemical inventory covering the entire University. The system should enable fast access to hazard and accident response information inform of either material safety data sheets (MSDS) or according to the new safety data sheet (SDS) format. Furthermore, it should provide a fast (location-based) summary of all chemicals, preferably summarized according to hazard classes.

42. In view of consistency of the inventory, database records on chemicals (including names, reference numbers, hazard and property information as well as SDS/MSDS links) must be restricted to administrators, while records on specific containers (amount, manufacturer and possibly specific information) shall be edited by the respective laboratory owners. The use of tracking system for every container is highly recommended. In order to promote the exchange of chemicals and identify potential substitutes due to hazards or availability, chemicals should be recorded together with structural formula, while the inventory should enable a substructure search. While reading access to the chemical inventory shall be provided to everyone working in a laboratory with chemicals, writing rights for containers shall be restricted to selected users only. A multi-level login system can ensure this constraint.

Chemical Storage

Evaluating Chemical Hazards for Storage

43. The following consists of hazardous properties of chemicals which might arise due to incompatibility:

a. Heat generation

b. Fire risk

c. Explosion

d. Flammable gas and/ due to vapor production

e. Toxic gas and/ due to vapor production

f. Formation of shockwave/ friction-sensitive compounds

g. Formation of a substance with bigger toxicity than the reactants

h. Solubilization due to toxic materials

i. Pressurization due to closed vessels

j. Dispersal of toxic mists and filths

k. Vicious polymerization

44. General approach to be taken is to separate all chemicals into compatible groups. The specific SDS or MSDS should always be referred to when assessing chemical properties and hazards of the materials for storage. Most chemicals have multiple hazards; decisions should be prioritized as follows:

a. **Flammability**. The most important consideration for storage is the flammability characteristic of the material. Under the Occupational Safety & Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013, flammable chemicals are classified into three sub-categories i.e. Extremely Flammable, Highly Flammable and Flammable. The precautions to be taken are diverse between liquids, solids and gases as mention below:

(1) **Liquids**. Three principles were used to classify a liquid, either as extremely flammable, highly flammable or flammable, as such:

(a) **Extremely Flammable Liquid.** Chemicals and/ or experiments having a flash point < 0°C and a boiling point ≤ 35°C

(b) **Highly Flammable Liquids**. Liquid chemicals and/ or experiments having a flash point < 21°C but which are not extremely flammable.

(c) **Flammable Liquids and Preparation.** Liquid substances and/ or experiments having a flash point ≥ 21°C and ≤ 55°C.

(2) **Solids**. Criteria of solids in order to classify it as highly flammable include: Solids which can ignite by brief contact with a source of ignition or be sensitive to friction, and that will continue to burn after removal of the source of ignition. E.g. matches, fire lighter, nitrocellulose and sulfur.

(3) **Gases.** Gases that are flammable in air at normal pressure are classified as highly flammable.

b. **Reactivity**. If the material will contribute significantly to a fire for example oxidizers, where these chemicals can supply their own oxygen and do readily assist and maintain combustion, may create fire if they meet organic combustible materials. Storage rules must therefore be strictly observed. Oxidizing chemicals should not be stored near combustible chemicals, it should be isolated from flammables items. If the material is expected to caught fire when water is applied (refers to water-reactive chemicals), it should be stored to ensure it is protected from any contact with water, including water that would be applied while dowsing a fire in the lab. Isolate materials that can react with themselves for example polymerization.

c. **Corrosives.** Corrosive substances are chemicals that trigger a reaction which lead to the damage of a solid structure. A material is considered corrosive if a liquid or solid causes irreversible destruction of human skin at the site of contact within a specified period. Corrosivity of the material need to be evaluated and store accordingly.

d. **Toxicity.** Toxic chemicals are harmful by inhalation, contact and ingestion. These chemicals should be avoided from contact with acids, heat, moisture and oxidizing chemicals. The toxicity of the material, with attention paid to regulated materials, means that certain chemicals will be isolated within a storage area. For example, an extreme poison that is also flammable should be locked inside the flammable storage cabinet.

Chemical Storage Practices

45. Safe chemical storage and segregation procedures are established and need to be followed for your laboratory:

a. Provide an appropriate storage place (refer to Table 1) for each chemical and return the chemical to that location after use.

b. Store in compatible containers for each category Incompatibles must not be stored together; refer to the Chemical Compatibility Chart: (http://www.merckmillipore.com/Web-SG-Site/en_US/-/SGD/ShowDocument-Pronet?id=201510.400) and the Chemicals Separation and Segregation section.

c. Avoid storing chemicals on bench tops.

d. Avoid storing chemicals in fume cupboards, except the malodorous chemicals.

e. Do not expose stored chemicals to heat or direct sunlight.

f. Keep volatile toxics and odoriferous chemicals in a ventilated cabinet, if available.

g. Storage shelves should be level, stable, and secured to the wall or stable surface; in case of an earthquake, shelves should have raised edges or rim guards (minimum height: 2 inches) to prevent containers from falling; shelves should be kept free of chemical contamination and dust sources.

h. Containers should not protrude over shelf edges.

i. Keep heavy bottles on lower shelves; store corrosives below eye level; ideally, cabinets and shelves should be tough and low to the floor and constructed of material that is impervious with the corrosive; they should also be ventilated or located near the ventilation system.

j. Containers of chemicals must be capped when not in use; make sure that caps on containers are secure; damaged caps should be replaced.

k. If a chemical does not require a ventilate cabinet, keep inside a closable cabinet or on a shelf that is anchored and that has a lip to prevent containers from sliding off. Storage space under fume cupboard is an option.

l. Chemicals should not be stored under, near, or in the sink to minimize the chance of accidents and improper discharges to the sanitary sewer. Some chemicals, including those corrosives, are water reactive and, in the event of a water leak, there can be unanticipated and unfortunate consequences.

m. Do not place/ keep chemicals in corridors, hallways, or exit ways.

n. Use secondary containment to prevent incompatible chemicals from mixing and reacting with each other if they must be stored adjacent to each other on a benchtop.

o. Use secondary containment or spill control, such as placing the container on an absorbent pad (generally required for containers on the floor).

p. Signs should be posted indicating “Toxic” chemical location and unique hazards.

q. Particularly hazardous substances (highly dangerous or toxic chemicals, select carcinogens, mutagens, and teratogens) should be stored together if compatible.

r. Maintain the lowest possible quantities of highly toxics.

s. Chemicals with a high degree of toxicity should be doubly contained and stored in a locked area accessible only by authorized personnel.

t. Use containers that are chemically resistant and non-breakable.

u. Store chemical wastes accordingly (see Chemical Waste section).

v. Waste containers must be labelled with a completed University of Malaya hazardous waste label. If reusing a container that previously held another compatible chemical, the original manufacturer’s label must be defaced.

w. Use properly designed refrigerators or freezers for storing volatile flammables which are to be stored cool. “Explosion-proof” appliances are usually not required for the typical laboratory setting.

x. If containers are placed in refrigerator/ freezer door shelves, use secondary containers, additional barriers, Velcro or other protective measures to keep them from falling out when the door is opened.

y. If chemicals are stored in a shared area or room, the storage space, cabinet, or container should be labelled with the responsible owner name so that ownership can easily be identified.

Table 1. Chemical Storage Recommendations

General chemicals	Store on laboratory benches or shelves with similar chemicals.
Flammables liquids	Precautions to be taken for all categories include storing flammable liquids in a cool dry place, away from sources of ignition and heat, and securely closed containers specifically designed for the purpose. In all cases adequate ventilation at high and low level will be needed to disperse any vapors from leaking containers.
Flammables solids	Storing flammable solids in a cool dry place, away from sources of ignition and heat, and securely closed containers specifically designed for the purpose.
Flammables gases	Cylinders of liquefied gases should be stored in upright position and in open air so that any leaks from valves etc. will be of vapor or gas rather than liquid.
Acids	Do not store with flammable solvents or combustibles. Ideally, store in a cabinet designed for acids; do not store acids on metal shelving. Segregate inorganic from organic acids. Isolate nitric acid and perchloric acid from everything; including other perchloric. No store should be used for the simultaneous storage of nitric acid mixtures and sulfuric acid mixtures. Sometimes it is necessary to store corrosive and poisonous liquids in special types of containers; for example, hydrofluoric acid should be kept in leaden ceresin bottles.
Bases	Store in corrosives cabinet or on protected shelving away from acids. Segregate inorganic from organic bases.
Light sensitive chemicals	Store in amber bottles in a cool, dry, dark place
Nitrated compounds	Nitrated compounds can be considered explosive; special care and handling may be required (Refer to Nitrated Compound under Special Chemical Hazards section)
Oxidizers	Store in a cool, dry place away from flammables and reducing agents. Oxidizers must not be stored on wooden shelves or in cardboard boxes.
Peroxidizable chemicals	Store in airtight containers in a dark, cool place. Most peroxidizable compounds are flammable and should be stored in a flammable liquid storage cabinet. Label containers with receiving and opening dates. Test for the presence of peroxides at least every six months. Discard before exceeding expiration date. Inspect peroxide forming chemicals often for evidence of contamination, degradation, or any change from normal physical or chemical characteristics. If you suspect a material may have become explosive, contact OSHE immediately and post “warning sign” so others do not handle or disturb the material (Refer to Organic Peroxide-Forming Solvents under Special Chemical Hazards section)
Pyrophoric substances	Store in a cool, dry place, making provisions for an airtight seal. Materials (e.g., tert-butyl lithium) will react with the air to ignite when exposed (Refer Pyrophoric Chemicals under Special Chemical Hazards section).
Toxic chemicals	Store according to the nature of the chemical, using appropriate security where necessary. Generally, store in a ventilated, dry, cool area in a chemically- resistant secondary container (Refer to Compounds that Generate Toxic Gases under Special Chemical Hazards section).
Water-reactive chemicals	Store in a cool, dry location away from any water source, including sprinkler systems. Have a Class D fire extinguisher available in case of fire (Refer to Water Reactive Chemicals under Special Chemical Hazards section)
Compressed gas cylinders	Store in a cool, dry place, preferable outside of the building and secured with a chain. Separate flammables and oxidizers by at least 6 meters.

Chemicals Separation and Segregation

46. The purpose of chemicals separation and segregation is to minimize the risks of fire or cross contamination often obtainable by mixed storage arrangements of incompatible materials. Correct separation will minimize the extent of hazardous zones and the requirement to bund or to install protected electrical equipment. Some chemicals with multiple hazards characteristic fit into different storage classes. Phenol, for example, is flammable, toxic and corrosive. The storage class it is put in depends upon the most likely hazard found in the facility. If sources of ignition are present, perhaps it should be stored as a flammable.

47. MSDS for reactivity data should be consulted to determine whether the chemicals are compatible. Some acids may react together to produce heat or toxic gases. Examples are:

a. Acid/hypochlorite: produce chlorine gas;
b. Acid/cyanides: produce hydrogen cyanide gas;
c. Acid/alkalis: produce heat;
d. Acid/sulfide: produce hydrogen sulfide.

48. Segregation of acids from other chemicals will go some way to ensuring incompatible chemicals is not stored together. The extent of such incompatibility problems is reduced because damage to two packages must occur before any reaction can take place. Also, mixing and reaction is likely to be slow if both incompatible components are solids.

Chemical Labelling

49. The employer shall ensure that chemicals to be stored should be classified, labelled and/ or relabelled as per the Occupational Safety and Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013, or The Pesticides Act 1974 or The Environmental Quality (Scheduled Wastes) Regulations 2005. The details on which containers are to be labelled and relabelled please refer to the Occupational Safety & Health (Use and Standard of Exposure of Chemical Hazardous to Health) Regulations 2000.

Label on Original Container

50. The label on an original chemical container must be legible and written in English. It must include the chemical/product name as shown on the SDS or MSDS and the manufacturer's name and address. Do not accept materials if the label is illegible or missing required information. (See Figure 1, Example of Original Label).

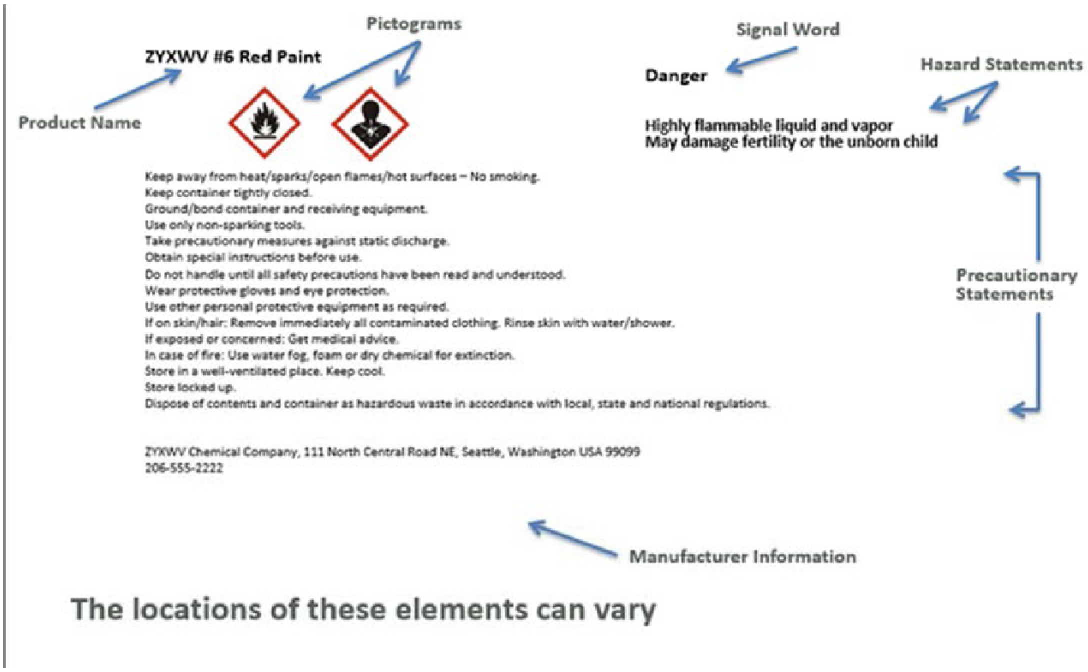


Figure 1. ***Example of Original Label***

Label on Permanent Container

51. Employers must ensure that no worker uses, stores, or allows any other person to use or store any hazardous substance in a laboratory if the container (including bags, barrels, bottles, boxes, cans, cylinders, drums and reaction vessels) does not meet the following labelling requirements in the Occupational Safety and Health (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013, or The Environmental Quality (Scheduled Wastes) Regulations 2005.

52. The identity of the chemical and appropriate hazard warnings must be shown on the label.

a. The hazard warning must provide users with an immediate understanding of the primary health and/or physical hazard(s) of the hazardous chemical using words, pictures, symbols, or any combination of these elements.

b. The name and address of the manufacturer, importer or other responsible party must be included on the label.

c. The hazard label message must be legible, permanently displayed and written in English.

Label on Portable/ Secondary Container

53. Laboratory operations may require transferring of chemicals from the original labelled container into a secondary container (e.g., bottle, beaker, flask). Portable containers must comply with the labelling requirements listed above if any of the following events occur:

a. The material is not used within the work shift of the individual who makes the transfer.

b. The worker who made the transfer leaves the work area.

c. The container is moved to another work area and is no longer in the possession of the worker who filled the container.

d. Labels on portable containers are not required if the worker who made the transfer uses all the contents during the work shift.

54. When a secondary container is used for longer than one shift or does not meet the requirements outlined in the Permanent Container Labels section, above, a label needs to be applied to the secondary container. This label must contain two key pieces of information: the identity of the hazardous substances in the container (e.g., chemical name) and the primary hazard symbol. There are many ways to communicate this hazard information. Employers should select a system that will work for each location.

Container Label Replacement

55. The existing label on a container entering the workplace from a supplier must not be detached, changed or defaced. If a chemical container's original label must be replaced, the new label must contain the same information as the original. Only use labels, ink and markings that are not soluble in the liquid content of the container.

Waste Containers Label

56. Waste containers must be labelled following this waste management guideline for hazardous chemical waste. If re-using a container to hold waste, the container must be compatible and appropriate for the waste. Completely deface all old labels on containers used for wastes and affix a new label.

Transporting Chemicals

57. Chemicals should be transported in a container that prevents leakage. The container should be closed. Transporting chemical containers which may have contamination on the outside should be avoided. Rules for example avoiding the need to wear gloves or other PPE while transporting chemicals. If the container is breakable, it should be placed in a secondary container with labelling.

a. **Transporting between Floors and Buildings on Campus**. This section applies to transportation by hand or by cart. In general, when possible, use only cargo lift when moving chemicals between floors.

(1) **Moving a Single Chemical**

(a) The person doing the moving must be trained in the hazards of the chemical and know what to do in the event of a spill of that chemical.

(b) The exterior of the container should be clean enough that it may be handled without the need for protective gloves.

(c) Chemical bottles must be labelled and should be securely capped and placed in a bottle carrier.

(d) Chemical containers that are glass and do not have closing caps or handles should be placed in bottle carriers or larger containers and surrounded by vermiculite or other absorbent material.

(e) When moving a lecture bottle, do so in a manner that protects the valve. Larger gas cylinders must be moved using precautions (see Moving Compressed Gas Cylinders under Special Chemical Hazards section).

(f) Whenever possible, use cargo lift to transport chemicals. If no cargo lift is provided, passenger lift may be used, but passengers should be discouraged from travelling with liquid and solid materials. Passengers (other than the material handler) are not allowed in the lift with compressed gas and cryogen transport.

(2) **Moving Multiple Chemicals**

(a) The person doing the moving must be trained in the hazards of the chemicals and what to do in the event of a spill of those chemicals.

(b) The person should know where to access a spill kit to handle the spill of those chemicals.

(c) The exterior of the containers to be moved should be clean enough that they could be handled without the need for protective gloves.

(d) Chemical containers must be labelled and securely closed. Lecture bottles should be packed in a manner that protects the valve.

(e) Chemicals should be grouped by compatibility and by hazard class (e.g., flammable, toxic, etc.) and each group should be placed in larger containers while being transported.

(f) Breakable containers should be cushioned against impact during transport.

(g) Carts used to move chemicals should be stable under the load and have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly.

(h) For laboratory moves across campus, PTj can arrange for a contractor to pack and move your chemicals for you, or you can pack and move them yourself using proper packaging and a UM Motor Pool vehicle (see Moving in/Moving out Lab section).

b. **Transporting Chemicals off Campus**

(1) **Vehicle Use.** Transport certain hazardous materials in UM-owned and operated Motor Pool vehicle. You cannot transport hazardous chemicals in your personal vehicles without prior authorization by PTj.

(2) **Shipment by others.** If you ship hazardous materials by vehicle or air, you are required to be trained. This includes situations when you use a commercial contractor (FedEx, United Parcel Service, etc.) to transport a hazardous material for you. You are responsible for complying with all applicable transportation regulations, which ensure the safety of your chemicals as well as those who transport them. Provide a Safety Data Sheet for each chemical (signed safety statement/SDS must be attached for non-commercial chemicals).

c. **Receiving Chemical Shipments.**
Inspect all incoming shipments to ensure proper labels are attached, accurate, and that the containers are intact and in good condition. Any leaking containers must be placed in an appropriate, secondary container and treated as a chemical spill. In the event of chemical spill, refer to SOP for Chemical Spillage. If you receive a shipment container that appears to be bulging or pressurized, isolate the package, and consult PTj for the next course of action.

SPECIAL CHEMICAL HAZARDS (SCH)

58. Particularly Hazardous Substances or Special Chemical Hazards (SCH) are natural/synthetic compounds that embody a high risk to employees/workers in the work environment. Working with these substances requires specific preparation and approval from your PI or director, and well-planned standard operating strategies that identifies designated work areas, regulatory device such as fume hoods and glove boxes, systems for disinfecting, and endorsements prior to work.
(Refer to standard operating procedures (SOP) in the Annexure).

59. SCH include the followings definitions:

a. **Highly Toxic**: Low dose chemicals that may cause death, permanent injury or illness.

b. **Highly Dangerous**: Chemicals that are highly reactive easily upon exposure to STP conditions such as one that is self-immolates or explodes upon contact with the atmosphere

c. **Select Carcinogens**: Chemicals identified to cause or highly suspected of causing cancer in humans.

d. **Reproductive Toxins**: Chemicals identified to likely cause harm to fetus , or even affecting infants or babies after birth.

e. **Select Toxins**: Chemicals that are known to affect humans due to their high toxicity.

60. The University recommends you to review the manufacturer's SDS and other sources of hazard information (e.g. Chemspider at http://www.chemspider.com) to determine if the chemicals of your interest fall within the above criteria and therefore require additional safeguards. Work personnel need to take caution with chemical substances that have one of these properties: reactive, explosive, highly toxic, select toxins, carcinogens and reproductive hazards, sensitizing or allergenic, synthesized chemicals These properties include any chemicals that are in compressed gas cylinders or at high pressure, that present exceptional flammability hazard, or have additional specific requirements due to federal regulations. The chemical is classified as a "Special Chemical Hazards" if the hazard rating could cause potential health side-effects to users or persons around the users. Expanded precautions for use include:

a. Additional security measures for the chemical's storage.

b. A second opinion on the proposed SOP by a qualified personnel.

c. Intensive training on the hazards rating, chemical usage and related equipment.

d. Record keeping and proficiency exercises and tests prior to procedures be implemented.

e. Compulsory presence of a second lab worker be in the laboratory.

f. Ensure all safety measures are documented and read by all laboratory members.

g. Check that additional measures for shipping of materials have been documented and confirmed.

61. This Section lists nine types of chemicals under the umbrella of "SCH". These are:

a. **Reactive.** A reactive chemical is defined as chemicals that may undergo violent changes such as explosion or production of potentially toxic fumes, during usage. It is suggested that the purchase of these chemicals must be in small quantities else, a suitable safety alternative must be present. Chemicals with an US-National of Fire Protection Association (NFPA) rating of minimum "3" of this category are considered as SCH. Extra precautions should be taken and need to be documented in your SOPs. Examples of chemicals belonging to this category:

Subtypes	Description	Examples
Generate Fumes	Some compounds that contain sulfide or a cyanide functional groups can generate toxic gases in sufficient quantities to present a danger to human health when combined with other compounds, such as hydrochloric acid.	Copper (II) cyanide Mercury (II) cyanide 1,4-Dicyanobutane Octyl cyanide Methyl sulfide Sodium sulphide
Oxidizers	Oxidizers initiate or promote combustion of other materials. The most commonly used are halogenated inorganics, nitrates, chromates, persulfates and peroxides. Care must be taken	Ammonium dichromate Lithium perchlorate Potassium chlorate Ammonium nitrate Nitric acid Potassium permanganate Nitric oxide

	when disposing of "used" oxidizers into common waste container (under the belief that the oxidizer were inactive) as this might lead to explosion/fire hazard.	Sodium acetate Chromic acid Oxygen Perchloric acid Sulfuric acid
Polymerizable chemicals	Uncontrolled waste of polymerizable chemicals can lead to potential hazard for the reaction that could release energy or drastically increase the volume of the chemical/container. The former might cause explosion/fire hazard while the latter potentially cause blockade in the piping/sewer system.	Acrylic acid Acrylonitrile 1,3-Butadiene Isopropenyl acetate Styrene Vinyl bromide 2-Vinylpyridine
Pyrophoric	Self-immolated chemicals that autocombust upon contact with air at/below 54°C is considered pyrophoric. The spontaneous oxidation of a compound by oxygen in the air that can proceed rapidly will cause fire/explosion. Extra precautions must be taken to ensure a safe working environment and need to be documented in the SOPs.	Barium metal Potassium metal Sodium methylate Lithium diisopropyl amide Rubidium metal Tert-butyllithium Magnesium powder
Water Reactive	Chemicals that react violently with water that would result in potential health hazards. For example, alkali metals reacts with water will rapidly produce heat and flammable hydrogen gas. Extra precautions must be taken to ensure a safe working environment and need to be documented in the SOPs.	Acetyl chloride Sodium metal Antimony trichloride Phosphorus oxychloride Tert-butyllithium Calcium hydride Phosphorus pentachloride Titanium (IV) chloride Hydrobromic acid Phosphorus pentasulfide Trimethylchlorosilane Lithium aluminum hydride Potassium metal

b. **Potential Explosive.** Potential Explosive materials is defined as any solid/liquid materials that upon contact or treatment to heat (increase in temperature), impact (high pressure), friction, electrical current/spark, or chemical reaction, will result in changes in either pressure, heat or gas (expansion of enthalpy). If these chemicals detonated/exploded in controlled or uncontrolled manners, the explosion may result in harm to UM personnel or property damages. Common potentially explosive chemicals include:

Subtypes	Description	Examples
Nitrated Compounds	Organic and inorganic substituents of nitrates that may explode when dehydrated. Consult the MSDS and plan ahead prior to the use of any nitrated compounds.	Diphenyl hydrazine Nitrocellulose Nitrotoluene Trinitrobenzene Trinitrophenol Picric Acid Metal picrates
Peroxide-Forming solvents	These solvents readily form appreciable quantities of shock sensitive peroxides upon exposure with oxidants (e.g. atmospheric air/oxygen) for a period of time and can also be catalyzed by light, or a change in temperature or pressure. The group of chemicals are mostly colourless liquid. It was reported that laboratory accidents such as explosion during distillation of peroxide-forming organic solvents occured. At moderate peroxide concentration, these peroxide-containing solvents	Moderate Hazard: Slow solvent forming peroxides. *Examples*: ethylene glycol ethers ethyl vinyl ketone oleyl alcohol tetrabutylammonium flourides.

	could detonate even bymodest shock, friction, or heat. Extra care must be taken when decanting and during distillation. Do not open or move the container if crystals are seen on or around the container cap. Ask your PI for assistance when required. Peroxides concentration test kit can be purchased if in doubt. As a guide, a peroxide quantity of 10 ppm or less is safe. Extreme hazardous status is applicable when the peroxide concentration reaches 30 ppm and above.	High Hazard: Moderately solvent forming peroxides. *Examples*: Acetaldehyde Cyclohexene Cyclopentene Diethyl ether Di-N-propyl ether Furan p-Dioxane Severe Hazard: Rapid peroxides forming solvents. *Examples:* Diisopropyl ether Potassium amide Potassium metal Sodium amide Vinylidene dichloride Divinylacetylene
Azides	Organic and inorganic chemicals containing azide functional group ($R\text{-}N_3$) may explode when heated but less sensitive to shock/pressure. Azides present a hazard when present around connecting joints (glassware connection points) as the act of joining glassware may result in shock/friction therefore explosion.	All chemicals containing R-$\mathbf{N_3}$ functional group
Fulminates	Organic and inorganic chemicals containing fulminate functional group ($R\text{-}ONC^-$). Explosion causes by fulminates are typically initiated by heat.	All chemicals containing R-$\mathbf{ONC^-}$ functional group

c. **Highly Toxic.** The University adopts the definition of “highly toxic” substance if it falls into these categories:

(1) A chemical that has a median lethal dose (LD50) of <50 mg/kg of body weight when administered orally to albino rats weighing between 200 and 300 grams, each.

(2) A chemical that has a median lethal dose (LD50) of <200 mg/kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms, each.

(3) A chemical that has a median lethal concentration (LC50) in air of <200 ppm of gas or vapor, or <2 mg/L of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams, each.

Materials under this section must have correct and compliant poison hazard signs on its container. The University also highly encourage (potential) users to develop and enforce written SOPs for working with each highly toxic material. Users can refer to the list of toxic substances provided by the United States Center for Disease Control at https://www.atsdr.cdc.gov/substances/index.asp.

Examples of chemicals belong to this category are: mercury- and cyanide-containing substances.

d. **Carcinogenic & Reproductive Hazards**. Typically, the hazardous effects of chemicals belong to this group is not acute, but chronic. Thus, additional care must be taken when handling chemicals or substances reported (known or suspected) to be carcinogenic and reproductive hazards. The United States Center for Disease Control has a list of chemicals belonging to this category (https://www.atsdr.cdc.gov/substances/ToxOrganSystems.asp).

Some examples include (known) asbestos, arsenic, benzene and vinylchloride; and (potential) chloroform and DDT.

e. **Hazardous Drugs.** The University adopts the Malaysia MOH Guidelines on Chemical Management for the classification of hazardous drugs (https://bit.ly/2moB5uQ). Examples of hazardous drugs are cytotoxic drugs that are used for cancer chemotherapy or research thereof, antiviral, hormones, bioengineered drugs and others. The health effects of these hazardous drugs on the users depends on the degree of exposure and the drug's toxicity. Hazards may manifest in the form of contact diseases, infertility, miscarriage, birth defects, leukaemia or other cancers.
Examples of hazardous drugs include all chemotherapeutic substances, and any registered drugs known to cause damage at the cellular level (https://bit.ly/2mtTjeD).

f. **Sensitizing & Allergenic.** Substances belong to this group may affect UM personals by forcing changes in style of life and, in some cases, force them to leave their areas of research, once affected/inflicted. This hazard is not limited to "traditional" laboratory chemicals only, rather, researchers may develop allergies to animals and other niche forest resources such as the molds. Once sensitized, allergic reaction can be triggered at extremely low amounts of the chemical. Hazardous health effects may range from contact dermatitis to anaphylactic shock.

The University suggests extreme caution to minimize exposure by always wearing PPEs and ensure staff working under controlled environment (e.g. fumehood, glovebox, etc). Situations that may lead to an acute exposure, such as cleaning up a spill, should be carefully assessed to keep the exposure at a safe level. If a person is sensitized or allergic to a similar chemical, any control, which will prevent exposure to the lab chemical, should be implemented, e.g., improved ventilation, barriers, or improved procedures.

Examples of sensitizing and allergenic substances includes beryllium, chromium, isocynates, diazomethane, latex, formaldehyde, nickel, phenols, cyclohexanedicarboxylic anhydride, uranium salts (e.g. HBTU).

g. **Synthesized Compounds.** Unfortunately, synthesized chemicals may potentially present with unexpected hazards, until proven otherwise. The University encourages staff to always perform literature review concerning expected hazards from proposed methods/procedures/reactions or chemicals with similar structure or functional groups – taking into account that similar hazards are potentially present. The University also suggests personnel to always generate only the minimal required quantity of a new substance until the hazard of such a chemical can be determined.

Subtypes	Description	Examples
Nanoparticles	Nanoparticle is a class of substances with, at least, having one dimension less than 100 nm andcan be engineered or synthesized from naturally occurring compounds. Nanoparticles may be more hazardous than their bulk-size counterparts. Special care must be taken to prevent its release to the environment. Laboratories that intend to create nanoparticles (special attention to aerosolized particles), must analyse the potential hazards before the project initiation and compare to subsequent hazard levels. Please refer to Ministry of Human Resource (DOSH) guidelines on control of safe handling of nanomaterials for further info (https://bit.ly/2m75kGo).	Aerosolised drugs Quantum dots (QD) Metal-Organic framework (MOF)
Other synthetic substances	A laboratory within the University that synthesizes chemicals for use by other parties (within or outside to the University) will be considered as the resource responsible for providing hazard cautions to those receiving the chemical. University personnel procuring a hazardous chemical should provide enough information about the hazard associated or the safety precautions when using the chemical.	All synthetic materials – known or novel

h. **Compressed Gases, Cryogenic Liquid and Gas Cylinder/Containers.** Compressed Gas describes these categories of gases: dissolved, compressed, liquefied compressed, and refrigerated liquefied cryogenic. Additionally, this section also includes “non-liquefied compressed gases,” non-liquid at normal temperature or high pressures and “liquefied compressed gases,” a group of gases that become liquid at normal temperatures only when pressurized in a cylinder.

(1) Refrigerated liquefied gases, also known as *cryogens*, become liquid at very low temperatures. The cryogenic gases have boiling points below -150°C. Dissolved gases are gases dissolved in other substances while stored in gas cylinders/containers.

(2) Cryogenic gases, and the more common, compressed gases are widely used in both teaching and research laboratories across the University. The pressure at which gases are contained in gas cylinders can be extremely high, which makes it both physical and health hazard if improperly handled.

(3) The main hazard from gas cylinders arises from the large amount of stored energy they contain due to the pressure of the compressed gas within them. If the pressurised gas is released in an uncontrolled manner, this can cause considerable damage. Uncontrolled release and flying particles (including the cylinder itself) can occur from failure of the cylinder or its fittings and may arise if it is involved in a fire or it suffers damage in a collision.

(4) Gas cylinders also present a hazard from their contents which, even if not directly hazardous by nature of their flammable, toxic, corrosive or oxidising properties, can still cause an asphyxiant hazard when expand into large volumes of gas that displaces oxygen. The inherent weight and size of cylinders may also

present a physical hazard during transport and manual handling or if they topple.

(5) The University request that personals handling SCH belonging to this category to be well trained. Do refer to the SDS of the respective gases and SOP for safe handling, usage and moving of gas cylinders.

i. **Special Note Safety Management on Compressed Gas Cylinders**

It should be noted that the compressed gas cylinders under the Section 3, FMA 1967 is classified as machinery and it under the interpretation of 'plant', while and the gas has been interpreted as a 'substance'. And, under the OSHA 1994 stipulates it is the duties and responsibilities of the employer (hence, the PI, PIC, etc) to ensure the use of a plant or substance is safe and without risks to health to the staff and and other persons (students, visitors, etc) at the workplace. Below are safety requirements and guidance for management and usage of compressed gases.

(1) Ensure you are aware of safe handling of gas cylinders before working with them. Wear proper PPE, especially moving the cylinders, such as –

(a) Wear safety goggles

(b) Wear work gloves

(c) Wear safety shoes (steel-toe capped shoe)

(2) All gas cylinders must contain labels that clearly identify the contents. Always check the label – Do not rely on color codes on the cylinders. It is encourage to include a label to indicate is volume, ie. full, ½ full, or empty.

(3) Post suitable warning signage for compressed gases. For example, proper signage is required at areas where hydrogen and/or acetylene is used or stored, ie. FLAMMABLE GAS – NO OPEN FLAMES - NO SMOKING.

(4) Physical tethering of compressed gas cylinders (empty or otherwise). Some methods of support include:

(a) Wall- or bench-mounted cylinder brackets;

(b) Chains or belts anchored to walls or benches. Metal chain (or belts) is necessary whilst <u>plastic chain is not acceptable</u> and should not be used. The chain (or bracket) should be secured above the cylinder gravity center, e.g. at the 2/3 location of its height. Ensure the wall or the support system able to support the weight of the cylinders;

(c) Chains or belts anchoring the free-standing dollies/carts designed for gas cylinders.

(5) When unused, gas cylinders must have the valve protection cap or pressure regulator in position. When moving cylinders, it is strongly suggested to remove the pressure regulators and replace valve protection caps to avoid sudden pressure release (in case of an accident), even if you have secured the cylinders to a dolly or

hand truck.

(6) Do not move cylinders by spinning, sliding, rolling, etc since these acts may cause damage to the cylinder. For movement within laboratories, it is advised that two UM personnel to work hand-in-hand to move any cylinders weighing less than 30 kg. For moving heavier cylinders, use appropriate dollies or hand trucks. Seek help from more personnel.

(7) For gases with a health hazard rating of three or four (ie, ammonia, carbonyl sulfide, methylamine, and nitric oxide), cylinders must be kept under exshaustable hoods or enclosures with direct-to-outdoor ventilation. These storage areas need to have marked 'first aid' and 'antidote' information at all room/lab entrances. MSDS must be accessible, and appropriate PPE should be available when required.

(8) Select and use pressure regulators and gauges that arecompatible with the cylinder valves. Consult the gas supplier to confirm which kind of regulator to use. Do not use adapters or "cheaters" instead of the correct regulator and gauge as unregulated adapters may lead to high levels of health hazards.

(9) Teflon tape must not be used on cylinder or tube fitting connections that have metal-to-metal face seals or gasket seals;

(10) For cylinders containing oxidizing gases, e.g. oxygen, ensure all valves, gauges, regulators, pipes and fittings to be scrupulously free of oil, grease, graphite or any other oxidizable substance before assembly. Presence of these oily products may lead to gas leak therefore danger of fire or explosion

(11) Storage of gas cylinders –

(a) Store and secure cylinders in a well ventilated areas and away from sources of heat, flames, and the sun.

(b) Ensure all compressed gas cylinders have labels to identify its contents.

(c) When possible, segregated cylinders by hazard classes.

(d) Where flammable or oxidising gases are stored, ensure it has portable fire extinguishers are available

(e) DO NOT store flammable gases next/near to an exit or near oxygen cylinders.

(12) Any leaking cylinder should be removed from the lab and isolated in a secured and well-ventilated area. Contact the PTj's emergency response personnel for help.

(13) If you have a gas cylinder with a damaged valve, do not use the cylinder and seek advice from the gas supplier. And, if there is a leak at the junction of the cylinder valve and cylinder DO NOT try to repair! Instead, contact the gas supplier immediately.

SCH Suggestions

62. We suggest the following when UM personnel plan to use any SCH (1-7) categorized above:

a. Substitution to a less hazardous chemical, if possible.

b. Purchase/synthesize/transport SCH in small quantity (volume/weight).

c. Purchase of chemicals (with inhibitors) to avoid unwanted hazards.

d. Familiar yourselves with the SOP of handling and usage of SCH.

e. When required, always work in a working fumehood (or well-ventilated area), with appropriate PPEs.

f. Each laboratory must ensure working eyewash and shower station by performing annual maintenance or testing.

g. Always write the weight/volume of the SCH compounds on the transportation/storage box/container.

h. Ensure the correct container is used (e.g. sealed, unsealed, metal, glass, plastic, PTFE).

i. Always keep the seals on until use.

j. Always record/update the current weight/volume of the SCH container after each use.

k. Visually inspect the SCH container for problems before usage/transportation.

l. Ensure the SCH container is dry.

63. Should the user plan on shipping any of these chemicals, locally or internationally, please consult with the manufacturer's guidelines. Special arrangements of such hazardous chemicals may be supported by the respective PTj. The responsibility of safe transportation will be the sole responsibility of each PTj.

SAFETY TRAINING AND LABORATORY ACCESS

64. Each department shall provide regular trainings (at least on annual basis) on laboratory safety for all laboratories under its responsibility. The format of the training (lecture, seminar, video-session, etc.) can be decided at the respective department. Attendance of the trainings shall be compulsory for everyone working in a laboratory and properly documented. To ensure an adequate awareness and knowledge on laboratory safety, safety-related tests shall be conducted at the respective departments. Any operation in a laboratory shall require a documented passing of the respective test. These tests shall be repeated on annual basis. To cater different levels of

laboratory safety competency, tests reflecting varying knowledge requirements shall be used for laboratory operations with and without close supervision (esp. undergraduate classes vs. research work).

65. For laboratories involving chemical hazards the following aspects must be covered:

a. Common laboratory hazards (fire, pressure/vacuum, routes for primary exposure to hazardous chemicals, etc.)

b. Familiarization with icons for chemical hazards (GHS symbols)

c. UM safety policy (esp. requirement of company during operations in the laboratory) and generic emergency response procedures

d. Personal protective equipment (lab coat, safety glasses, masks & respirators, etc.)

e. Familiarization with emergency response infrastructure (eye-wash, fire extinguisher etc.)

f. Safety data sheets (SDS)

g. Storage and transport of chemicals (esp. compound incompatibilities)

h. Spill and waste management

i. Risk analysis of experiments and development of a specific emergency response plan.

Compatibility Chart for Chemical Mixtures

Reactivity Group No.	Reactivity Group Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Acids, Mineral, Non-oxidizing	1																			
2	Acids, Mineral, Oxidizing		2																		
3	Acids, Organic		G, H	3																	
4	Achohol and Glycols	H	H, F	H, P	4																
5	Aldehydes	H, P	H, F	H, P		5															
6	Amides	H	H, GT				6														
7	Amines, Aliphatic and Aromatic	H	H, GT	H		H		7													
8	Azo compounds, Diazo compounds and Hydrazines	H, G	H, GT	H, G	H, G	H			8												
9	Carbamates	H, G	H, GT						G, H	9											
10	Caustics	H	H	H		H				H, G	10										
11	Cyanides	GT, GF	GT, GF	GT, GF					G			11									
12	Dithiocarbamates	H, GF, F	H, GF, F	H, GF,		GF, GT		U	H, G				12								
13	Esters	H	H, F						H, G		H			13							
14	Ethers	H	H, F												14						
15	Fluorides, Inorganic	GT	GT	GT												15					
16	Hydrocarbons, Aromatic		H, F														16				
17	Halogenated Organics	H, GT	H, GT, P					H, GT	H, G		H, GF	H						17			
18	Isocyanates	H, G	H, GT, P	H, G	H, P			H, P	H, G		H, P, G	H, G	U						18		
19	Ketones	H	H, F						H, G		H	H								19	
20	Mercaptans and other Organic Sulfides	GF, GT	H, GT, F						H, G									H	H	H	20

Reactivity code	Consequence
H	Heat generation
F	Fire
G	Innocous non-flammable gas generation
GT	Toxic gas generation
GF	Flammable gas generation
E	Explosion
P	Violent polymerization
S	Solubilazation toxic substance
U	Maybe hazardous but unknown

Example	
H, F, GT	Heat generation, fire and toxic gas generation

21	Metals, Alkali and Alkaline Earth Elemental	GF,H,F	GF,H,F	GF,H,F	GF,H,F	GF,H,F	GF,H	GF,H	GF,H	GF,H	GF,H	GF,H	GF,GT,H	GF,H								21																			
22	Metals, other Elemental Alloys as powders, vapors or sponges	GF,H,F	GF,H,F	GF					GT,H,F	U	GF,H						H,E	GF,H		GF,H,F			22																		
23	Metals, other Elemental Alloys as sheets, rods, moldings, etc.	GF,H,F	GF,H,F						H,F,G								H,F							23																	
24	Metals and Metal compounds, Toxic	S	S	S			S	S			S														24																
25	Nitrides	GF,H,F	H,F,E	GF,H	GF,H,E	GF,H			U	H,G	U	GF,H	GF,H	GF,H			GF,H	U	GF,H	GF,H	E					25															
26	Nitriles	H,GT,	GT,H,F	H							U										H,P				S	GF,H	26														
27	Nitro compounds, Organic		GT,H,F			H					H,E										GF,H,E					GF,H,E		27													
28	Hydrocarbons, Aliphatic, Unsaturated	H	H,F			H																H,E							28												
29	Hydrocarbons, Aliphatic, Saturated		H,F																											29											
30	Peroxides and Hydroperoxides, Organic	H,G	H,E		H,F	H,G		GT,H	H,F,E	GT,H,F		GT,H,E	GT,H,E				H,E	H	GT,H,F	H,E	H,G	H,G		H,G	GF,H,E	GT,H,P		H,P			30										
31	Phenols and Cresols	H	H,F						H,G									H,P			GF,H				GH,H						H	31									
32	Organophosphates, Phosphothioates, Phosphodithioates	GT,H	GT,H						U		H,E										H										U		32								
33	Sulfides, Inorganic	GT,GF	GT,H,F	GT		H			E									H													GT,H			33							
34	Epoxides	H,P	H,P	H,P	H,P	U		H,P	H,P		H,P	H,P	U							H,P	H,P	H,P		H,P	H,P						H,P	H,P	U	H,P	34						
101	Combustible and Flammable materials, Miscellaneous	H,G	GT,H,F																			H,G,F			GF,H,F						GT,H,F					101					
102	Explosives	H,E	H,E	H,E					H,E		H,E			H,E							H,E	H,E	H,E	E	E						H,E	H,E		H,E	H,E	H,E	102				
103	Polymerizable compounds	P,H	P,H	P,H					P,H		P,H	P,H	U								P,H	P,H	P,H	P,H	P,H						P,H	P,H		P,H			H,E	103			
104	Oxidizing Agents, strong	GT,H		GT,H	H,F	H,F	GT,H,F	GT,H,F	H,E	GT,H,F		GT,H,F	GT,H,F	H,F	H,F		H,F	GT,H	GT,H,F	H,F	GT,H,F	H,F,E	H,F,E	H,F		H,F,E	GT,H,F	H,E	H,F	H,F	H,G	H,F	GT,H,F	GT,H,F	H,G,F	H,G,F	H,E	GT,H,F	104	
105	Reducing Agents, strong	GF,	GT,	GF,	GF,	GF,	GF,	GF,	GF,				GT,	H,				H,	GF,	GF,	GF,						GF,	H,			H,	GF,	GF,		H	GF,	H,	GF,	H,	10

		H	H,F	H	H,F	H,F	H	H	H				H	F				E	H	H	H						H	E			E	H	GT			H	E	H,P	F,E	5		
106	Water and mixtures containing water	H	H						G										H,G			GF,H	GF,H		S	GF,H								GF,GT						GF,GT	106	
107	Water reactive substances	E	X	T	R	E	M	E	L	Y		R	E	A	C	T	I	V	E		D	O		N	O	T		M	I	X	!	!	!									107
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107

NOTES:

1. Source from EPA-600/2-80-076, April 1980. 'A method determining the compatibility of chemical mixtures.
2. This chart can be used to identify hazards that can be expected when chemical wastes are mixed.
3. This list is not an exhaustive list as there are different activities of the thousands of compounds that may be encountered.
4. Any blanks that appear in the chart does not mean that the mixture cannot result in a hazard occurring.
5. Detailed information on hazards involved in handling and disposing of any given waste should be obtained from the waste generator.

BIOLOGICAL MANAGEMENT

Biosafety Programmes

66. UM has established biosafety programmes that provide oversight for activities involving biological agents. These biosafety programmes consist of committees to oversee the development, implementation and monitoring of the biosafety and biosecurity in the University. The Institutional Biosafety and Biosecurity Committee (IBBC) oversees all activities involving the handling, manipulating, working, using, storing, transporting, and disposing of infectious and potentially infectious agents/materials and biological toxins, as required by the Universiti Malaya Policy and Procedure on Laboratory Biosafety and Biosecurity, 2015. The Institutional Biosafety Committee (IBC) was set up under the regulations of the Biosafety Act 2007, which oversees modern biotechnology research and development.

Biorisk Assessment

67. Activities involving handling and working with biological agents may pose a risk to the laboratory personnel as well as the community and the environment. Biological agents are infectious and potentially infectious agents/materials, including recombinant DNA molecules, GMOs and LMOs. Some of these biological agents are biohazardous materials that can cause infections, or are a probable cause of infection and pose significant health risk to laboratory personnel. These biohazardous materials are specifically microorganisms such as bacteria, fungi, viruses and protozoa). The biohazardous materials can cause diseases in humans via various routes of transmission such as aerosol, direct contact, fomite, oral and vector. It may also cause diseases in animals. WHO has classified these biohazardous materials into four risk groups depending on the likelihood of it to cause and spread diseases, as well as the severity on the consequences of the diseases spread:

Risk group 1	Risk group 2	Risk group 3	Risk group 4
• unlikely to cause human or animal disease	• can cause human or animal disease • is unlikely to be a serious hazard • effective treatment and preventive measures are available • the risk of spread of infection is limited	• usually causes serious human or animal disease • but does not ordinarily spread from one infected individual to another • Effective treatment and preventive measures are available.	• usually causes serious human or animal disease • can be readily transmitted from one individual to another, directly or indirectly. • Effective treatment and preventive measures are not usually available

Source: *Laboratory Biosafety Manual, World Health Organization, 3rd Edition, 2004)*

68. For further details on the examples of biohazardous materials in each risk group, refer to the Seventh Schedule [Subregulation 6(1)] of Prevention and Control of Infectious Diseases Act 1988 (which is found in **Annex A**). Laboratory personnel are required to perform biorisk assessment when laboratory work activities involve biological agents. All PI's in UM must submit their application to the IBBC and/or IBC before the initiation of their laboratory activities. For further details, refer to the relevant committees; IBBC (https://umcms.um.edu.my/sites/um-research/institutional-biosafety-and-biosecurity-committee-ibbc) and IBC (https://umcms.um.edu.my/sites/um-research/biosafety-committee).

69. Biorisk assessment is a stepwise process to identify the hazard and evaluate the risk(s) arsing from handling the biological agent, so that strategies or measures to control and mitigate the risk(s) can be implemented. The following section provides information on strategies or control measures for biorisks.

Core Requirements

70. The core requirement is the term described in the Laboratory Biosafety Manual, World Health Organization, 4th Edition (draft document) as a combination of biorisk control measures for the minimum requirement and considerations that are necessary to work safely with biological agents. It is determined based on the biorisk assessment and additional requirements may be required for more effective biorisk control.

a. **Engineering Control.** Engineering controls can be described as a physical modification to a process, or process equipment, or the installation of further equipment with the goal of preventing the release of biological agents and to minimize the biorisk. Engineering controls are a reliable to minimize exposure of the laboratory personnel to biological agents as long as the controls are designed, used and maintained properly. Examples of engineering control are biological safety cabinets (BSCs), enclosed transport containers, directional airflow indicators, and safety centrifuge cups, micro-isolator tops on animal cages, self-sheathing needles and sharps containers.

(1) **Facility Design.** The design of a facility is important in providing a barrier to protect the laboratory personnel, as well as the community and the environment from the biological agent. Facility design must commensurate with the laboratory's function and based on the biorisk assessment for the agent being used or stored. The facility design features listed below are core requirements for biosafety for all laboratories handling biological agents. The laboratory must be designed in a way that provide ample space for the safe conduct of laboratory work and can be easily clean and maintenance.

(a) Laboratory lighting (daylighting and artificial lighting) must be adequate for all activities. Maintenance considerations are important in the design and selection of facility lighting. Emergency lighting must be design to allow safe continuation of work and sufficient to permit safe stopping of work as well as safe exit from the laboratory.

(b) Laboratory storage space must be adequate for appropriate storage of equipment, materials and consumables used in the daily work to hold supplies for immediate use.

(c) Use of the chemical in laboratory must be equipped with proper chemical storage and safe handling of the laboratory personnel

(d) First-aid facilities must be readily accessible and suitably administered and equipped

(e) Appropriate and effective methods for decontamination of waste, equipment and work surfaces must be available in proximity to the laboratory.

(f) The management of waste must be considered in the design and space should always be clearly allocated for the storage of waste materials.

(g) Based on the biorisk assessment, the laboratory design must be equipped with safety systems such as suppressions measures, electrical emergencies, gas supply and alarm systems

(h) Should be sized to meet the planned needs of the facility and must be a reliable.

(i) The design of the laboratory must be practical and take into consideration on the management of emergency based on the local risk assessment, such as geographical/ meteorological context.

(j) Design of the laboratory must take into consideration on the fire prevention and suppression measures and flood risk. For further information and an expansion of these core laboratory requirements and recommendations, refer to Laboratory Biosafety Manual, World Health Organization, 3rd Edition, 2004.

(2) **Biosafety Cabinet (BSC).** The most common containment device that is used for handling biological agents is a BSC. BSC is designed to contain aerosols generated using laminar airflow and high-efficiency particulate air (HEPA) filtration. Three types of BSCs (Class I, II and III) are used in laboratories. The different types of BSCs are described in detail in the Biosafety in Microbiological and Biomedical Laboratories, Centers for Disease Control and Prevention, 5th Edition, 2009 chapter: Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets. Laboratory personnel must be trained and be able to work competently at a BSC.

(3) **Laboratory Equipment.** Management of the laboratory equipment must prioritize the safe work practices and handled by competent laboratory personnel to minimize the likelihood of exposure of personnel when handling or manipulating biological agents. The laboratory designed must ensure that sufficient space is provided for the placement and the use of the equipment. The laboratory personnel must be trained and able to demonstrate proficiency when operating or maintaining the equipment. The laboratory equipment management must ensure appropriate resources must be allocated for the equipment's operation and maintenance to ensure the equipment is functioning as expected. Records of equipment including the use, maintenance performed, training of laboratory personnel, details of the supplier and validation/calibration procedures undertaken and their results must be maintained and accessible.

(4) **Specialized Laboratory Equipment.** Using some of the common laboratory equipment may require certain best practices to reduce any potential exposure during the handling. These types of equipment are described below:

(a) **Pipettes:** Using a pipette may create aerosols and it may expose the laboratory personnel when liquid from a pipette is dropped onto the work surface, when cultures are mixed by pipetting, or when the last drop of inoculum is blown out.

(1) Never use force to empty pipettes, but allow gravity to do its work

(2) Do not forcibly expel biohazardous material out of a pipette.

(3) Use pipettes and/or the pipette tips that have cotton plugs to reduce the contamination of pipetting devices.

(4) Laboratory personnel must adequately be trained in the correct use of pipettes.

(5) To avoid further dispersion of any biological agents or accidental release of biohazardous materials, it is recommended to place an absorbent material on the working surface and disposed of as infectious waste after use.

(6) Discard contaminated disposable pipettes or pipette tips in an appropriate waste container. Autoclave the container when it is 2/3 to 3/4 full and dispose of as infectious waste. Reusable pipettes can be completely submerged in a suitable disinfectant and left for the appropriate length of time before disposal or washing.

(b) **Centrifuges**: Hazards associated with centrifuging include mechanical failure and the creation of aerosols.

(1) To minimize the risk of mechanical failure, only trained laboratory personnel should use a centrifuge. Service of the centrifuge must be according to the manufacturers' instructions, and must be serviced by appropriately qualified personnel.

(2) Where safety buckets are available for a centrifuge, use sealed tubes and safety buckets with O-rings. Before use, inspect tubes, O-rings and buckets for cracks, chips, erosions, bits of broken glass, etc.

(3) Always balance buckets, tubes, and rotors properly before centrifugation. The contents of centrifuge tubes must be filled to the same level and placed in the centrifuge at opposite locations.

(4) If work involves biohazardous materials, it is recommended to fill and open centrifuge tubes, rotors, and accessories in a BSC.

(c) **Refrigerators and freezers:** Refrigerators and freezers must be spark-proof if they are storing flammable solutions. Biohazard warning symbol must be placed to identify containers for storage of biohazardous materials as well as refrigerators, and/or freezers where biohazards are stored. Appropriate PPE must be worn when handling specimens from the storage cabinet.

b. **Administrative Control**

(1) **Signs and Labels.** A biohazard warning symbol is required for all areas, doors and equipment, wherever biohazardous materials are handled and/or stored. For image of the symbol – refer to Laboratory Biosafety Manual, World Health Organization, 3rd Edition, 2004.

(2) **Personnel competence and training.** Training of laboratory personnel is a critical component of the biosafety programme to ensure laboratory personnel are competent and safety-conscious, are well informed on how to recognize and control biorisks, to ensure prevention of laboratory-associated infections and/or other incidents. The laboratory personnel must be trained on Good Microbiological Technique (GMT), Good Laboratory Practices (GLP) and other relevant practices prior the initiation of the activiites. The proposed laboratory biosafety and biosecurity training requirement stated in section 6.1.4 of the UM Policy and Procedure on Laboratory Biosafety and Biosecurity, 2015 must include:

(a) Institutional specific training
(b) Basic laboratory biosafety and biosecurity.
(c) Agent-specific laboratory biosafety and biosecurity.
(d) Job-specific laboratory biosafety and biosecurity such as the proper use of biological safety cabinet, waste disposal management, equipment handling, etc.

(3) **Emergency/Incidence Response Plan.** To reduce the likelihood of exposure to/release of a biological agent or to reduce the consequences of accidents and incidents, a contingency plan must be developed that provides specific SOPs to be followed in possible emergency scenarios. Laboratory personnel must be trained on these procedures and have periodic refresher training in order to maintain competency. Plans to include liaison with local emergency groups and consultation with relevant authorities where necessary are recommended. Emergencies response plan should include those related to chemical incidents, fire, electrical breakdown, radiation incidents, pest infestation, flooding, or personal health issues of personnel (e.g. a heart attack or collapse). Refer to section on ERP and, incident reporting and investigation for more details.

(4) **Standard Operating Procedure (SOP).**

(a) **Good microbiological practices and procedures (GMPP).** GMPP is a term that is described in the Laboratory Biosafety Manual, World Health Organization, 4th Edition (draft document) as a set of standard operating practices and procedures or a code of practice that is applicable to all types of activities with biological agents. It is defined as basic laboratory code of practice applicable to all types of activities with biological agents, including general behaviors and aseptic techniques that should always be observed in the laboratory. Protection of laboratory personnel, community from infection and the immediate laboratory environment from exposure to infectious agents, is provided by good practice of GMPP. Laboratory personnel must be trained and proficient in GMPP to ensure safe working practices when conducting work involving biological agents. The biorisk assessment performed will determine the appropriate procedures and practices.

(Refer to **Annex B** – Guideline on Completing Biological Risk Assessment)

(b) **Best Practices.** Best practices describe behaviors that are essential to facilitate safe work practices and control biorisks.
Examples of laboratory best practices are outlined below.

i. Food or drink, or personal items such as coats and bags in the laboratory are stored outside the laboratory. Activities such as eating, drinking, smoking and/or applying cosmetics are only to be performed outside the laboratory.
ii. Thoroughly wash hands, after handling any biological material, including animals, before leaving the laboratory, or any time contamination is known or suspected to be present on the hands.
iii. Coverings should be placed over any cuts or broken skin prior to entering the laboratory.
iv. Ensuring work is performed with care, in a timely manner and without rushing. Working when fatigued should be avoided.
v. Work area should be tidy, clean and free of clutter.
vi. It is best practice to remove any jewelry or otherwise ensure that the item must be covered properly to avoid any cause of damage to the worn PPE. Use of electronic devices such as mobile phones in the laboratory is not recommended. If it is unavoidable, laboratory personnel must place a physical barrier or to be decontaminated before leaving the laboratory
vii. The use of earphones must be prohibited to avoid any failure on the alarms from being heard and it can cause distraction when conducting laboratory activities.

(c) **Technical Procedures.** Implementing the GMPP may require technical procedures that may reduce the biorisks and allow work to be performed with best practices to minimize the likelihood of cross-contamination (i.e. contamination of other samples, or previously sterile substances or objects as well as surface contamination). The following procedures help to avoid certain accidents and incidents from occurring:

i. Avoid inhalation of biological agents
ii. Avoid ingestion of biological agents and contact with skin and eyes
iii. Avoid injection of biological agents
iv. Prevent dispersal of biological agents

(d) **Sample receipt and storage**. Management of biological agents starts at the point of the collection which is before it arrives in the laboratory. The collected samples must be properly packaged as any leakage or damage may pose a bio risk to the laboratory personnel. For more information on the control requirements for handling of biological agents before they reach the laboratory (i.e. while in transit, please refer to section on *Transportation of Biological Agents*)

i. All biological agents are to be identified prior to arrival at the laboratory, including all blood borne pathogen materials, such as human tissue and body fluids. Laboratory personnel who receive and handle the samples must be advised on the condition and any possible biological agents contained in the samples.
ii. If any containers containing samples are found to be damaged, leaking or otherwise contaminated, they will be immediately isolated and notified.
iii. Only authorized laboratory personnel can have access to keep and remove samples from storage. Storage, removal and use of all such biological agents must be updated in the inventory record.

c. **Personnel Protection Control**

Personnel protective equipment (PPE; eg. respirators, goggles, gloves and clothing) is the last critical barrier to accord protection against possible exposure to infectious agents and microbial toxins. It is designed to further minimize the risk of accidental exposure after other controls including engineering, SOP and administrative controls are already in place.

(1) **PPE**. PPE refers to a set of wearable equipment and/ or clothing worn (e.g. gloves) or held (e.g. a monitor) by personnel to provide an additional barrier between them and the biological agents being handled, which effectively controls bio risk by reducing the likelihood of exposure to the biological agents. PPE may include, but is not limited to face protection, lab coats and gowns, respirators, and shoe covers/booties.

(a) Appropriate PPE should be donned before handling biological agents, removed immediately, and replaced if gross contamination of the equipment occurs.

(b) PPE is removed before exiting the laboratory and is not worn in non-laboratory areas.

(c) PPE is used to supplement the containment provided by laboratory practices and should be used in conjunction with appropriate engineering and administrative controls.

(d) PPE is considered the least desirable control measure because its failure may result in direct exposure of laboratory personnel to the biological agent.

(e) Selection of PPE depends on the biorisk assessment and is must be ensured that the selection of PPE fits the laboratory personnel properly. Adequate training must be given to personnel to ensure PPE is used properly and effectively.

(2) **Heightened and Maximum Control Measures**. Core requirements are typically sufficient to mitigate biorisks, however, a situation may be identified during bio risk assessment, which requires additional control measures (heightened control measures) to reduce bio risks to acceptable levels. There may be circumstances that the biorisk may require the application of maximum control measures, particularly when working with biological agents that pose a severe health risk to laboratory personnel and community, are highly transmissible, cause disease with no countermeasures available, or have pandemic potential.

(More information on maximum control measures can be found in the Laboratory Biosafety Manual, World Health Organization, 4th Edition (draft document).

d. **Engineering Control**

(1) **Facility design.** The following are additional facility design to be considered as heightened control measures based on the identified biorisks.

(a) Physical separation of work area to reduce biorisk of exposure to individuals not directly involved in the project activity.

(b) Windows must be closed and sealed, including during gaseous area decontamination.

(c) Inward airflow to laboratory or work area.

(d) Exhaust air from laboratory or work area should be discharged in a manner to reduce biorisk of exposure of any people, animal and/or environment. Alternatively, the exhaust air can be filtered.

(e) On-site treatment of laboratory waste should be available. Alternatively, specific secured storage for laboratory waste is required until it is collected by authorized bio-waste disposal agent.

It is recommended that facility with maximum control measures be located in a separate building, or a specific zone within a secure building. The design of the facility should include a containment system, specific entry and access requirements and dedicated heating, ventilation and air-conditioning system.

These features may depend or not depend on the bio risk assessment. (More information on facility design for maximum control measures can be found in the Laboratory Biosafety Manual, World Health Organization, 4th Edition (draft document)).

(2) **Laboratory equipment**. The following are specific considerations when using equipment during higher risk procedures as identified during biorisk assessment:

(a) Use of additional containment accessories such as safety buckets or aerosol-tight rotors in centrifuges.

(b) Dedicating specific equipment such as pipetting devices for higher risk activities to avoid cross-contamination.

(c) Use of specific safety equipment or containment devices such as BSC to protect against infectious aerosols.

(d) For heightened control measures, it is important that the appropriate type of BSC is used. It is also important to train laboratory personnel to understand the function of BSC, as well as to operate and work at the BSC correctly. The BSC must be maintained periodically to ensure proper protection of laboratory personnel when using it.

For maximum control measures, only dedicated laboratory equipment should be used and it must be able to withstand fumigation or have provision for decontamination procedures. Sharps are not recommended. Specific SOPs must be available and training provided to laboratory personnel when the use of sharps in the facility is unavoidable and required.

e. **Administrative Control**

(1) **Emergency/incident response plan**. The following are to be considered for heightened control measures based on the biorisks identified.

(a) Availability of post-exposure prophylaxis and therapeutics.

(b) Emergency shower to disinfect laboratory personnel who may be exposed to large volume of biological agent such as during a splash or spill, or during animal handling.

(c) Specific protocols when work is performed outside normal working hours such as buddy system in case of emergency.

In facility with maximum control measures, an emergency response plan must be devised due to the complexity of the design and engineering. Testing and training exercises of the plan performed with the laboratory personnel, local emergency groups and relevant authorities are recommended.

(2) **Personnel competence and training.** Additional training on relevant procedures and/or equipment will be required for heightened control measures, and should include competency assessment and its documentation. A period of mentorship is recommended to train the personnel until competent, and the competency of personnel must be reviewed periodically to ensure compliance to practices and procedures. For work with maximum containment measures, only highly trained, experienced and specialized laboratory personnel should be allowed to work. Strict supervision and mentoring must be implemented until the personnel is suitably competent and proficient in the practices and procedures. Personnel must be trained and should include emergency response scenarios. Periodic refresher training should be conducted.

(3) **Standard Operating Procedures**

(a) **Working Practices and Procedures.** GMPP will be the basic element for all work that is performed. The following are additional practices to be considered as heightened control measures based on the bio risks identified.

i. Restricted access to only trained laboratory personnel and/or specified laboratory personnel.

ii. Specific entry conditions to laboratory personnel e.g. particular immunization requirement.

iii. Handling of biological agent to be performed in containment device i.e. BSC, and or respiratory protection may be required.

iv. Practices and procedures in core requirements and/or heightened control measures should be applied for maximum control measures with the following additions:
   - Complete change of clothing and shoes before entering and leaving the work area.
   - Working alone is not allowed.
   - Emergency extraction procedure must be established and laboratory personnel must be trained in the procedure.
   - Communication system between laboratory personnel in work area and support personnel outside work area must be established.
   - Visual monitoring and recording of laboratory personnel working in the work area must be implemented.

(b) **Sample receipt and storage.** The following are additional heightened control measures to be considered

i. Opening samples in containment devise such as BSC and/or wearing additional PPE when doing so.

ii. Implementing more stringent restricted-access to sample storage areas.

iii. Establishing internal transfer and transport protocols.

For maximum control measures, samples received or to be transported out of the facility must be accordance to national and international regulations. Samples received must only be opened and handled within the specific work area by trained laboratory personnel. Storage of samples must be in dedicated storage areas that can only be accessed by authorized personnel. An inventory of the samples and its movement must be kept and available.

(c) **Decontamination and waste management.** On-site decontamination of waste generated from activities requiring heightened control measures is recommended to minimize biorisk of exposure or release during transportation of waste. Alternatively, decontamination can be performed close to the work area, with the waste packaged, stored (if required) and transported appropriately according to institutional and local requirements. Separation of solid and liquid waste is recommended.

For maximum control measures, all waste and effluents must be decontaminated before it leaves the work area to ensure no infectious threat. The disinfection and decontamination procedure must be validated to ensure effectiveness of the procedure. A double-door, pass-through autoclave must be available in the work area. Other methods of decontamination must be available if steam sterilization cannot be applied.

f. **Personnel Protection Control**

(1) **PPE.** The following are additional and/or specialized PPE protocols to be considered for heightened control measures based on the biorisks identified.

(2) **Laboratory coats/clothing.** Laboratory coats to overlap at the front for additional protection against splashes and spills.

(a) Gowns, scrubs and coveralls as alternative protective clothing can be used.

(b) Additional fluid-resistant protective clothing such as apron, laboratory coat and/or sleeves if large splashes are anticipated.

(c) Additional decontamination procedure such as autoclaving before laundering for reusable items.

(d) Specific laboratory clothing such as scrubs to prevent contamination of personal clothing.

(e) Footwear. Change of footwear before entry into work area to prevent cross-contamination is recommended.

(f) Gloves. Additional gloves such as double gloving for some activities may be required based on biorisk assessment. A range of sizes for gloves should be provided to ensure proper fitting and sufficient dexterity. Handling or practicing work activities with additional gloves must be included in training.

(g) Eye protection. Requirement for eye protection will be the same as in core requirements, however, it must be compatible with respiratory protection required in heightened control measures.

(h) Respiratory protection. Respiratory protective equipment is aimed to protect only the wearer from biological agent/material present in the air or aerosol particles. It is important that control measures be taken to ensure other laboratory personnel at risk are also protected. There are various types of respiratory protective equipment and the selection of the appropriate type will depend on the following:

i. The biorisk identified and the level of protection provided must be appropriate to reduce exposure of personnel.
ii. The personnel using must be able to work freely and movement not hindered.
iii. It must be worn correctly and must fit suitably.
iv. If reusable respiratory protective equipment is used, it must be decontaminated after use and maintained.
v. It must complement other PPE being used.

As there are various sizes and types available, as well as different laboratory personnel and/or work activities, a range of respiratory protective equipment should be provided. Besides, it is important that laboratory personnel are trained to understand the suitability of types of respiratory protective equipment with different activities and it is used correctly.

(3) **Respirators.** Respirators with particulate filter will remove contaminants i.e. biological agents from the air breathed in. Respirators have a range of protection levels and the protection factor is a number rating indicating the level of protection the respirator provides. An example is respirator with assigned protection factor of 95 will reduce the wearer's exposure by at least 95%, if it fits the wearer properly and if used correctly. Therefore, fit-testing should be performed to ensure proper fitting of the respirator on the wearer's face, and fit-testing should be done periodically to check its fitting.

(4) **Surgical masks**. Surgical masks are intended to protect patients and clinical areas from biological agents/materials in the nose and mouth of the wearer. Therefore, surgical masks are not categorized as respiratory protective equipment. In facility with maximum control measures, a suit laboratory system is used for personnel protection. SOP for the safe use of the suit should be developed, and the laboratory personnel must be trained and practice the SOP to ensure it is correctly performed. Besides, a maintenance system must be established for the suit to ensure it is cleaned, disinfected, checked, repaired and/or replaced and tested.

For more information on Biosafety Level 3 Personal Protective Equipment, refer to Biosafety in Microbiological and Biomedical Laboratories, Centers for Disease Control and Prevention, 5th Edition, 2009 chapter: Laboratory Biosafety Level Criteria: Biosafety Level 3.

Transfer and Transportation of Biological Agents

71. Transfer refers to the process of exchanging biological agents between facilities. Transferring biological agents within or between facilities should always be performed cautiously to minimize potential events such as spillage and collision. Transportation refers to the packaging and shipping of biological agents by air, land or sea, usually by a commercial courier vendor. Transportation of biological agents is subjected to national and international regulations.

a. **Transfer Within the Facility.** Moving and exchanging biological agents within the facility include, for example - the movement of tissue culture flask from the BSC to the incubator and the exchanging of tubes containing saliva between laboratories in the same building. These activities must be undertaken carefully, following the GMPP to prevent incidents of cross-contamination and accidental spillage. Transfer containers must be labelled to identify their contents and surface sterilized before leaving the laboratory.

In addition, the following considerations should be considered when transferring biological agents within the facility;

(1) Use sealable containers such as screw-capped tubes instead of tubes with snap-cap as the primary receptacle.

(2) Use deep-sided, leak-proof plastic boxes which can be easily cleaned and disinfected as the secondary transfer container. Lockable plastic food storage boxes may be used (see Figure 1).

(3) Ensure that biological spill kits are available for use in the event of spillage during transfer.

Figure 2. *Example of a plastic food storage box that can be used as the secondary transfer container.*

b. **Transfer Between Facilities.** Additional considerations need to be considered for the type of containers and layers of outer packaging to minimize the event of leakage while transferring biological agents between different facilities in the University. Some of these considerations are listed below;

(1) Use sealable plastic bags, screw-capped tubes and lockable plastic food storage boxes, as the secondary packaging. Absorbent materials such as lab towels and tissue papers should be used to wrap the primary receptacle to absorb the biological agents, should there be a leakage.

(2) Redundant layers of packaging (as shown in para 69 d. *Triple Packaging of Biological Agents)* should be considered. The outermost transport container as the third layer should be rigid and may vary in sizes depending on the available resources. A plastic ice container may be used to transfer biological agents

between different facilities in the University as it is secure and can be easily decontaminated (see Figure 3).

(a) Packaging should have a biohazard warning sign when appropriate with the contents of the package clearly described.

(b) Recipients should be notified ahead of the transfer by the sender.

(c) Ensure that biological spill kits are available for use in the event of spillage during transfer.

Figure 3. *Example of a plastic ice container that can be used as the outermost transport container.*

c. **Transportation of Biological Agents**

(1) The transportation of biological agents from one organization to another organization, using land, sea or air transportation is subjected to various national and international transport regulations. These regulations have been developed to regulate the packaging, labelling, marking and documentation of biological agents to minimize the likelihood of exposure and /or release during transit. A triple packaging is commonly recommended, and required for the transportation of biological agents.

(2) For the purpose of air transportation, international regulations classify materials that may contain biological agents as dangerous goods, under the class of 'toxic and infectious substances'. Infectious substances are then further classified, based on a pathogen risk assessment, into subgroups for which different procedures are described. These are all described in the IATA Dangerous Goods Regulations, 59^{th} Edition.

(3) It is ultimately the responsibility of the laboratory personnel sending the biological agents (referred to as the 'shipper') to ensure that they comply with all applicable regulations that apply to their shipment.

(4) Material transfer agreement (MTA) govern the transfer of materials of biological materials and toxins between institutions. The University of Malaya requires an MTA (or another form of contract such as a subcontract) for University

materials being sent out or received from other institutions. The MTA template document by the IBBC, UM can be referred to at the Appendix – Material Transfer Agreement.

d. **Triple Packaging of Biological Agents**

(1) A triple packaging system is commonly practiced by all regulations with regard to the transfer and transportation of biological agents. This system utilizes redundant layers of packaging for containing leakage or any breach of containment of an infectious substance to reduce the likelihood of exposure and/or release during transfer or transport.

(2) A triple packaging system comprises of three packaging layers – the primary receptacle, the secondary packaging and the third outer protective packaging (see Figure 4). The primary receptacle containing the biological agents must be watertight, leak-proof and appropriately labelled to identify the contents it is carrying. The primary receptacle must be wrapped with sufficient absorbent materials and if multiple primary receptacles are packed together, cushioning materials must be used to prevent contact between them.

(3) The secondary sealable and leak-proof packaging is used to confine and protect the primary receptacle. Several wrapped primary receptacles may be placed into a secondary packaging. The third outer packaging protects the secondary packaging from damage during transit. Dry ice may be used in between the secondary and third packaging when necessary, and as such subjected to additional requirements, as outlined in the applicable regulations. The outer layer of the third packaging must be labelled with information of the package, and when necessary marked appropriately with the shipper and recipient's details.

Figure 4. *Example of a triple packaging system*

Laboratory Biosecurity

72. Laboratory biosecurity is defined as the protection, control and accountability for biological agents within laboratories, in order to prevent their loss, theft, misuse, diversion of, unauthorized access or intentional unauthorized release (adapted from: *Laboratory Biosecurity Guideline, World Health Organization, 2006*). The University's obligations are outlined in the University Malaya Policy and Procedure on Laboratory Biosafety and Biosecurity, which comes under the remit of the IBBC. The University's policy is aligned to the national guidelines, as set out in the *Malaysia Biosafety and Biosecurity Policy and Guideline, Ministry of Health, 1st Edition, 2015*, as well as taking into account the fundamentals from the *Laboratory Biosafety Manual, World Health Organization, 4th Edition* (draft document).

73. The key elements of the biosecurity and responsibilities of laboratory personnel are briefly outlined below. PIs should take reasonable measures to ensure their laboratories are secure by undertaking an approach similar to the biorisk assessments. In most cases, the biosecurity and biosafety risk assessments can be combined into a single activity. A similar framework for biosecurity and biosafety risk assessments applies, with the following key steps.

a. Gather information on the nature of the biological agents, their location, the laboratory personnel involved and their responsibilities;

b. Evaluate the risks in terms of likelihood of unauthorized personnel gaining access to the biological agent and the consequences of release;

c. Develop a risk strategy to determine the minimum requirements for working with the biological agents;

d. Implement control measures with reference to appropriate procedural and physical security.

e. Conduct periodic reviews of the implemented control measures.

74. When undertaking biosecurity risk assessments, workers should consider the following five pillars of biosecurity risk mitigation:

a. **Physical security.** This provides protection against unauthorized access and the level of security is based on biorisk. For example, low risk areas include offices and general storage facilities, moderate risk areas could include laboratories or offices holding sensitive information and high risk areas could include high containment laboratories and computer network hubs etc. Appropriate access control measures should be implemented depending on the level of perceived biorisk.

b. **Personnel management.** Appropriate personnel management is essential for the functioning of a laboratory and for implementing a biosecurity programme. Processes should be in place to determine whether laboratory personnel need access to sensitive biological materials and similar procedures should be in place to cover visitors and other outside personnel. Security awareness should form part of any biosafety training programmes.

c. **Material/inventory control.** A comprehensive inventory is required to establish what at-risk biological agents are held within a particular laboratory, the precise location and the laboratory personnel responsible. The inventory needs to be complete, accurate and updated regularly to ensure there is appropriate control and accountability. Such measures are necessary to discourage theft and misuse.

d. **Transport security.** This aims to ensure that the same level of protection is applied to biological agents when they are in the laboratory or being transported outside the facility and aims to reduce the risk of unauthorized acquisition of high-risk biological agents. The transfer and transportation of biological agents must comply with national and international transport regulations for packaging, labelling and documentation (refer to section on *Transfer And Transportation*). For the transport of high-risk material, transfers should be prearranged and approved by responsible parties and can use chain of custody documentation (or similar) that contains a detailed description of the biological agent, contact information of responsible persons and time/date signatures of those who assume control.

e. **Information security.** This ensures that sensitive or valuable information stored in a laboratory remains confidential and is protected from theft. As such, procedures should be in place to identify, label and protect sensitive information against unauthorized acquisition. Such measures are necessary to prevent the malicious use of high-risk biological agents, such as pathogens and toxins.

The Use of Animals in Research, Teaching and Testing

75. Humane care and use of animals in research, testing and teaching (RTT) must be provided and comply with the Animal Welfare Act 2015 and UM Animal Care and Use Policy. The Institutional Animal Care and Use Committee (IACUC) maintains a program on animal care and use in the institution to ensure compliance to national and international requirements. Besides, exposure to, or working with, animals in RTT is not risk free. As a regulatory requirement, the institution should ensure a safe and healthful workplace to the staff by conducting occupational health and safety programs to safeguard them from unnecessary risks.

76. A broadened occupational health and safety program is necessary to address the health and safety hazards and the risks of occupational illness and injury that are associated with the care and use of animals in RTT to reduce the risks to acceptable levels. A collaborative participation is deemed paramount not only from individuals who have substantial contact with animals, but also extended to administrators and management, including IACUC in ensuring the success of the occupational safety and health program. All proposed work involving animals in RTT must be reviewed and approved by IACUC before work can commence. The following key elements and examples are essential components of an effective animal care and use occupational safety and health program:

Administrative Procedures

77. Procedures should be developed for conducting a health and safety review of activities that involve biological agents that are not exempt from national and international requirements, hazardous chemicals, radiation, or the use of animals that present unique hazards. Project-review process by the IACUC must be done to incorporate these procedures which involve the use of animals.

Facility Composition and Operation

78. Special consideration should be given to the ventilation system, space arrangement and layout, support areas, traffic patterns, and access to utilities and mechanical areas. Adequate space should be made available for storage of hazardous materials and for the collection, storage, and processing of wastes. Careful attention should be given to prevention and control of ergonomic hazards in the design of animal facilities.

Engineering Controls

79. Engineering controls are a combination of safety equipment and physical features of the facility that helps to minimize hazardous exposures of laboratory personnel and the surrounding environment. Safety equipment provides a barrier between employees and hazards, and physical features can prevent or reduce the potential for release of biohazardous materials from the immediate work area. Some engineering controls commonly used in animal care and research are barriers and airlocks, chemical fume hoods, biological safety cabinets, and isolation cages.

WORK PRACTICES

Handling and Transport of Animals

80. Safety precautions are needed during animal handling and animal transportation to prevent transmission of zoonotic agents to laboratory personnel, community and the environment. Laboratory personnel must wear appropriate PPE and follow recommended transportation procedures as determined by bio risk assessment. Additional PPE must be donned as determined by bio risk assessment.

Personal Hygiene

81. Rigorous attention to personal hygiene is essential for all laboratory personnel involved in animal related activities. Hands should be washed before and after handling animals and whenever protective gloves are removed. There should be no eating, drinking, smoking, application of cosmetics, or other activities that can increase the risk of ingesting hazardous materials or contaminating mucous membranes in animal care and animal use areas.

Housekeeping of Animal Facilities

82. All animal care areas, including areas in which biohazardous materials are used or stored, should be kept neat and clean. Clutter can become contaminated and add to problems of employee exposure, area decontamination, and waste disposal. Work surfaces should be wiped with disinfectant before work begins, immediately after any spill, and at the end of the workday. Floors should be disinfected or decontaminated daily or weekly as appropriate to the potential hazards. Appropriate dust suppression methods should be routinely used. Wet mopping and the use of a HEPA-filtered vacuum cleaner are recommended for suppressing dust.

Waste Disposal

83. Wastes should be removed at scheduled intervals based on the amount of waste

generated and the biorisk posed by the biohazardous materials in the waste material. It is recommended to ensure that sufficient space is available for on-site collection, storage, treatment, and disposal of waste. The disposal of hazardous wastes is to comply to national regulations. Specific SOPs must be established when disposing animals which have been exposed to biological materials as determined by bio risk assessment.

Animal Restraint

84. Animals can be restrained either manually or with restraining devices. It is the responsibility of the principal investigator to train their staff/student on appropriate restraint for each species used. The use of mechanical restraint devices or chemical restraints can reduce the potential for escape or injury when animals are being examined or handled. Laboratory personnel should be aware that physical restraint can increase the inherent risks associated with the animal by intensifying excretions, secretions, and aggressive behaviour of the animal.

Stainless steel metal mesh glove   Leather gloves with Kevlar lining

Figure 5. *Examples of personal protective equipment used for the restraint of animals*.

Cleaning Cages

85. Precautions should be taken, while changing animal bedding, to minimize or eliminate the aerosolization of biohazardous materials which may have been shed by the animal. The use of a biological safety cabinet (BSC or cage changing station should be used when transferring animals dosed with biohazardous materials from a soiled cage to a clean cage. Automatic cage washers pose several problems that should be addressed, including excess noise that might require hearing protection and ergonomic deficiencies that might contribute to back injuries and repetitive-motion injuries.

WORKING WITH BIOHAZARDOUS MATERIALS

86. SOP must be developed and approved for any work which involves the use of biohazardous materials in animals for RTT. Such procedures should detail the safe handling of the animal throughout the duration of exposure. Work involving the exposure of animals with biological agents must be conducted with appropriate control measures as determined through risk assessment to ensure adequate protection of personnel and the environment. For work with hazardous drugs or other toxic chemicals and work with radioactive materials in animals, please refer to the *Occupational Health and Safety in the Care and Use of Research Animals (1997)*.

a. **Safe Use of Anesthetic Gases**. Anaesthetic gases for e.g. halogenated agents e.g. halothane, isoflurane, methoxyflurane can present a risk of potential exposure to the laboratory personnel performing animal surgeries which have been linked to adverse effects due to exposure, such as reproductive and neurological effects. Emphasis must be in places on protecting laboratory personnel from exposure by adequately "capturing" the waste gas being generated.

b. **Personal Protective Equipment**. Gloves are the most commonly used personal protective clothing. Latex, vinyl, or other appropriate protective gloves should be worn for handling potentially contaminated animals or biohazardous materials. Uniforms, gowns, or laboratory coats are often provided to prevent contamination of animal care personnel by animal urine and faeces. These garments should not be worn outside the work area unless it is covered. Cage washing personnel might wear heavy rubber aprons to protect themselves when using strong detergents and cleaning agents. Safety shoes might be advisable for laboratory personnel engaged in moving cage carts and other heavy equipment. Face protection is advised if the eyes, nose, or mouth might be exposed through splashes or splatters of potentially biohazardous materials. Safety glasses should be considered minimal eye protection and worn to prevent injury from projectiles, minor splashes, or contact of contaminated hands with eyes.

c. **Personnel Training**. Approaches for providing an education and training effort depend on the size, resources, animal species, research activities, staff experience, and technical expertise of the institution. A clear definition of duties and the hazards associated with procedure and processes related to animal handling and restraining (such as zoonosis, chemical hazards, physical hazards like radiation and allergies, handling waste materials) must be provided. This includes the information about levels of risk associated with working with animals and personal health conditions (e.g., special precautions to avoid hazards for pregnant women or persons with chronic diseases, etc.). Laboratory personnel should be proficient in implementing safety precautions. Specific training on animal safe handling and restraining should be in in place as determined by bio risk assessment.

Medical Evaluation and Preventive Medicine for Laboratory Personnel

87. Replacement health evaluations and discussions with health professionals can provide an opportunity to establish a potential exposure profile and train and inform new employees of institutional policies and requirements. Laboratory personnel handling animals should undergo medical evaluations and immunization programs should be implemented where applicable. Please refer to the Occupational Health and Safety in the Care and Use of Research Animals (1997).

a. **Zoonoses.** The awareness of zoonotic hazards and routinely carrying out appropriate hazard-control measures can help to reduce the exposures of zoonotic diseases to laboratory personnel working with animals use in RTT. By understanding the reservoir and incidence, mode of transmission, clinical signs, susceptibility and resistance, and also the diagnosis and prevention, the control measures can be heightened and minimized the occurrence of zoonotic disease. The repeated occurrence of laboratory-acquired infections and the emergence of newly recognized zoonoses point to a need for laboratory personnel to become more involved in their institutions' efforts to prevent occupationally acquired zoonotic disease. Personal hygiene affords a critical barrier to the transmission of zoonoses and should be reinforced routinely in an institution's educational efforts and materials, in group and laboratory meetings of involved personnel, and in messages that emphasize appropriate practices for the care and use of research animals.

b. Allergens. Animal allergies and associated asthma are among the most common conditions affecting individuals who work with animals in RTT. Typically, allergies to animals result from repeated exposure to an animal's dander, urine, saliva, serum, or other body tissues. Symptoms can range from mild (e.g. itchy or runny nose and eyes) to severe (e.g. shortness of breath or red, itchy wheals on skin). Levels of airborne allergens tend to rise significantly with certain activities such as changing or cleaning animal cages. To reduce the levels of airborne allergens, it is recommended to use:

(1) Ventilated hoods (cage changing station, biological safety cabinet (BSC), or chemical fume hood) for cage changing.

(2) Dust-free bedding, or

(3) Filtered caging systems.

STUDENTS AS VOLUNTEERS AND ANCILLARY PERSONNEL

Guests, Visiting Researchers/Scholars

88. Each PI or instructor will provide those with substantial contact to animals with the following information:

a. The availability of, and the option to request medical evaluation and treatment from their personal provider at their expense.

b. Educational material regarding general information, potential hazards, universal precautions and personal hygiene.

c. Other potential health and safety hazards.

Ancillary Personnel

89. Ancillary personnel are those employees who do not have direct/substantial animal contact in their daily job functions, but who may need to enter an animal area in the course of performing their duties. Ancillary personnel will be provided, by their supervisor or designee, information based on their need for entry into animal care facilities.

a. The availability of, and the option to request medical evaluation and treatment of a medical condition.

b. Educational material regarding general information, potential hazards, universal precautions and personal hygiene.

c. Other potential health and safety hazards.

ENGINEERING AND MACHINERY SAFETY

90. Engineering and machinery safety is important an important tool to identify and manage the risks when using the equipment, machineries and plants. Many safety legislations have been introduced to ensure that the safety measures are taken, maintained and complied with at work place. While this section focuses on engineering and machinery safety, users should take into electrical safety in the laboratory activities. Safety consideration of generators if required, especially for facilities that do not have a built – in back up electrical power supply during a power outage/power failure.

In this section, we will focus on commonly used equipment, such as autoclaves and centrifuges, and boilers because of it risk and specific requirements. The local exhaust ventilation (LEV) system is also being included as it is very important engineering control to ensure the health of the lab users are not compromised.

Autoclaves

91. The autoclave is a steam sterilizer comprised of an insulated chamber where saturated steam is used during timed cycles to raise both temperature and pressure to perform sterilization. An efficient sterilization is dependent on time, temperature and steam quality. Autoclaves are used to sterilize glassware, instruments and media solutions. The extreme heat will destroy any microorganisms present in the sterilized item.

Procedures

92. Procedures to safely operate autoclaves are as follows:

a. Ensure that the items to be sterilized are safe and crack free prior to autoclaving. Avoid items that can produce toxic fumes.

b. The materials should be prepared well by packaging it with suitable wrappers.

c. The containers must be covered loosely to prevent pressure accumulation.

d. Pour the respective liquid to fill 2/3 of the container.

e. All the items used must be tagged with autoclave tape. Discard sharps in specifically designed and named as “Sharps’ container.

f. The items must be placed in a stable autoclavable container and easy to handle.

g. Use secondary pan to prevent spills from leaks.

h. As for the loading, wear Personal Protective Equipment (PPE) when handling the autoclave.

i. Do not overload the autoclave

j. Ensure the autoclave door is latched firmly before starting.

k. Choose gravity, liquid or dry cycle in accordance to the autoclave manual.

l. Set time and temperature for the chosen cycle and begin.

m. A complete cycle takes between 1-1.5hours.

n. Never open the autoclave while it is operating.

o. If there is any problem while operating the autoclave, immediately inform the person in charge or lab supervisor for further assistance.

p. Upon cycle completion, allow the temperature and pressure to drop to a safe range.

q. Stand at the back of the door and open small to allow pressure release.

r. Allow the autoclaved load to stand for 10 minutes in the chamber. Do not shake the container.

s. Wear heat-insulated gloves to remove items from the autoclave.

t. Place the hot items to cool in a place with 'Hot' precaution note.

u. Lastly, clean the autoclave and close the door.

Hazards

93. The operation of autoclaves is simple but there are serious hazards associated with its operation. Users need to take note of the risks and its hazards and take necessary measures to prevent any untoward incident or accidents form occurring.

a. Mechanical Hazard

(1) Explosion.

(a) Disintegration of pressure chamber

(b) Pressure relief valve fails

(c) Flammable liquids/gasses placed in the chamber

(2) Heat burns and steam burns caused by exposing to high temperature.

(a) Steam from opening door, source pipe or leaking door seal.

(b) Heat from contents or tray

b. Electrical Hazard.

(1) Electric Shock.

(a) Poorly maintained electrical cables

(b) Water and steam near electrical systems

(1) Radiation Hazard.

(a) Incomplete cleaning of contaminated material prior to autoclaving.

c. Physical Hazard.

(1) Slip, trip or fall.

(2) Cut, stabbed and punctured.

(3) Hot fluid scald.

Safety

94. Most common autoclave accidents are results of user's error or negligence. To ensure safety, user should strictly follow the manufacturer's operating instructions in manual according to each autoclave model they use and also all necessary safety measures based on risk assessment.

a. Operate the autoclaves safely as mentioned in part 90.

b. Contingency Plans. There are few events which causes malfunction of the equipment. Few quick steps must be carried out during the occurrence of these situations:

(1) If the autoclave malfunctioned, do not attempt to fix the problem. Place a notice indicating that it is not to be used until the problem is diagnosed and corrected.

(2) Record the problem in the autoclave log sheet (see **Annex C**)

(3) Contact your supervisor to report the problem.

(4) Only qualified professionals are permitted to make repair.

c. **Training**

(1) The lab supervisor needs to train new users in safe usage and maintenance of the autoclave and supervise their use where necessary.

(2) The users especially students need to attend a mandatory training session on autoclave lab safety, use, care and maintenance before operating the autoclave.

(3) Students must read and follow all instructions for proper and safe usage and maintenance of the autoclave.

(4) After the training takes place, the users should fill out 4(JSA) (see **Annex D**) to analyze and understand the hazards, risks and controls in operating the autoclave.

(2) The students also must sign the declaration to confirm that they understand the safety work procedures before using the autoclave.

(6) The safety procedures and autoclave use log must be kept close to the instrument.

(7) Students should fill out the autoclave use log (**Annex C**) each time the instrument is used.

d. **Maintenance**

(1) Autoclaves shall be maintained and repaired by qualified persons.

(2) No person shall operate an autoclave unless it has been inspected by a qualified inspector and a certificate of inspection has been issued.

(3) A current inspection certificate must be posted near the autoclave. Users are not to make repairs.

(4) Maintenance and care of the autoclave must be referred to user's manual.

(5) The autoclave must be immediately taken out of service if the autoclave is experiencing problems or even maintenance is required.

(6) The unit should be disconnected from the power source and clearly marked do not use until serviced. This includes the date, the reason and the signature of the person in charge.

(7) When maintenance work or repairs are needed, the user must provide a safe work environment for the service technician.

(8) Remove all items from the sterilizer chamber, clean any spills or leaks inside the chamber, remove untreated biohazardous materials from the vicinity, etc.

Any regular and periodic maintenance carried out and the repair details in autoclave must be recorded in the maintenance log (see **Annex E**).

Boilers

95. Boiler provides steam to operate equipment and produce steam throughout the industrial process. Steam provides sufficient heat transfer and contains high amount of latent heat. Water is boiled and converted to steam in a boiler under a controlled condition. For example, process equipment that uses steam are turbine reactor distillation columns, stripper columns and heat exchanger.

96. The common types of boilers are water tube, waste heat and fire tube boilers. Water tube

boilers contain water filled tubes to allow water to circulate through heated firebox. Waste heat boilers uses waste heat from processes to produce steam while fire tube boiler passes hot combustion gases through the tubes of heat water on shell side of boiler to form steam when the water boils. On the other hand, electric boiler can be installed in a central heating with induced circulation sealed or open system which are environmentally friendly operation without requirement for venting of combustion product.

97. Basically, the boilers have general components in common which are burner, firebox, drums, tubes, economizer, a steam distribution system and boiler feed water system. Steam distribution system of boiler includes valves, fittings, piping and connections suitable for pressure of steam to be transported throughout the process. Most steam boiler uses natural gases, oil or coal as a fuel to drive burner in order to provide heat to the boiler. Steam boiler in our laboratory uses liquified petroleum gas (*LPG*) as a fuel to drive the burner. Burner injects air and fuel through a distribution system that mixes them in proper concentration so that combustion can occur.

Rules and Regulations

98. Malaysian government has funded Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970 under Factories and Machinery Act, 1967. This regulation should be strictly followed by all the industries and individuals who use, manufacture, imports or exports boilers in Malaysia. The chief inspector will validate the locally manufactured quality and imported quality to comply with the standard conditions under this regulation. The validation will be done in accordance with design, materials used in design, method used in construction and provided with fittings following the provisions of the regulation. The steam boiler is ready for operation once it is validified by the chief inspector (Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations 1970).

Procedures

99. The lab supervisor or person in charge and the licensed person to operate the boiler (called boiler man) should be informed prior to the usage of boiler. The boiler man should inspect the following prior to the operation:

a. The boiler is clean and free of debris.

b. Refractory lining, tubes and tube supports are all intact.

c. Loose flanges around inlet and outlet of piping are tightened

d. All blinds are removed.

e. All valves in proper startup positions

f. Pressure relief valve is properly lined up

g. Draft fan, damper and fuel gas system are in good condition

h. Open the damper, start up the draft fan as per standard operating procedure.

i. Fill the boiler with water for a specific level to satisfy interlock.

j. Open the fuel gas supply to burner and pilot gas block valves after the draft in the boiler is stable and has been pursed for required length of time.

k. After the pilot is being ignited, lit and burning open the primary and secondary air registers are required.

l. Main burner block valves must be slowly opened one at a time until all burners are burning.

m. Inspect the flames for flame patterns and general operation while the operation is conducted.

n. Use peephole to inspect the inside of boiler and look for uniform colour of the tube.

o. Gradually reduce load, firing rate to shut down and turn of the fuel.

p. Shut the steam header valve and feed water pump.

q. Then, open vents and drains.

r. Leave fans on to help cool the boiler.

s. Block in all the burner, shutdown the fan and close the dampers.

Hazards

100. There are mechanical and electrical hazards that can cause damages to the assets, explosion severe injury, burns, electric shocks and even death. Thus, the scenarios and root causes of these hazards are listed down as below: -

a. Mechanical Hazard - Mechanical failure of boilers due to: -

(1) Oil Firing.

(a) High fuel temperature.
i. Improper setting of thermostat.
ii. Steam control valve stuck open in steam heater.
iii. Electrical supply contacts welded closed.

(b) Low fuel temperature.
i. Faulty heater element.
ii. Low setting of oil temperature control.
iii. Steam supply disrupted or closed.
iv. Electric power of heater is turned off.

(c) Wet steam during atomizing
i. Steam line not insulated.
ii. Steam traps not working.
iii. Steam wet from source.

(d) Low steam pressure.
   i. Improper setting of control valve.
   ii. Supply line valves inoperative or not open.
   iii. Low supply pressure.

(e) Worn or damaged atomizer
   i. Normal wear and tear
   ii. Abrasive material in oil
   iii. Burner tip is not serviced

(2) Gas Firing

(a) Gas line leaks and repair.
   i. Improperly assembled joints.
   ii. Excessive pressure.
   iii. Leaking gaskets.
   iv. Damage to piping, valves and fittings carrying fuel.

(b) High gas pressure.
   i. Defective gas pressure regulation

(3) Steam leaks

(a) Damaged or corroded pipes and pressure parts

(4) Accumulations of hot fly ash in boiler flues and plenums

(5) Steam Explosion

(a) Low water level.
   i. Defective low water cutoff.
   ii. Low water cutoff bypass.
   iii. Improper water column blows down procedure.
   iv. Tampering with low water control.
   v. Defective boiler water feed system.
   vi. Defective or inoperative gauge glass.
   vii. Operator error.

(b) Defective Safety Valves
   i. Obstruction between boiler and valves.
   ii. Damaged or corroded valve.
   iii. Level tied down.
   iv. Valve outlet obstructed.

(c) Defective steam pressure gauges
   i. Broken gauge
   ii. Poor calibration of gauge
   iii. Line from boiler to gauge is blocked
   iv. Gauge cock is closed

v. Conflict of multiple gauges

(d) Scaling or corrosion in boiler’s internal surfaces
   i. Poor maintenance and test methods
   ii. Improper chemical cleaning
   iii. Improper water treatment or contaminated boiler water
   iv. Poor feed water control

(e) Bypassed controls
   i. Defective electrical wiring
   ii. Control and electrical wiring tampered

(f) Poor maintenance
   i. Lack of maintenance policy and procedures
   ii. Poor or no training to workers.

(g) Condensate tank explosion.
   i. Improperly vented tank.
   ii. Vent designed too small.
   iii. Trapped vent which may has frozen condensate.

(6) Explosion in furnace.

(a) Inadequate pilot/ igniter.
   i. Low pressure of oil/ gas.
   ii. Improper setting of light-off.
   iii. Plugged orifice.

(b) Ignition delayed.
   i. Pilot / igniter is not adequate.
   ii. Fuel pressure may be low or not sufficient.
   iii. Excessive air rate.
   iv. Low oil temperature.
   v. Water in fuel.

(c) Combustion air is not sufficient.
   i. Lack of adequate air opening in boiler room.
   ii. Dirty combustion air blower.
   iii. Blockage in blower inlet or in outlet damper.
   iv. Boiler gas passage may be plugged.

(d) Combustion safety control tampered
   i. Poor operator training

(e) Leaks in fuel safety shutoff valves
   i. Defective valves

(7) Implosions

(a) Excessive negative pressure

i. Flame out

(8) Poor maintenance

(a) Release of fluid pressure / Electric shock
i. Lockout/ tagout not following
ii. Equipment not in zero mechanical state

(b) Airborne contaminants
i. Leakage
ii. Ventilation or exhaust not proper

(c) Congestion in work area
i. Poor housekeeping

b. Electrical Hazard – Risk of Electrocution

(1) Exposed to electrical wiring

(a) Damaged electrical wiring

(b) Poor maintenance

(2) Exposed electrical boxes

(a) Negligence

Safety

101. Boiler possess high risk potential to user if it is operated without strictly following the manufacturer's operating instructions in manual according to each boiler model they use. Negligence can cause loss of lives and assets.

Safety Precautions

102. It is important to adhere to the manufacturers' instructions and regulations to avoid accidents from boilers.

a. A proper license should be obtained from Factories and Machinery Act 1967 to operate the boiler.

b. The room placed with boiler should have adequate ventilation.

c. Ensure safe exits in the boiler room.

d. Place an adequate number of suitable fire extinguishers in and outside the boiler room.

e. Link the boiler room with the fire alarm system of the factory by installing a fire alarm switch/box.

f. Place First aid kit just outside the boiler room.

g. Ensure easy access to ladders, runways and controls.

h. Good housekeeping of the boiler room should be maintained and dumping of waste or unnecessary articles in the boiler room should be strictly avoided.

(1) Floor and drains must always be clean, clear and unclogged.

(2) Ensure that no flammable or combustible materials are stored in the boiler room or next to it.

i. PPE such as respirators, ear plugs, guides, shields, or covers should be fitted in rotating equipment, mechanically automated devices, or electrically and pneumatically operated control components to prevent accidents.

j. Restrict the usage of the boiler without the authorized personnel (boiler man).

k. The operator should ideally have a formal qualification and training to run a boiler of given capacity.

l. The boiler in operation should not be left to a person who is not trained or qualified.

m. Clear direction should be provided for start-up, running and shutdown procedures, blow down, high and low water conditions, and emergency procedures.

(1) The water for the boiler should be treated for hardness before using.

(2) Each boiler should have a temperature gauge.

(3) Ensure sound boiler piping support, foundation and settings for all equipment.

(4) Piping systems including flow direction should be properly marked.

(5) Post piping diagram at the location.

(6) Fuel-piping connection should be of high quality using the correct gasket, bolts, thread lubricants and tightening torque as fire boiler utilizes flammable potentially explosive fuel and to prevent leaks.

(7) Implement an extensive preventive maintenance program.

(8) Gauge, control equipment pressure relief valves, pumps and valves, water quality and treatment methods, burner and fuel systems must be checked periodically to prevent hazards.

(9) All pipes and fitting should be well-maintained and in good condition.

(10) Refractory and insulation should be used on boiler surfaces to reduce surface temperature.

(11) Protect the water supply to the boiler by installing an approved back flow stopper.

(12) Regularly, repair leaking steam, water, fuel and other boiler connections.

(13) Periodically, clean and inspect exhaust venting, breeching and chimney to remove combustion gases.

(14) Conduct periodic boiler water analysis and chemical treatment to prevent corrosion, pitting and scale.

(15) Safety or relief valves should be tested by lifting the test lever at least once a year.

(16) High voltages exist in control panels and control components. Power must be shut off before these components are serviced.

(17) The boiler should have a documented lockout and tag-out procedure that is strictly enforced when the maintenance work is going on.

(18) Workers must be trained in safe operation of the boiler equipment. The training should be a continuous process to emphasize the importance of safety.

(19) Ensure all accidents and emergency are reported immediately to the respective person in charge or lab supervisor.

Emergency Plans

103. Any emergency scenarios should be quickly informed to lab supervisor to take further actions. Basically, one fuel gas block valve will be designed as main shut off valve. The person in charge or the boiler man is responsible to block in the burner, block in fuel and stop all the pumps.

Training

104. Competency boiler man training is mandatory for any staff is required to operate a boiler.

a. The person in charge should obtain license to operate the boiler (referred as boiler man).

b. The person should attend competency course and pass the respective exams in order to obtain the license.

c. The license of the boiler man must be renewed in required period to avoid exceeding the expiry date.

d. Boiler man is responsible in performing specific procedures to operate and maintain the boiler equipment safely.

e. The boiler man role in operation and maintenance are divided into observe, listen and inspect.

(1) Observe.

(a) Firebox for flame impingement on tubes

(b) Burner flame colour and pattern

(c) Wall hotspots (external and internal)

(d) Draft balance for pressure

(e) Temperature gradient

(f) Burner balance for fuel and air

(g) Boiler stake for smoke

(h) Proper steam flow

(i) Operation of mud drum.

(2) Listen

(a) Abnormal noise from fans, burners, water leaks, steam leaks, alarms.

(b) Huffing and puffing which indicates improper draft operation

(3) Inspect

(a) Controlling instruments

i. Water level
ii. Fuel level
iii. Feedwater flow
iv. Pressure
v. Steam pressure
vi. Temperature

(b) Air flow and oxygen level and adjust draft as needed

(c) Excessive vibration of fans and burners

i. Burner automization for uniformity
ii. Firing efficiency of Carbon dioxide, Carbon Monoxide and Oxygen in the stack
iii. Burner wear which can cause uneven flame or hotspot

iv. Collect boiler feedwater samples and ensure proper chemical treatment
v. Failure to perform proper maintenance and monitoring can cause damage of equipment and safety issues to the users.
vi. The boilerman should present when there is need in boiler operation. Other only can assist him/her.
ii. The boiler should not be operated without the boilerman for safety purposes.
iii. The safety procedures and boiler use log must be kept close to the instrument.
iv. Students should fill out the boiler use log (**Annex F**) each time the instrument is used.
v. Any regular and periodic maintenance carried out and the repair details of respective boiler must be recorded in the maintenance log in **Annex G**.

Maintenance

105. Proper maintenance is necessary for the safe operation of the boiler.

a. Maintenance and care of the boiler must be referred to user's manual.

b. Technicians must follow lockout or tagout procedures before performing any maintenance works.

c. The person in charge / lab supervisor / boiler man should ensure the tools are newly implemented or serviced monthly, annually according to its necessity.

d. The implementation of tools must be recorded as per **Annex H**.

e. Annual inspections overhauling of steam boiler must be conducted by the respective servicing company.

f. Records of annual inspections overhauling of steam boiler must be kept up to date.

g. The maintenance of the steam boiler must be recorded accordingly as per **Annex G**.

Centrifuges

106. Centrifuge is an equipment used for separation of solid and liquid in a fluid. This device is generally characterized by their ability to separate finely divided solid particulates suspended in liquid in order to conserve the solid particulate materials for further uses. For example, samples taken from people's, animal's and plant's components of different densities can be separated using this centrifuge equipment. This process is accomplished by delivering the fluid to high speed rotating bowl which create centrifugal gravitational forces. This will cause the fluid to be displaced radially outward against the wall of the bowl and eventually the solid particles will adhere to the walls and purified liquid exits through discharge opening. Centrifuges are divided into three classes depending on the speed of the centrifugation processes held which are low speed centrifuges (≤ 15,000 rpm), high speed centrifuges (>15,000 rpm to 25,000 rpm) and

ultracentrifuge (≥ 25,000 rpm). Occupational Safety and Health Administration (OSHA) of United States has stated the safety procedures while operating the centrifuge equipment to avoid any accidents.

a. **Procedures.**

(1) Sample solutions must be weighed in and poured equally to all the centrifuge containers or tubes.

(2) The sampling load must be balanced to avoid overfilling tubes as centrifuged force may push the solution to the sides of the container and cause leakage.

(3) Make sure to be equipped with Personal Protective Equipment (PPE) such as lab coat, gloves and closed footwear while loading and unloading centrifuge containers or tubes.

(4) Place the sampling tubes into the rotor. Seek assistance from the person in charge of the lab if the rotor does not appear to attach correctly and do not force it.

(5) Ensure the spindle is clean and the rotor is properly seated on the drive shaft.

(6) Close the lid gently when ready to begin centrifugation process.

(7) Now set the speed you needed which is between 100 rpm to 4200 rpm.

(8) Also, set the time you needed for the centrifugation process which should be between 10 seconds to one hour.

(9) Hit the lock and then the start buttons to begin the run.

(10) Ensure the lid is always closed during the operation to avoid any spillages.

(11) The machine will beep once the run has ended.

(12) Open the lid and unload the sampling tubes carefully.

(13) Switch off the machine and clean out the centrifuge if there have been any leaks.

b. **Hazards**

(1) Mechanical Hazard - Mechanical failure of centrifuge

(a) Rotor imbalance due to inappropriate usage.

(b) Rotor falls due to excessive speed.

(c) Rotor disengages from spindle.

(d) Rotor falls due to extensive wear and tear.

(e) Centrifuge tubes breakage while in rotor due to excessive wear and tear.

(2) Chemical Hazard - Exposure to hazardous chemicals.

(a) Damaged tubes

(b) Tubes are not sealed properly

(c) Unbalanced tubes on rotors

(3) Electrical Hazard – Risk of Electrocution

(a) Exposure to live current

Safety Precautions

107. Centrifuge possess high risk potential to user if it is operated at high speed without proper observation. Injury or even death can cause by operation of unbalanced centrifuge rotors. If there is any sample container or tube breakage during centrifugation process is going on, it releases aerosols which are harmful upon inhalation of the user. Most common centrifuge accidents are results of user error. The user should strictly follow the manufacturer's operating instructions in manual according to each centrifuge model they use. There are few safety steps by Occupational Safety and Health Association (OSHA) to prevent any accidents in laboratory due to centrifuge usage: -

a. The work surface under the centrifuge shall be level, firm and capable of supporting the weight of the centrifuge equipment.

b. Ensure that centrifuge containers/tubes, bowls and spindles are clean, dry and free of scratches.

c. Make sure to use matched sets of tubes, buckets and other equipment.

d. Use safety centrifuge cups to contain potential spills and prevent aerosols without fail.

e. Overfilling tubes and other containers should be avoided. For example, as for fixed angle rotors, the centrifugal force may drive the solution up the side of the tube or container wall.

f. The rotor must be seated on the drive shaft properly.

g. Vacuum grease must be applied correspond with the manufacturer's guidelines.

h. Make sure do not exceed the rotors' maximum run speed.

i. Centrifuge lid should be closed during the operation.

j. Ensure the lid is open once the rotor has come to complete stop.

k. Make sure to wait for at least 10 minutes before opening lid when it comes to centrifuging infections materials.

l. Do not try to open lid to retrieve samples in case of power failure for at least half hour.

m. If vibration occurs, stop the run immediately. Never open the lid when the rotor is moving.

n. Check for fractured tubes because even a tube with fracture may hold fluids before centrifugations but the cracks will open under centrifugal force.

o. Repeated use of tubes especially nitrocellulose tubes increases the chances of the tube collapse due to internal molecular stress with tube walls. Thus, try to use new tubes instead of old ones.

p. Ensure gaskets, O-rings on centrifuges lid, safety cups are clean, pliable and not damaged.

q. Allow only properly trained person to check the O-rings on the rotor.

r. Use appropriate decontamination and cleanup procedure for spilled materials if any spills occur.

s. Ensure all accidents and emergency are reported immediately to the respective person in charge or lab supervisor.

Emergency Plans

108. There are few events which causes the rise of emergency situations during the usage of centrifuge equipment. For instance, events such as spillage during centrifugation, equipment malfunctions, rotor failures and sample tube breakages. Few quick steps must be carried out during the occurrence of emergency situations: -

a. The centrifuge should be turned off and the lid should be closed immediately.

b. Notify the lab supervisor and other lab users to evacuate the lab; post biohazard spill signs near the equipment.

c. Leave the lab at least for 30 minutes to reduce the risk of aerosols.

d. The person in charge should wear appropriate gloves for the spill cleanup.

e. One should remove debris, clean and disinfect centrifuge interior rotors, safety cups/ buckets following manufacturer's instructions.

f. The contaminated gloves, cleanup materials should be placed in biohazard bag.

g. Wash hands and exposed skin surfaces with sanitizers and water.

h. Report the incidents to lab supervisor for any further assistance.

Training

109. Centrifuge is a useful laboratory appliance, and training is required to ensure users understand the potential risks, hazards and how to operate the instrument safely.

a. The lab supervisor needs to train new users in safe usage and maintenance of the centrifuge and supervise their use where necessary.

b. The users especially students need to attend a mandatory training session on centrifuge lab safety, use, care and maintenance before operating the centrifuge.

c. Students must read and follow all instructions for proper and safe usage and maintenance of the centrifuge.

d. After the training takes place, the users should fill out Job Safety Analysis (JSA) (**Annex I**) to analyse and understand the hazards, risks and controls in operating the centrifuge.

e. The students also must sign the declaration to confirm that they understand the safety work procedures before using the centrifuge.

f. The safety procedures and centrifuge use log must be kept close to the instrument.

g. Students should fill out the centrifuge use log (**Annex J**) each time the instrument is used.

Maintenance

110. Centrifuge is common and frequently used equipment in laboratory, where wear and tear is expected. Centrifuges can be often exposed or contaminated with fine spray of salts and chemicals. In case of long-term exposure and lack of maintenance can lead to chemical corrosion that may affect the rotors and rotor-buckets than can make centrifugation operation unsafe. Regular maintenance including cleaning is necessary to maintain its optimal condition and safe for use.

a. Maintenance and care of the centrifuge must be referred to user's manual.

b. Rotors and cups are to be cleaned and decontaminated after each use with corrosive cleaning solutions. For example, alkaline can be used for anodized rotors. Mild detergents are recommended to prevent damage to the rotors.

c. Cleaned rotors and cups are stored inverted. Keep the rotors clean and dry.

d. Rotors shall be retired after the manufacturer's recommended revolutions or years of service.

e. Conduct annual stress test (magnaflux or other professionally recognized analysis) proves an absence of structural flaws.

f. The centrifuge must be immediately taken out of service if the centrifuge is experiencing problems or even maintenance is required. The unit should be disconnected from the power source and clearly marked do not use until serviced. This includes the date, the reason and the signature of the person in charge.

g. Any regular and periodic maintenance carried out and the repair details in centrifuge must be recorded in the maintenance log **(Annex K**).

Local Exhaust Ventilation (LEV) and Other Ventilation System

111. Ventilation is a primary engineering control available to reduce the concentration of gases, dusts, vapours, smoke, and fumes in the air. Dusts, fumes, vapours, and gases in the air are drawn into the ventilation system and carried to the collecting device by a pressure gradient created by the fan. The fan must have sufficient power to overcome the resistance to air flow created by the system. There are two types of ventilation systems: general and local exhaust.

a. **General Ventilation.** General (dilution) ventilation systems supply clean air that mixes with the air in the workplace, diluting the concentration of the contaminant. General ventilation is not suitable to control exposure to toxic substances because these systems actually spread the contaminant throughout the workplace before exhausting it. Also, they require large amounts of air and may be costly to operate during the winter because of additional heating. General ventilation systems are used primarily to control temperature and humidity, to remove odours, and sometimes to remove traces of volatile organic compounds (VOCs) and microorganisms emitted from carpeting, paneling, furniture, and people.

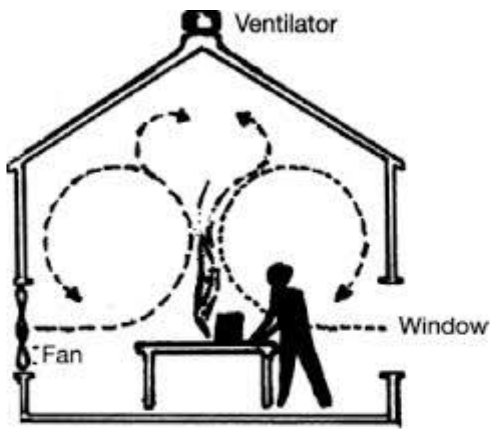


Figure 6: *General Exhaust Ventilation*

b. **Local Exhaust Ventilation.** Local exhaust ventilation system is the most common type of engineering control equipment used to control exposure of employees to chemicals hazardous to health. Local exhaust ventilation system operates on the principle of capturing a contaminant at or near its source before they are dispersed into the workroom environment. Contaminants can be in the form of dust, smoke, mist, aerosol, vapor and gas. Local exhaust ventilation (LEV) is only one of many engineering control options that may be used to remove and prevent employee exposure to vapour, mist, dust or other airborne contaminants. To be effective in protecting the employee(s), it is important that it is of good design, is fit for purpose, is regularly maintained and the system's performance is monitored. Failure to do so can lead to employees being exposed because they have the impression that the system is effective when it is not.

Local exhaust ventilation systems are comprised of up to four basic elements: hood, ducting system, air cleaner and fan

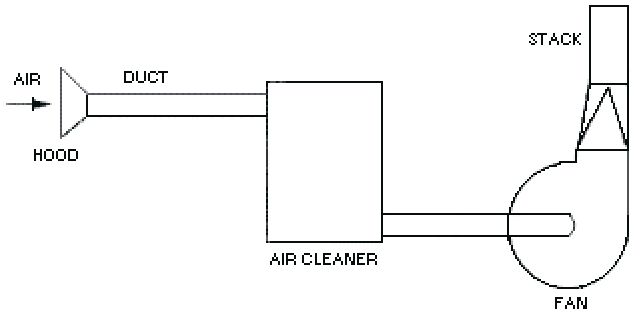


Figure 7*: Components of Local Exhaust Ventilation*

The hood captures the contaminant by overcoming its momentum and then drawing it into the system. Factors affecting the design and location of the hood include the form of the contaminant (dust, fume, vapours, or gas), and the speed at and direction in which the contaminant is released. For large, heavy dust particles released at high speeds (e.g., grinding), the hood must be positioned in the path of the particles.

Typical face velocities of the hood required are:

- 100 feet per minute (fpm) for vapours and gases
- 200 fpm or more for dusts

The duct work provides a pathway to carry the contaminant to the air cleaning device. The velocity of air in the duct must be high enough to prevent heavy particles from settling in the ducts. The heavier the particle, the greater the velocity needed

- 1000 fpm for vapours and gases
- 4000 fpm for heavy dusts

Also, there should be no obstructions or unnecessary bends and constrictions. These can cause excessive pressure drops.

The air cleaning device removes contaminants from the air stream before it is passed to the fan and expelled to the atmosphere or recycled to the work area. There are two types of air cleaning devices: air filters and dust collectors

Air filters are designed to remove low dust concentrations of the magnitude found in atmospheric air. Dust collectors are designed for the heavier concentrations that are generated by industrial processes

The fan is the device that draws the air through the entire system. It must be capable of generating enough of pressure drop to draw the required volume of air through the hood, ducts, and collecting devices at the correct velocity, and of overcoming the resistance to air flow from hoods, ducts, and collecting devices

Hazards of Poor or No Ventilation

112. Depending upon workplace conditions and activities, the hazards of poor or no ventilation could include:

a. Lack of oxygen (headache, fatigue, asphyxiation), particularly in confined spaces.

b. Excessive heat, cold, and humidity.

c. Toxic fumes (e.g., lead, cadmium, zinc) toxic vapours (e.g., benzene, toluene, trichloroethylene, MEK).

d. Toxic gases (e.g., hydrogen sulphide, ammonia).

e. Dusts (causing poisoning or gradually reduced lung capacity).

f. Fire/explosion.

Controls

Ventilation Control Program

113. All ventilation systems require inspections and testing. Training on routine and emergency operating procedures should also be provided. Incorporate these into a ventilation control program. Some factors to be considered and incorporated into the program are:

a. Written standards and procedures for operation

b. Regular monthly and yearly inspections, depending on the Regulation 17 (1) (a) and Regulation 17(1)(b) USECHH 2000

c. Regular cleanout schedule for settling chambers, dropout boxes, dust collectors

d. Posting of emergency and operating procedures

e. Regular maintenance

f. Operator training

g. Use of personal protective equipment, when warranted

h. Regular medical examinations, where applicable

i. An emergency plan in case of fan failure or blockages of ducts

j. Explosion-proof venting for ducts

Inspection

114. Never assume the system is operating properly just because the fan is running. Some things to be considered during inspections are:

a. Determining the velocities at which the system is to operate

b. Doing visual checks of the system – physical condition of ducts, dampers, hoods, stack, motor, fan, blades, belts

c. Checking the electrical system regularly

d. Checking noise levels from fans (increase in noise levels is an indication of problems; any increase in noise could also raise noise exposure levels to above legal limits)

Training

115. Training requirements should include the following:

a. Familiarity with the Occupational Health and Safety Act and Regulations

b. The role of ventilation in contaminant control

c. Breakdowns which cause hazardous or nuisance conditions

d. How to handle fire in ducts

e. Knowledge of tests carried out (to reinforce why there is such a ventilation system)

f. Position required to be in while working near exhaust hood

g. Shutdown procedures of fans, etc

Maintenance

116. Any ventilation system will have slight performance fluctuations. As with any piece of machinery, a ventilation system is subject to wear, misalignment and breakdowns. Only through regular and thorough maintenance can it remain in effective operating condition. The following are a few of the more common problems to be aware of:

a. **Hood System.**

(1) Adjustable slots have been altered.

(2) Resistance has been changed (i.e., the hood has been modified or more fume hoods have been inappropriately added, so the velocity and flow rate of air are less than specified).

(3) Holes in the enclosure resulting in air entering the hood in other locations.

(4) Inspection doors left open or removed, allowing air to enter.

b. **Ducting.**

(1) Duct partially plugged, increasing the resistance of air flow and decreasing the flow rate

(2) Damper settings changed which lessens the amount of air flowing through (some ducts have fused dampers, designed to close in case of fire, and occasionally, fuses will melt, causing damper to close inadvertently)

(3) Additional ducts added since last inspection

(4) Too many corrugated ducts (high static pressure)

(5) Corrosion, leaks, holes, bent, crushed, dust

(6) Inspection doors left open

(7) Ducts joints have worked loose or become separated

(8) Hangers missing and/or damaged

(9) Blast gates/dampers

(10) Incorrect position (causing system to become unbalanced)

c. **Air Filter.**

(1) Bags missing, blocked, overloaded.

(2) Cleaning mechanism not working.

(3) Hopper full of dust.

(4) Filters clogged.

d. **Motors/Fans.**

(1) Duct or corrosion on fan blades

(2) Incorrect rotation of blades (with flow axial fans, air flow may be reversed; with centrifugal fans, rate of flow may be reduced, making detection more difficult)

(3) Fan blade assembly incorrectly mounted (turned around)

(a) Incorrect fan size for system

(b) Incorrect speed

(c) Field modification to fan wheel or casing

(d) Broken fan belt

(e) Belt slippage/pulley sizes changed

(f) Motors not lubricated, drives belts and other parts worn out

(g) Poor fan inlet connections causing uneven air flow into fan (can reduce fan capacity by 20%)

Record Keeping

117. The employer has to keep record specify below:

a. Design;

b. Construction;

c. Testing, inspection and examination; and

d. Maintenance.

Legal Provision

118. Occupational Safety and Health (USECHH Regulations 2000) have specified requirements in term of design, commissioning, inspection and testing of local exhaust ventilation system. The effectiveness and efficiency of the local exhaust ventilation system depend on the design, usage and maintenance of the system.

119. USECHH Regulations 2000 defined engineering control as any equipment which is used to control exposure of employees to chemicals hazardous to health and includes local exhaust ventilation equipment, water spray or any other airborne chemical removal and containment equipment.

a. Regulation 17 stipulated that any engineering control equipment has to be inspected at an interval not longer than one month and has to be examined and tested by Hygiene Technician at an interval not longer than twelve months.

b. Regulation 18 stipulated that local exhaust ventilation system has to design according to approved standard by registered professional engineer. This regulation also stipulated the responsibility of registered professional engineer to test the local exhaust ventilation system after construction and installation.

c. Regulation 19 stipulated the type of records the employer has to keep and produced for inspection when requested by Director General of Occupational Safety and Health.

Approved Standard for Design of Local Exhaust Ventilation

120. There is no specific standard for designing of local exhaust ventilation system. Industrial ventilation – A Manual of Recommended Practice by ACGIH is the most common reference book used by designer of local exhaust ventilation system. So the designer has to submit standard to be used for approval by Director General of Occupational Safety and Health before can proceed with the design. Appendix A list out some of the standard that can be used.

Fume Hoods

121. A fume hood is ventilation equipment that vents separately from the building's heating, ventilation, and air conditioning (HVAC) system. The primary means of controlling airborne chemical exposure is a fume hood. Fume hoods should be used when working with toxic compounds or compounds with a boiling point below 120C. (However, some aqueous solutions may be an exception to this rule.) It may be necessary to use a closed system, such as a glove box or bag, for highly hazardous chemical materials.

a. **Fume Hood Use**

(1) Training – Personnel using fume hoods should take a training class before using it.

(2) Verify Operation – Make sure the fume hood is operating before starting work. Some new fume hoods have monitoring devices that indicate acceptable working conditions. Otherwise, a strip of Kimwipe™ taped to the underside of the sash can be used as an indicator of air flow. Since this strip may flutter, even when the air flow is inadequate, the strip should be placed and its movement observed when you know that the air flow is proper.

(3) Exhaust Fan Speed – Some older buildings have fume hoods equipped with two- speed exhaust fans with local control at the hood. The low exhaust setting is only appropriate for storage. The high setting provides protection for working with chemicals.

(4) Minimize Cross Drafts and Eddy Currents – Air flow into the fume hood is adversely affected by cross drafts and eddy currents. Cross drafts occur when people walk in front of a fume hood or when nearby windows or doors are open. Eddy currents occur around the person using the fume hood and around objects inside it. To limit these effects, fume hoods should not contain unnecessary objects and the slots within the fume hood, which direct air flow, must not be blocked. The slot at the rear of the work surface is essential for proper air movement. If large pieces of equipment or large numbers of bottles are placed in front of the slot, they should be raised up on blocks or placed on a shelf to allow air to flow into the slot. Equipment should be placed as far to the back of the fume hood as practical, leaving six inches at the rear. Work should be performed at least six inches inside the fume hood opening to prevent cross drafts and eddy currents from pulling contaminated air out of the fume hood and into the room.

(5) Sliding Sashes – The sash should be kept as low as possible to improve overall performance of the hood. The more closed the sash is, the better protection

from an unexpected chemical reaction. Procedures should be done with the sash at the level of the maximum approved sash height marking or lower. Use a separate safety shield, such as a face shield, when working with an open sash.

(6) Chemical Evaporation – It is illegal to evaporate chemicals in the hood to "dispose" of them. Any open apparatus used in hoods which emit large volumes of volatile chemicals should be fitted with condensers, traps, or scrubbers to contain and collect hazardous vapors or dusts.

(7) Storage – Do not store chemicals or supplies in the fume hood. Chemicals and supplies should be stored in approved cabinets.

(8) Flammable Liquid Vapor – Laboratory fume hoods are designed to reduce flammable vapors below lower explosive limits when properly operated and maintained. As an added precaution, use only non-sparking and explosion proof electrical equipment (hot plates, stirring plates, and centrifuges) in fume hoods where a large volume of flammable liquid vapor may be generated. Take care with flammable liquids and heat sources.

(9) Containers – All containers of chemicals must be securely capped when not in use. A rule is that containers should be open for minutes (at the most) – which is the maximum time it normally takes to pour a small amount of chemical into another container and replace the cap. All containers must be labelled with the chemical identity and appropriate hazard warnings (or the material must be used up during the work period and be under continuous control of the researcher using it).

b. **Fume Hood Prep for Maintenance**

(1) Prior to any maintenance of fume hoods the entire interior surfaces must be decontaminated and/or cleaned by the researchers using the hood.

(2) Maintenance may require access to storage cabinets below or to the side of the hood.

If access is required, the entire cabinet and adjacent area also needs to be emptied, decontaminated, cleaned, and rinsed. Lab staff needs to identify a contact for coordinating with Facilities Services regarding the work to be done.

c. **Fume Hood Performance and Testing**

(1) A functional performance test annually should be performed to assure hoods are performing as designed. If a hood fails, it may need to be taken out of service until repaired and post a "Do Not Use" sign if repair is required.

(2) Fume hoods can be tested using up to five functional performance criteria, depending upon the fume hood design. This includes face velocity, variable air volume (VAV) tracking, sound, and containment to monitor functionality. Specific performance measures for each test are outlined below.

d. **Face Velocity**

(1) Standard Flow Hoods: 80 – 120 Feet Per Minute (FPM)

(2) Sash height should not be less than 18 inches

(3) High-Performance Hoods: 60 – 84 FPM

e. **VAV Tracking.** The sash is lowered about 50% from the target sash height to assure the HVAC system responds appropriately to maintain optimal capture velocity.

f. **Sound.** Measure sound using a sound meter on Scale A with the sash optimized and the sound meter located about one foot from the front of the hood at 18 inches above the work surface (roughly ear level of the testing technician). The ambient sound level must be less than 80 dBA.

g. **Containment Test.** Use visual powder or dry ice; check for effective containment.

h. **Monitor Alarm Properly Functioning**.

(1) Confirm monitor has power and is properly calibrated

(2) Raise sash to reduce face velocity below 80 LFM (60 LFM for low-flow fume hoods) and to confirm that both visible and audible alarm signals function

(3) Test monitor's mute function by pressing the mute button

(4) Test the reset button

(5) Test Failure: Monitor fails to alarm, is more than 10 FPM out of calibration, fails any functional test, or is damaged

i. **Perchloric Fume Hoods.** Procedures using concentrated perchloric acid (>70%) or which heat any amount or concentration of perchloric acid must be performed in a closed system or within a specially designed perchloric acid fume hood with wash down systems to prevent the accumulation of explosive perchlorates in the hood and ducting.

k. **Glove Boxes.** Glove boxes generally operate under either positive or negative pressure to the lab, depending on the process or material used. Positive pressure glove boxes are used when you are trying to protect your material from contamination. Negative pressure glove boxes are used to provide increased operator protection. Glove boxes should be thoroughly tested before each use and there should be a method of monitoring the integrity of the system (such as a pressure gauge).

l. **Biological Safety Cabinets.** Biological safety cabinets (BSCs) are laboratory hoods designed to protect the worker and the experiment by drawing air across the samples and away from the worker and into a HEPA filter. There are two types of BSCs. Class II type A and Class II type B1 units recirculate filtered air into the laboratory and are not designed for chemical use for this reason. The Class II type B2 unit is designed for use of some chemicals but is not substitute for a fume hood. The use of chemicals in this type of hood needs to be evaluated carefully so that the protective barrier (HEPA filters) is not destroyed by the chemicals.

BSCs need to be certified annually. If a BSC fails the certification, it may not be used until repaired. BSCs may not be repaired or moved until decontaminated.

Laboratories are solely responsible for maintaining any UV lights in their cabinets, and will need to use outside contractors for servicing. The sterilization/decontamination activity of UV lights is limited by a number of factors, requiring them to be regularly maintained. BSCs with UV lamps should be labelled with a UV Light Source Caution sticker.

m. **Laminar Flow Hoods.** Laminar flow hoods are designed to protect the work surface from contaminants and may blow out into the face of the person using the hood. Therefore, any chemical use will cause the person to be exposed to the chemical. Toxic or volatile chemicals may not be used in a laminar flow hood.

n. **Ductless Laboratory Hoods.** In some cases, installation of a ducted fume hood may be impossible and a request for a "ductless hood" must be approved by the University. This type of device uses special filters or absorbents to clean the contaminated air in the hood prior to recirculating the air back into the room.

Recirculation of potentially contaminated air into the room presents special dangers and special requirements must be met. The requesting department must demonstrate that the following concerns are addressed as long as the hood is in use:

o. **Chemical Characterization**. Each of the chemicals to be used in the ductless hood must be completely characterized as to the quantity which may be released within the hood at one time and the frequency of use. The hood manufacturer will need this information for the design of the hood. Once designed, use of other chemicals in the hood must be forbidden unless the hood manufacturer approves the alternate chemical. Records as to the design of the hood and the designated chemical usage must be maintained in the laboratory.

p. **Ductless Hood Approval**

The PI must verify that the size, shape, and layout of the proposed hood, as offered by the hood manufacturer, is appropriate for the intended use. The PI must also develop a management plan for the hood which addresses staff training, procedures for using the hood including: emergency procedures, ongoing maintenance, certifications for the hood, and recordkeeping. This plan needs to assure continuity if management of the hood is taken over by another individual. Hood approval by the University is contingent upon submittal of the hood design information from the proposed manufacturer and submittal of the management plan.

q. **Laboratory Staff Information and Training.** All personnel in the laboratory must be trained as to the fact that the ductless hood recirculates air back into the room, that only certain designated chemicals may be used within the hood, and that failure to operate properly and maintain the hood may result in personal exposures.
Also, a sign must be placed on the hood identifying which chemicals may be used and warning that the air is recirculated back into the room from the hood.

r. **Cold Rooms, Warm Rooms and Environmental Chambers**

(1) **Room Design**. Controlled environmental rooms generally are completely enclosed with no fresh air and with heating/cooling and other environmental systems independent of the building. Rooms large enough to enter should be designed or retrofitted with doors that allow anyone trapped inside to get out easily. The electrical system within environmental rooms should be independent of the main power supply so that people are never left in these areas without light.

(2) **Chemical Use.** Controlled environment rooms usually recirculate the air using a closed air-circulation system. Hazardous chemicals must not be stored in these rooms because ambient concentrations of volatile chemicals can accumulate to dangerous levels. Flammable solvents should not be used in controlled environment rooms. Ignition sources in these rooms could ignite vapors. Avoid using volatile acids in cold rooms because vapors can corrode the cooling coils, leading to possible refrigerant leaks. If solid carbon dioxide (dry ice) is placed into a cold room, its sublimation will raise the carbon dioxide levels within the room, possibly to dangerous levels. Use extra precautions if you must use or store dry ice in these spaces.

s. **Other Ventilation Systems.** A ventilation engineer must design all other local exhaust systems used in the laboratory. All local exhaust systems should have a visual indicator that the system is functioning properly at all times, even if the indicator is just a Kimwipe™.

(1) **Discharge of Hazardous Vapors**

Laboratory apparatus that may discharge hazardous vapors (vacuum pumps, gas chromatographs, liquid chromatography, and distillation columns) must be vented to an auxiliary local exhaust system such as a canopy or a snorkel, if not already vented to a fume hood.

(2) **Hazardous Chemicals.** Hazardous chemicals should be stored in approved cabinets.

t. **Isolation/Clean Rooms.** Isolation rooms typically operate under negative pressure and clean rooms typically operate under positive pressure to the anterooms or hallways. These rooms require considerable engineering. Procedures for entering and exiting these areas should be written out and employees should be trained accordingly.

u. **Maintenance of Ventilation Systems.** All ventilation systems need routine maintenance for blocked or clogged air intakes and exhausts, loose belts, bearings in need of lubrication, motors in need of attention, corroded ductwork, and minor component failure. When maintenance is scheduled for fume hood exhaust systems, warning signs will be posted on the affected fume hoods and researchers must cease fume hood use during the maintenance procedures in accordance with the requirements listed on the sign.

v. **Filters.** Filters should be replaced periodically in certain types of ventilation systems such as electrostatic precipitators, cyclones for dust collection, and BSCs. For laboratory maintained equipment, keep a record of these filter changes in a notebook or file that can be easily located in case a regulatory agency requests a copy of this documentation.

w. **Monitoring Devices.** Monitoring devices should be included in new ventilation systems to make the user aware of malfunctions. All personnel within the laboratory need to understand the meaning of associated alarms and readout devices and the actions to take if an alarm or unacceptable reading occurs.

RADIATION AND LASER SAFETY

Radiation Safety and Health

122. Radiation is a general term to describe emission and transmission of energy through space in the form of charged and uncharged particles. There are two types of radiation that make-up the electromagnetic spectrum ranging from low energy radiation such as radiowave, microwave and visible light to high energy radiation such as X-ray and gamma ray. Generally, low energy radiation is termed as non-ionising radiation while high energy radiation is termed as ionising radiation.

123. The type of radiation we heard about most often is Ionising Radiations (IRs) because it has enough energy to dislodge electrons from an atom resulting in the form of charges. It is an energetic radiation emitted either by radioactive materials undergoing decay or by irradiating apparatus. Sources of IRs are commonly used in the medical field for diagnostic and treatment purposes, manufacturing and service industries, defense industries, research institutions, universities and in the nuclear power industry. The final concern of this radiation hazard is its effect on living things or biological systems such as genetic effects and somatic effects.

124. Non-ionising radiations (NIRs), on the other hand, have low energy and can only cause movement or vibration of atoms or molecules resulting in an increase in temperature. The WHO defines NIRs as a term given to radiation in the part of electromagnetic spectrum where there is insufficient energy to cause ionisation. It cannot be perceived by human sense unless felt as heat at high intensity. The ability of NIRs to penetrate the human body is based on the frequency of emission and interaction with tissues through heat. Therefore, the biological effects of NIRs on living cells are referred to as thermal effects and non-thermal effects. It includes electric and magnetic fields, radio waves, microwave, infrared, ultraviolet and visible radiation.

Responsibilities

Radiation Protection Officer (RPO)

125. It is the responsibility of the RPO to manage the Radiation Protection Program (RPP) and ensure the compliance and safety of all staff working with ionizing radiations. RPO has the authority to monitor the use of radiation sources and enforce controls for the safe use of radiation.

Radiation Protection Supervisor (RPS)

126. Assist RPO to implement, supervise and ensure the application of appropriate radiation protection regulations, measures and procedures.

Radiation Worker (RW)

127. They are authorized to responsible for all aspects of radiation safety associated with the possession and use of ionizing radiation under his/her permit. They are exposed to radiation sources as a result of working with radiation sources as part of their work

Students

128. Students are authorized to use only specific radiation sources under the guidance of a RW. Students must follow the direction of the RW to use radiation sources. It is the responsibility of the students to comply with the requirements outlined in RPP.

Control Measures

129. Control measures shall be optimized in order that the magnitude of individual doses and the number of people exposed can be kept as low as reasonable achievable.

a. **Engineering Control**. The following outlines the engineering control measures required for radiation sources installation:

(1) **Interlocks system**. An interlock system is one step to prevent the accident occur to workers and damage to the machine, it is because an interlock sensor detects potentially dangerous change in state, the machine will automatically stop running.

(2) **Key control.** There are types of keys used at radiation area, whether traditional locks with regular keys, cipher locks with numeric keyboard or access card. The RW in charge to keep the key must control it, make sure only the authorized person can enter the area.

(3) **Warning alarm.** A warning alarm is used to warn people around the area for the presence of radiation. The alarm should in the form of light or audible signals or both.

(4) **Appropriate shielding / Protective barriers.** Thickness, density as well as types of materials determine the effectiveness of shield against a particular radiation sources.

b. **Administrative Control.** The following outlines the administrative control measures required for dealing with radiation sources:

(1) **Operating Procedures.** Radiation Protection Program (RPP) is a mechanism to ensure radiation protection to workers and members of the public as a part of the radiation protection management system enforced by AELB to organization that deal with ionizing radiation in non-medical sectors. The RPP affirms the commitment of the management and workers towards radiation safety and health.

(2) **Education and Training.** All individuals work with radiation sources must be educated about potential health hazards involved in their job, trained in precautions to be taken and given training on radiation protection relevant to their duties.

(3) **Authorized Personnel.** Trained and experienced RW that are qualified to handle, supervise the use of radiation sources at UM are designated by UPPS as authorized personnel.

(4) **Warning Signage.** Radiation (Tri-foil) signs of adequate size must be made available. It is suggested that the name, address and telephone number of the person responsible for the site to be included on each warning sign.

(5) **Classification of working area**

Ref.	Area	Descriptions
7.2.5.1	Clean Area	• Area for public and where the annual dose is not likely to exceed 1mSv/year or 0.5μSv/hour as dose limit for a member of the public.
7.2.5.2	Supervised Area	• Area for which occupational exposure conditions are kept under review even though specific protective measures, radiation signage and safety provisions are normally needed. • No person shall enter the area unless he has been assigned to the area. • The limit on the effective dose for a worker shall not exit 20 mSv/year or 3.0 μSv/hr.
7.2.5.3	Controlled Area	• Area in which specific radiation protection measures, radiation signage and safety provisions are required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures. • No person shall enter the area unless he has been authorized to enter the area • The limit on the effective dose for a worker shall not exit 50 mSv/year.

(6) **Monitoring of work place.** The monitoring is performed at the workplace to ensure the safety of workers and members of the public. It is also performed to establish classification of working areas or to verify the validity of the workplace classification. Monitoring the supervised and controlled areas using survey meter before operation, during operation and after operation of X-ray machine.

(7) **Log Book**. Each equipment must have separate log book which provide information about the date, time, name of worker, name of student, type of sample, number of samples, and purpose.

(8) **PPE.** All radiation workers must have their radiation dose monitored by wearing an OSL provided by UM. OSL dosimeter badges are the standard means used to measure external radiation dose to radiation workers on an ongoing basis.

General Radiation Safety Operating Procedure

130. The general safety operating procedure will relate to all phases of a practice started from design through installation to process control that include protection of both workers and the public. It is important to ensure that the safety operating procedure is well adapted to the situation and on the stage of the activities.

a. Radiation areas or equipment clearly marked with radiation warning signage.

b. No person shall enter the radiation area unless he has been authorized to enter the radiation area

c. Pregnant workers or students are not allowed to enter radiation area or deal with radiation sources. Foetus or unborn babies are more sensitive to radiation.

d. Identify types of radiation sources involved in course of work or study. Safe handling of radiation sources depends on the types and characteristics of the source themselves. Types of radiation sources include irradiation apparatus, sealed and unsealed radioactive sources.

e. All university personnel (including students and staffs) who enter or work in laboratories and other areas that contain radiation sources must at a minimum wear full length pants or clothing that otherwise fully covers the legs and ankles) and closed shoes.

f. Any person under age of sixteen years shall not be allowed to enter radiation area or deal with radiation sources.

g. Students shall not be allowed to enter radiation area or deal with radiation sources unless the person is supervised by RW and only for the purpose of training. Students are allowed to use only specific radiation sources under permission, guidance and supervised by RW.

h. Students must follow the direction of the RW to use radiation sources. The dose limit for students who are required to use radiation source in the course of their training or studies shall not exceed 6mSv in a calendar year. Students must wear personal dosimeter provided by RW at all time while handle with radiation sources.

i. RW with an OSL must wear their OSL badge at all times while undertaking radiation work.

j. Area monitoring of radiation area must be carried out continuously using survey meter. Monitoring shall start before operation, continues during operation and after operation. Radiation sources contamination or leakage shall be measured using survey meter and notify to RPO as soon as possible.

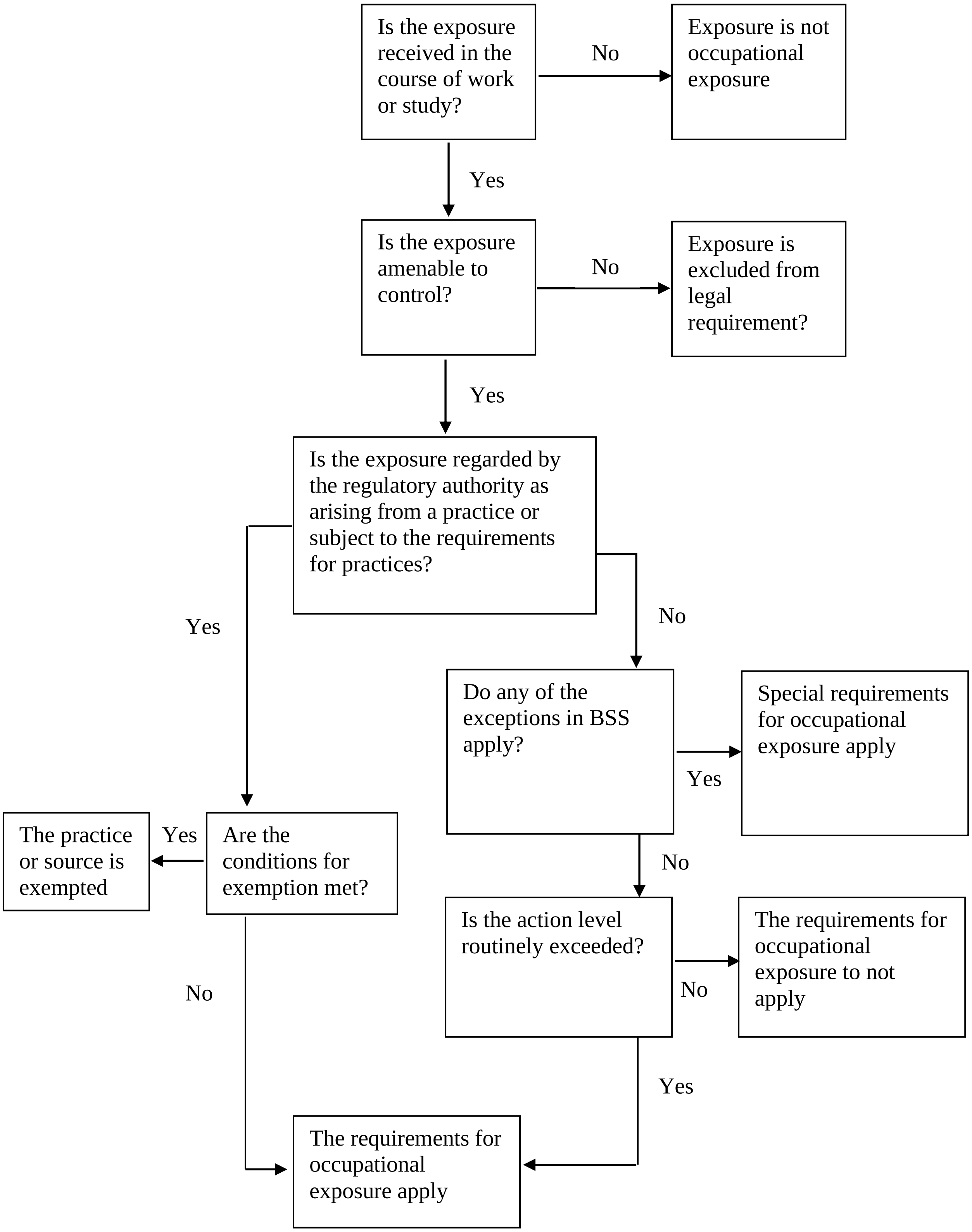
k. Wear disposable gloves when handling radioactive material and change frequently.

l. Prevention (or mitigation) of radiation exposure well below the annual limits is espoused in the ALARA principle. ALARA is the effective use of Time, Distance, and Shielding to mitigate or eliminate exposure.

m. No person shall transport any radiation sources outside the designated premises unless he is RPO or holder of a valid license issued by the RPO in accordance with Radiation Protection (Transport) Regulations 1989.

n. Notify the RW or RPO of any accident or abnormal incident involving or suspected of involving radiation sources.

FLOW CHART ON THE OCCUPATIONAL EXPOSURE DECISION



LASER SAFETY

131. Radiation is a form of emission and transmission of charged and uncharged particles that carry energy. There are two types of radiation that make-up the electromagnetic spectrum ranging from low energy radiation such as radio wave, microwave, laser and visible light to high energy radiation such as X-ray and gamma ray. Generally, low energy radiation is termed as non-ionising radiation while high energy radiation is termed as ionising radiation.

132. Laser is a form of non-ionizing radiation in the electromagnetic wave and has its own specific characteristics of excellent directivity and high power densities. Protective measures in laser are depend on its biological actions and response, health effects and exposure category.

Responsibilities

Laser Safety Officer (LSO)

133. A LSO should be appointed when handling with laser equipment in Class 3B and 4. LSO is accountable for the assessment and management of laser hazards and has the authority to control the usage of laser equipment.

Laboratory Coordinator (LC)

134. Notify the LSO before any purchasing and acquiring any laser equipment to ensure that laser users and laboratory personnel have received the training on laser safety and understand the procedure for their laser system prior to initial operation.

Laser User

135. Maintain engineering controls on the laser system as designed, instructed, and permitted by LSO. Should wear the suitable personal protective equipment when operating the laser system. Report details of incidents, disabled, broken, or bypassed safety features are reported to LC and LSO.

Classification of Lasers

136. Lasers are classified based on radiation emitted during normal operation and any reasonably foreseeable fault condition as stated in International Electro Technical Commission (IEC) 60825-1: 2007 as below:

a. **Class 1**. This laser is eye-safe for all operating conditions.

b. **Class 1M**. Direct viewing is safe for the naked eye, but may be hazardous with the aid of optical instruments. For instance, the use of magnifying lenses might turn the harmless diverging beam (e.g LEDs and bare laser diodes) into a harmful one. Other examples of optical instruments that pose the similar hazards are binoculars, telescopes, beam collimators.

Laser/light in classes 1 and 1M can be visible or/and invisible

c. **Class 2**. Visible lasers. This class is safe for accidental viewing under all operating conditions. However, it is hazardous to a person's eyes for deliberately staring into the laser beam longer than 0.25s by overcoming one's natural aversion response to intensity light.

d. **Class 2M.** Visible lasers. Similar to Class 2, this class is safe for accidental viewing with the naked eye but could be hazardous (including accidental viewing) with the aid of optical instruments (as with class 1M).

Laser/light in classes 2 and 2M can be visible or/and invisible.

Classes 1M and 2M broadly replace the old class 3A under IEC and EN classification.

e. **Class 3R.** This class is considered low risk but potentially hazardous. The power limit for 3R is five times the limit for Class 1 (invisible light) or Class 2 (visible light). The CW visible light in the range of 1 to 5 mW falls under Class 3R.

f. **Class 3B.** This class is considered dangerous. For a CW laser, the maximum power into the eye should not be higher than 500mW. The laser can be a hazard to the eye or skin. However, the diffused reflection is considered safe.

g. **Class 4.** This is the highest class of laser. The viewing of the direct beam or diffused reflection is dangerous. Class 4 lasers are capable of setting fire to materials.

Laser Hazards

From Beam Exposure

Hazards to the Eye

137. Laser safety emphasize on the minimizing the risk of laser accidents particularly involving the eye injuries. The eye is an organ that is most sensitive to light and a small amount of light can cause permanent damage to the eyes. The hazard is related to the amount of energy absorbed by the tissues and the absorption depends on laser wavelength. Different wavelengths will cause harm to different parts of the eye. The resulting hazard presented by a laser is based on the irradiance (power per unit area, normally specified in W/m^2) that incidents on the surface of the tissue

Hazards to the Skin

138. Skin damage can also result from lasers depending on their power density. The laser injury to the skin is considered less serious than to the eye. The skin can tolerate higher levels of radiation than the eye and also there is no focusing mechanism in the wavelength region 400–1400 nm. This means that the injury threshold for the skin is much higher compared to the injury threshold for the eye. The interaction between radiation and tissue can be categorized as being photo chemically induced or thermally induced. From Non Beam Exposure:

a. **Electrical Hazard**. Many laser systems utilize high voltage components and parts for laser excitation. The hazard can cause serious injuries and fatalities.

b. **Compressed Gases**. Some gases used in laser applications such as chlorine and fluorine are hazardous.

c. **Dye Laser.** Laser dye is a type of lasing medium. They are highly toxic and carcinogenic.

d. **Fire and Explosive.** Use of flammable materials in conjunction with high-powered lasers increases the potential of a fire hazard. Arc lamps, filament lamps, and capacitor banks are potential explosion hazards.

Control Measures

139. Control measures are established for reducing the risk of eye and skin exposure to laser. Control measures applied require LSO evaluation, assessment and determination.

a. **Engineering Control**. The following table outlines the engineering control measures needed for each laser classification:

Engineering Control	Classification of Lasers						
	1	1M	2	2M	3R	3B	4
Interlocks Protective Housing	√	√	√	√	√	√	√
Key Control	×	×	×	×	×	√	√
Fully /Limited/Enclosed Beam Path	×	×	×	×	×	√	√
Laser Warning Emission	×	×	×	×	×	√	√
Laser Controlled Area	×	×	×	×	×	√	√
Entryway Control	×	×	×	×	×	√	√
Protective Barriers	×	×	×	×	×	√	√

b. **Administrative Control**. The following table outlines the administrative control measures needed for each laser classification:

Administrative Control	Classification of Lasers						
	1	1M	2	2M	3R	3B	4
Standard Operating Procedures	×	×	×	×	×	√	√
Education and Training	×	●	●	●	●	√	√
Authorized Personnel	×	×	×	×	×	√	√
Warning Signage	×	×	×	×	×	√	√
Periodic Inspection	×	×	×	×	×	√	√

× - No requirement
● - Should
√ - Shall

Personal Protective Equipment

140. Laser damage to eyes can happen in a flash of a second because of the high concentration of energy within a short span of time and the damage caused can be permanent. Despite the enforcement of both engineering and administrative control measures, the use of appropriate PPE is important particularly for the eye protection.

a. **Eye Protection.**

(1) Wear appropriate eye protection (eye wear or goggle) when lasers are in use.

(2) Eye wear must be of the correct optical density and offer protection at the wavelength of the laser used.

(3) Eye wear must be inspected regularly and before used to identify any defective.

(4) Do not look directly into any laser beam even with laser eye protection on

b. **Skin Protection**

(1) Wear long sleeves lab coats (cloth gloves if necessary) when working with the lasers to protect exposed skin area.

(2) Exposure to laser can result in short and long term skin hazards.

(3) Do not wear any accessories (such as bracelet, watch) that will reflect the beam during operation.

General Laser Safety Operating Procedure

141. This general safety procedure is a part of the administrative control to ensure safe use of lasers and laser system in laboratories and in University where applicable. It should be used together with the specific laser manufacturer instructions.

a. The lasers must be operated by trained personnel inside controlled area which is restricted area where protective control measures are required.

b. The controlled area should be physically enclosed and properly displayed with laser warning sign. The controlled area must be restricted area with minimum control access to public.

c. Design and set up of a laser experiment should be systematically arranged to ensure no personnel is within area of laser beam operation. The laser path should not be on the eye level of any sitting or standing observers.

d. The use of Personal Protective Equipment (PPE) and safety control are compulsory to ensure optimum protection during operation.

e. Make an announcement or activate warning light to warn other personal inside the area about laser operations. Do not work alone when performing laser operations.

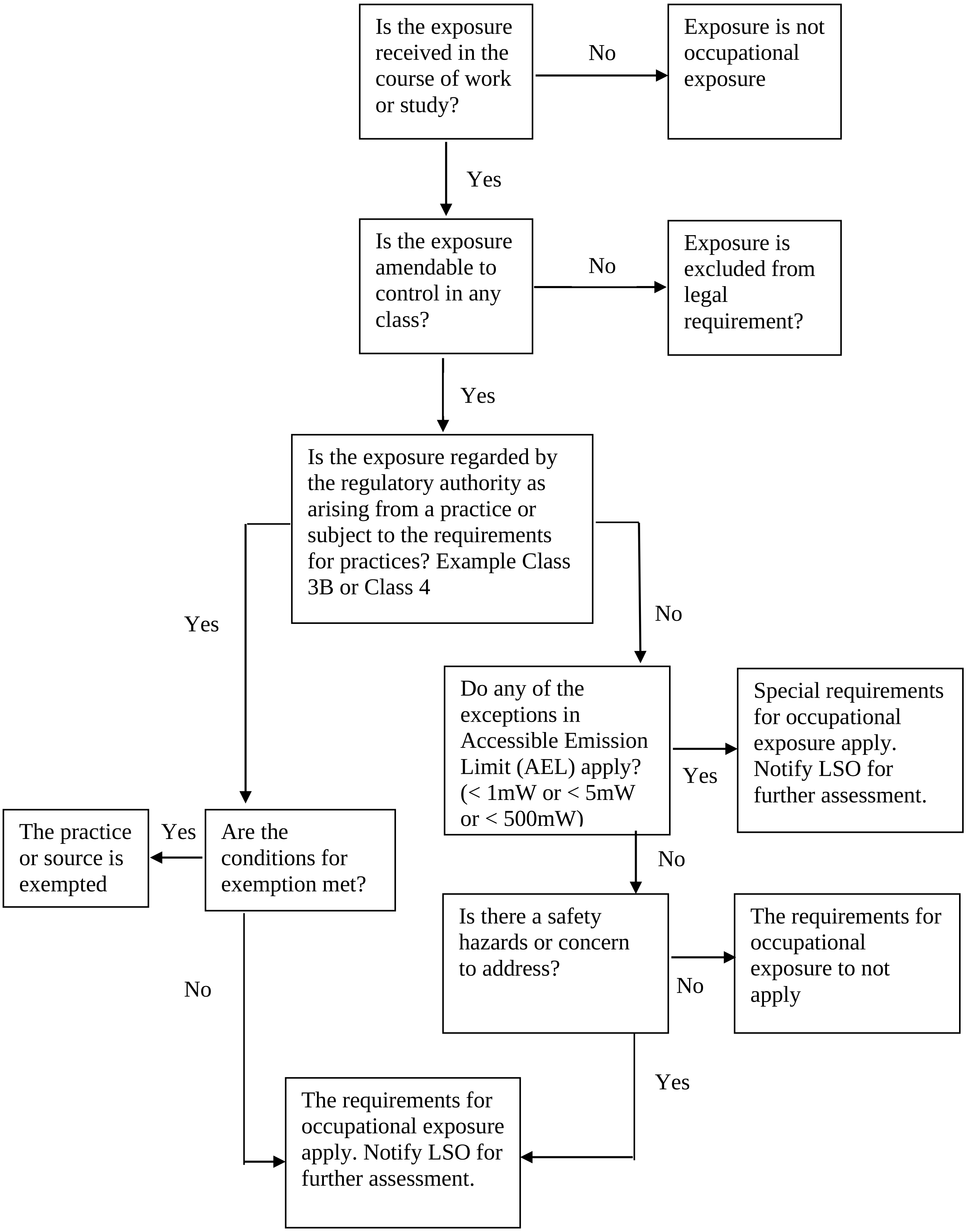
f. Terminate all unused beams and turn off all laser operations after used. Ensure all systems properly turned off before leaving the labs.

g. Press emergency stop switches in the case of emergencies (fire and accidental exposures or unauthorized access). Notify lab supervisor as soon as possible.

Process of Work

ACTIONS	RESPONSIBILITIES
1. Accept application from PTj	LSO, LC
2. Evaluate the application 2.1 Determine the Classification of Lasers will be used 2.2 Identify control measures will be required	LSO, RPO
3. Monitor the implementation of control measures	LSO, LC, LU
4. Periodic Inspection	LSO

FLOW CHART ON MANAGEMENT OF THE OCCUPATIONAL EXPOSURE



LAB WASTE MANAGEMENT

142. Research and laboratory activities will ultimately generate waste and will require proper waste management of a variety of wastes which may contains a combination of hazard types, such as chemical, biological and radioactive hazards. The strategies and objectives in managing the laboratory waste are to maximize safety and minimize environmental impact, optimizing the cost disposal, and this requires cooperation of all the responsibility centres, PI, researchers to take into the consideration of these objectives from the time of purchase of research materials, such as chemicals, etc, and including minimization of waste. Most of the university laboratory waste are mainly chemicals, hence all lab users must be familiar with the chemical waste disposal procedures.

GUIDELINES ON THE DISPOSAL OF CHEMICAL WASTE FROM LABORATORIES –

LABORATORY CHEMICAL WASTES MANAGEMENT COMMITTEE

143. The types of the chemical wastes generally generated in laboratories and the suggested methods for their disposal are shown in Figure 8. Laboratory Chemical Wastes Management (LCWM) Committee led by a senior officer of a laboratory should be set up. The committee should comprise of researchers, lab managers/supervisors and senior laboratory personnel.

144. The committee should be responsible for:

a. Endorsing the procedure for the LCWM Committee;

b. Assigning competent laboratory personnel who will be responsible for managing waste disposal;

c. Monitoring record of the amount of wastes generated;

d. Ensuring the wastes where applicable, are treated, recycled, recovered or disposed of in a safe and environmentally sound manner.

e. Ensuring proper trainings are provided to the laboratory personnel;

f. Ensuring the personnel are equipped with proper Personal Protection Equipment (PPE).

Appendix I

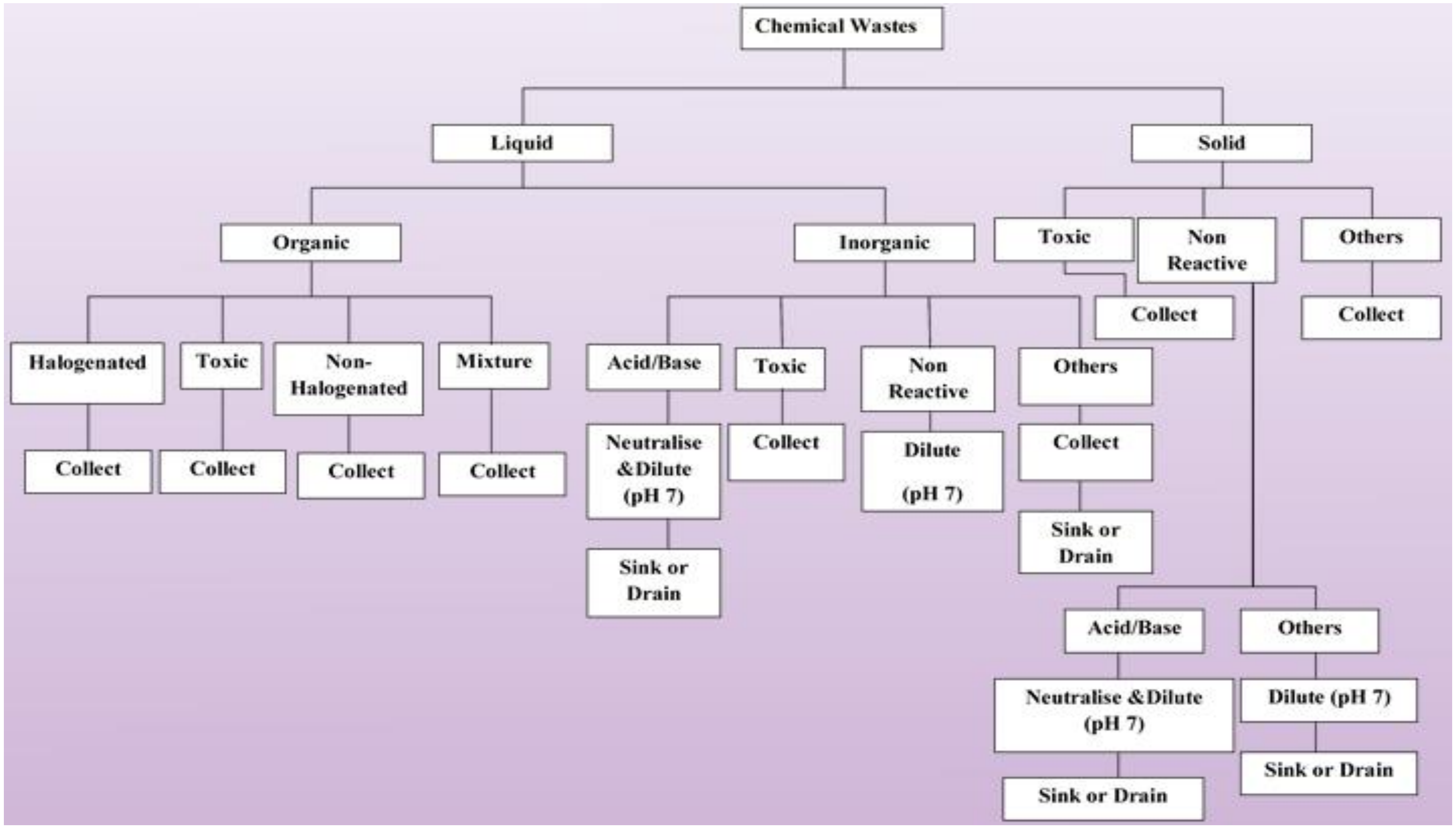


Figure 8. *Types of chemical wastes and suggested methods for disposal*

TYPES OF LABORATORY CHEMICAL WASTES

145. Chemicals that are abandoned, discarded, intended to be discarded or disposed into the atmosphere, placed on any soil or surface of any land or inland waters need to be disposed off in a proper manner to reduce their effect on health and the environment.

a. Types of LCW according to Environmental Quality (Scheduled Wastes) Regulation 2005.

Table 2. Types of LCW

Code	Description
SW 409	Disposed containers, bags or equipment contaminated with chemicals, pesticides, mineral oil or scheduled wastes (Description)
SW 410	Rags, plastics, papers or filters contaminated with scheduled wastes
SW 429	Chemicals that are discarded or off-specification
SW 430	Obsolete laboratory chemicals

146. Types of laboratory chemical wastes (Table 2) for treatment and disposal at the integrated scheduled wastes treatment and disposal facility at Kualiti Alam Sdn Bhd (KA) can be classified according to the following groups:

Table 3. Types of Laboratory Chemical Wastes

GROUP	WASTE TYPE
A	**MINERAL OIL WASTE** Waste containing lubricating oil, hydraulic oil etc.
B	**ORGANIC CHEMICAL WASTE CONTAINING HALOGENS AND / OR SULPHUR > 1%** Freon, PVC wastes, chloroform, solvents, capacitors and transformers containing PCB etc.
C	**WASTE SOLVENTS CONTAINING HALOGENS AND / OR SULPHUR < 1%** Acetone, alcohol (eg. Ethanol, methanol), benzene, turpentine, xylene etc. Waste should be pumpable, containing < 50% water 18MJ / kg calorific value
H	**ORGANIC CHEMICAL WASTE CONTAINING HALOGENS AND / OR SULPHUR < 1%** Glue, latex, paint, phenol, printing ink, synthetic oil, epoxy etc.
K	**WASTE CONTAINING MERCURY** Mercury, vapour lamps, COD-fluids, mercury batteries etc.
T	**PESTICIDE WASTE** Insecticides, fungus and weed killers, rat poison, etc.
X	**INORGANIC WASTE** Acid, alkaline, sodium hypochlorite, inorganic salts, metal hydroxide sludge, chromate and cyanide waste etc.
Z	**MISCELLANEOUS** Medicine waste, lab-packs, asbestos waste, mineral sludge, isocyanate (MDI, TDI), batteries, etc.

Source: Kualiti Alam Sdn Bhd

SAFETY IN HANDLING OF LABORATORY CHEMICAL WASTES

147. LCW containing hazardous and toxic chemicals can pose a serious threat to health through various route of exposure; inhalation of vapour or dust, absorption through the skin from contaminated clothing, spillage on benches, floors or apparatus and ingestion from contaminated hands or food or smoking.

148. Personnel should be made aware of the potential hazard of the waste, the limitations of the protective equipment and the safety procedures for handling waste. The PPE should be in accordance with the Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulations 2000. It should include the following:

a. rubber, PVC or polythene gloves, preferably disposable;

b. laboratory coats;

c. laboratory safety glasses or goggles or if there is a danger of liquids splashing, a full-face shield; and

d. an approved respirator with a suitable particulate/vapour cartridge or an approved disposable face mask.

149. Example of appropriate PPE can be referred in **Annex L**.

a. PPE should be stored adjacent to the work area and should not be taken to other areas of the laboratory.

b. Avoid the usage of expired PPE.

c. PPE should be removed and stored before leaving the laboratory.

STORAGE AND LABELLING OF LABORATORY CHEMICAL WASTES

150. LCW should be stored in containers which are durable and able to prevent spillage or leakage of the contents into the environment. These containers should be able to withstand the chemical attacks likely to cause by their contents and must be leak-proof and gas tight.

151. Incompatible wastes should be stored in separate containers (Refer to **Annex M** and **Annex N**).

152. Areas for storage of the waste containers should be separated from the working area of the laboratory and maintained to ensure that there is no spillage or leakage.

153. The containers should be located in a well-ventilated place and kept tightly closed at all times to stop volatile materials escaping.

154. Containers of LCW should be clearly labelled for identification and warning purposes in accordance with labelling requirements for scheduled wastes.

155. The labels may be a stick-on type, a metal plate type or a stenciled or printed type on the container. However, the labels should not fade off with time.

156. All hazards must be clearly identified on the labels. In the case of wastes capable of presenting two or more hazards, all hazards must be clearly identified and the wastes labelled accordingly.

157. Storage of LCW should not be more than 180 days. Any application to extend the storage period should obtain written approval from DOE State Office.

TREATMENT AND DISPOSAL OF LABORATORY CHEMICAL WASTES

158. The disposal of any waste should be endorsed by an internal LCWM Committee.

159. Toxic or hazardous wastes should not be disposed of down the sink, drain or into the atmosphere.

160. Acidic or alkaline wastes should be neutralized before it is disposed down the sink or the drain or disposed into a pit. Waste chemicals should be disposed off quickly to avoid accumulation of large stocks.

161. Chemicals immiscible with water must not be discarded into sinks or drains. Flammable solvents must similarly not be discarded.

162. All waste solvents should be collected in the appropriate waste containers and clearly labelled. The wastes containers should not be filled to the brim. Always leave some air space.

163. Where solvent mixtures are collected, the name of each solvent component should be specified. Avoid mixing waste solvents.

164. Incompatible chemicals should not be mixed (refer to **Annex M** and **Annex N**). For example, waste chloroform should never be mixed with ether solvents because it may react dangerous with impure acetone.

165. Waste mercury should be collected by means of a suction pump and placed in glass bottle, sealed and handle separately for disposal.

166. A method for packing the containers is:

a. Separate the types of wastes before packing. Pack them separately into different drums. Care must be taken not to mix them up.

b. Line or cushion the bottom of a 200L steel drum (into which bottles containing wastes can be packed) with a polystyrene sheet and saw-dust.

c. Place the bottles containing the waste into the drum, making sure that the contents and volume of each bottle are recorded correctly.

d. There must be cushioning between the bottles and also between the bottles and the walls of the drum to prevent breakage. Each bottle should sit stable.

e. Fill up all gaps and crevices with saw-dust.

f. Cover the bottles with saw-dust.

g. Place another polystyrene sheet and again pack the bottles as in steps (c) to (g).

h. Each time record the number of bottles, waste and quantity packed. Finally total them up and keep a list for contents of each drum.

i. The 200L drum can take at least sixteen 4L bottles when packed and stacked in this way.

j. Label each drum according to DOE requirements and use the correct sticker as instructed.

k. Store the drum under shade in a well-ventilated place.

l. Warning signs should be used around where the drums are kept.

167. Laboratory Chemical Wastes should be transported by a licensed transporter to the licensed facilities for the treatment and disposal in accordance with the Environmental Quality (Scheduled Wastes) Regulations 2005.

168. A waste generator premises are required to use 'e-SWIS' web application to include information in accordance with the Sixth Schedule (Regulation 12) Environmental Quality (Scheduled Wastes) Regulations 2005 for every outward movement of scheduled wastes from waste generator's premises www.doe.gov.my.

169. A waste generator shall keep accurate and up to date inventory in accordance with the Fifth Schedule (Regulation 11) Environmental Quality (Scheduled Wastes) Regulations 2005 of the categories and quantities of scheduled wastes being generated, treated and disposed as in **Annex O**. Besides, waste generators also need to ensure that record keeping of the chemicals is compliance with (Classification, Labelling and Safety Data Sheet of Hazardous Chemicals) Regulations 2013 under Occupational Safety and Health Act 1994.

GUIDELINES ON THE DISPOSAL OF CLINICAL WASTE FROM LABORATORIES

Clinical Waste (SW)

170. Clinical waste is classified as Scheduled Waste that listed in the First Schedule of Environmental Quality (Scheduled Wastes) Regulation 2005.

Laboratory Clinical Wastes

171. Any waste which consist wholly or partly of human or animal tissue, blood or other body fluids, excretions, drugs or other pharmaceutical products, swabs or dressings, syringes, needles or other sharp instruments, being waste which unless rendered safe may prove hazardous to any

person coming into contact with it.

172. Any other waste arising from medical, nursing, dental, veterinary, pharmaceutical or similar practices, investigation, treatment, care, teaching, or research, or the collection of blood for transfusion, being waste which may cause infection to any person coming into contact with it.

a. **Laboratory Operator**
A person who operates a clinical/ biological laboratory and he or she holds a management position. (Appointed by the management of the respective schools)

b. **Laboratory Personnel**
Personnel who works in a laboratory and handles clinical/ biological wastes.

Types of Laboratory Clinical Wastes

173. Types of laboratory clinical wastes according to Environmental Quality (Scheduled Wastes) Regulation 2005 -

Table 4. Types of Laboratory Clinical Wastes

Code	Description
SW 403	Discarded drugs containing psychotropic substances or containing substances that are toxic, harmful, carcinogenic, mutagenic or teratogenic.
SW 404	Pathogenic and clinical wastes and quarantined materials.
SW 421	A mixture of scheduled wastes.
SW 422	A mixture of scheduled and non-scheduled wastes.

174. Types of laboratory clinical wastes (Table 4) for treatment and disposal at the integrated scheduled wastes treatment and disposal facility at Kualiti Alam Sdn. Bhd. (KA) can be classified according to the following groups:

Table 5. Group Types of Laboratory Clinical Wastes

GROUP	WASTE TYPE
A	**BLOOD AND BODY FLUID WASTE** Plaster, swabs, cotton, wool, dressing, bandaging, urine, stools, human biopsy materials, pathological waste (human tissue, organ, limbs, body parts, placenta, human fetus, tissues from laboratories, etc.
B	**WASTE POSING THE RISK OF INJURY (SHARPS)** Sharp instruments: Syringes, needles, broken glass, scalpel blades saws, other sharp instruments that could cause a cut or puncture, etc.
C	**INFECTIOUS WASTES** Clinical waste arising from laboratories: Pathology, hematology, blood transfusion, microbiology, histology and forensic activities (post mortem rooms).
D	**PHARMACEUTICAL WASTES** Expired medicines or vaccines. Drugs or medicines that have been spilled or contaminated, or are to be discarded because they are no longer required.

Source: Guidelines on the Handling and Management of Clinical Wastes in Malaysia, Department of Environment, 2009.

Segregation of Laboratory Clinical Wastes

175. Responsibility of laboratory staff to ensure that segregation of clinical waste is carried out at source and all clinical waste deposited only in yellow bag and sharps in sharp bins only.

176. Standard color coding that widely accepted for clinical waste:

a. Black : General wastes

b. Yellow : Clinical waste for incineration only

c. Light Blue : Wastes for autoclave before ultimate disposal

177. Clinical wastes that require autoclave before disposal shall be stored in light blue autoclave before such treatment and should be placed in yellow plastic bags after treatment.

178. All clinical wastes that have been properly sealed in yellow plastic bags shall be disposed in provided biohazard bin.

Labelling and Marking of Laboratory Clinical Wastes

179. All bags and biohazard bin should be indelibly and clearly marked with biohazard symbol.

180. For storing of waste in container, the appropriate label should be pasted on the container. The information that need to include in the label are the first date of waste generated, name, address and telephone number of the waste generator.

Handling, Storage and Internal Transportation

181. Manual handling of waste bags should minimize wherever possible.

182. Dedicated wheeled containers, trolleys or carts shall be provided to transport the waste containers from the laboratories to the clinical waste storage area. The transportation of clinical waste only reserved for clinical waste only and shall be ensure thoroughly cleaned and disinfected immediately for any spillage or accidental discharge.

183. The clinical waste storage area must be:

a. Located separately from the general waste storage areas and should be clearly identifiable.

b. Locked and accessible only to authorized persons.

c. Well ventilated and well functioned.

d. Located on well-drained and impervious-hard standing.

Spill or Accidental Discharge

184. The same response procedure applied as the clinical and hazardous wastes regardless of whether the spill from material or waste itself. The response to emergencies should ensure the following:

a. The waste management plan should be followed.

b. Contaminated area should be cleared and disinfected if necessary.

c. The exposure of workers to the hazard should be limited as much as possible during the operation.

d. The impact on the environment should be limited to the best extent possible.

185. The staff should be well prepared and trained for emergency response and biohazard spill kit shall be provided.

Record Keeping and Documentation

186. Proper record keeping and documentation of generation and handling of clinical waste

must comply with the Environmental Quality (Scheduled Wastes) Regulations 2005. The inventory shall be kept and consignment note system applied for the transportation and disposal of wastes to the approved licensed facility (Kualiti Alam Sdn. Bhd.).

187. The consignment note shows the details of the waste generator (laboratories, clinic), the transport contractor and final receiver (approved licensed facility).

188. An inventory used to record an accurate and up-to-date quantities and categories of clinical wastes being generated, treated and disposed of.

189. These records shall be kept for a period of three years.

GUIDELINES ON THE DISPOSAL OF RADIOACTIVE WASTE FROM LABORATORIES

Radioactive Waste

190. Radioactive waste are generated from application of radionuclide in research and teaching activities in UM. Under Atomic Energy Licensing Act 1984 (Act 304), radioactive waste is defined as any substances that contains or is contaminated with radionuclide at activity concentrations or activities greater than clearance level which contains all or part of:

a. Substances or item which if it not waste is considered radioactive source
(Example: Cobalt 60 from industrial application, Iodine-131 from medical usage)

b. Substances or item which was contaminated during production, storage or use of radioactive material or prescribed substances
(Example: tray or tissue paper which were are contaminated by radioactive source)

c. Substances or item was contaminated by means of contact of any radioactive waste.
(Example: Contaminated radioactive waste container)

191. Whereas waste management means all the activities, administrative and operational that are involved in the handling, pretreatment, treatment, conditioning transportation, storage and disposal of radiation waste. The main objective of radiation waste management is to protect human and environment and not to impose any undesirable effect or burdens of radiation to the present and future generations. Hence, application to dispose any radiation sources or suspected as radiation sources or anything that labelled with radiation signage has to be notify to UPPS prior to disposal of the substances or item to ensure all stages of radiation waste management in UM are carried out in safe and accordance with regulations. The radioactive waste is segregated by UPPS into 3 classes of solid waste, liquid waste and gas waste. UPPS will covers the whole process of waste handling starting from collection and transfer, waste treatment, waste storage and finally waste disposal.

a. Action to be taken by radiation worker:

(1) Recognize the radioactive source and gather the information of on the type of source, its activity and other physical characteristics.

(2) Report the information and request for disposal to RPO

(3) Secure the radioactive source inside appropriate containers and label with radiation label.

(4) Check and ensure the physical security and control of the source

(5) Assist RPO to inspect the radioactive source before collection for disposal.

b. Action to be taken by public/student/researcher/worker:

(1) Recognize the radiation signage or label at the casing of suspected radioactive source.

(2) Avoid touching suspected radioactive source and the area that might be contaminated

(3) Not to handle but to report to the radiation worker or person in charge of the area or RPO immediately.

(4) To go to a designated safe area and wait for radiation worker or RPO to assess the doses received by each people involved

(5) Keep the hands away from the mouth and do not smoke, eat or drink until hands are washed. Shower and change clothes when instructed by RPO

(6) To continue and listen for and follow official instructions given by radiation worker or RPO.

(7) If contamination is not suspected, the public involved will be release. If the public may be contaminated, they will be arranged and monitored for decontamination before release.

DECONTAMINATION OF RADIOACTIVE

192. Contamination involves deposition of radionuclide on the outer of the body, or on wall and floor. Contamination involves unsealed source or originally sealed radionuclides that leaks due to a compromise seal. Personal contamination can range from simple and localized contamination up to whole body. Water is the first choice for removing contamination from hands and other exposed areas of the skin. Care must be taken not to cause any tear in the skin and so give rise to an internal hazard. Contamination of clothing could be overcome by disposing of the cloth. It is economical to dispose and let the activity of radioactive die down naturally to within the permissible level. Decontamination of equipment and tools is better to let the activity reduce within permissible limit and should be washed thoroughly with decontamination solution. Decontamination of working areas by carry out preliminary survey of the area first. The areas are then marked so that precautions can be taken to prevent further spread of contamination during decontamination operations. Decontamination operation will be start with the lowest level first and progressively moved to the highest levels.

EMERGENCY RESPONSE PLAN (ERP)

193. Emergency guidelines and requirements for laboratory works are serve as supplements for emergency procedures explained in OSHEM. General information concerning building emergencies is as described in OSHEM. Principal Investigators (PI) are responsible for the emergency preparation of their laboratory personnel such as injuries, fires or explosions, chemical spills, floods, and power failures. To prepare for an emergency, laboratory personnel ought to plan, acquire response kits and materials, and practice proper responses. New laboratory staff emergency procedures need to be included as part of their new staff training. All staff should participate in periodic drills and exercises, including "table top" briefings, for any new safety information and knowledge.

Accident Prevention

194. Emergencies in in laboratories can be prevented and the effects can be minimized by doing the following:

a. Display emergency phone numbers and the Emergency Procedures for Laboratories where people can easily see

b. Determine the locations of emergency equipment on a floor plan and ensure staff are informed on the locations of the equipment

c. Identify the locations of shutoffs for all equipment including electrical, gas, and water

d. Train staff to retrieve MSDSs/SDSs for laboratory chemicals

e. Identify and isolate incompatible chemicals

f. Routinely dispose of chemical wastes and clean out unnecessary chemicals and surplus; dispose of unwanted items

g. Ensure electrical wires and equipment are working properly and in good state

h. Review and report accidents to prevent future accidents

i. Schedule laboratory inspections and complete the checklists

j. Discuss and review safety topics and safety issues periodically in staff meetings

Fire and Explosion Prevention

195. Prevention of fires and explosions and minimization of the effectscan be done by doing the following when using flammable, reactive, or explosive materials:

a. Identify and acquire non-flammable substitute for your material

b. Use a smallest amount of the material at anytime

c. Ensure all aisles, underneath and around sprinkler heads are not blocked while eyewashes and emergency showers, are functioning and ready to use

d. Close fume hood sash completely when no one is using it

e. Always make sure containers are securely closed

f. Regularly perform housekeeping, such as recycling and properly disposing of unnecessary or outdated chemicals

g. Determine and acquire the appropriate fire extinguisher available for the materials in use

h. Use fire-resistant lab coats

i. If handling chemicals in a closed system, regularly check that the connections are tight

j. Handle chemicals and reaction systems in a ventilated area, such as a fume hood

k. Minimize or remove open flames and spark-producing equipment

l. Use refrigerators/freezers specifically designed to store flammable materials

m. Use barriers that give adequate protection from an explosion

n. Examine if utility outages would increase risks while using the material

o. Identify any wastes that can be flammable or explosive

p. Use appropriate containers and locations to store scheduled wastes

q. Schedule staff training for the chemicals, their hazards and precautions; record the training; exercise responses periodically

Unattended Operations and Floods

196. Do not leave operations or experiments unattended.

a. Display the name and phone number of the person in charge (PIC) for the operation on the door of the room in case of emergency. Additionally, identify the chemicals in use and provide clear directions for shutdown in order for an untrained person could shut down the operation during an emergency.

b. Generally, to avoid equipment failures while no one is in the lab, make sure the equipment is being maintained and operated properly. Replace any damaged equipment and electrical wires. Do not use extension wires for hooking up to electrical power; use strip outlets if the wire does not reach the outlet. Check equipment regularly. Discard and replace damaged any batteries.

c. If it is necessary to have running water unattended, install a designated water flow device that sets off alarm if leak occurs or use a shutoff valve that stops water if the level rises too high.

d. Do not leave open flames unattended at any time.

Spill Prevention

197. PI or laboratory supervisors should identify chemicals likely to spill during common laboratory procedures and emergency events.

a. The procedures for cleaning spills should be included in the SOPs developed for every laboratory's processes. Additional precautions are needed for pyrophoric, water reactive, oxidizing chemicals, and those that may generate toxic gases if a reaction were to occur.

b. Use small amount of chemicals to limit the amount spilled if a container ruptures. Chemicals should be transported between rooms in a proper tub or bottle carriers designed to prevent breakage and to hold the contents in case of breakage.

c. Each and every laboratory should have a chemical spill cleanup kit suitable for the chemicals in the lab.

Gas Leaks

198. All staff are required to know which gases and volatile chemicals in their own laboratory may produce an odor. Identify the contents of pipes, hoses or gas lines with appropriate labels. Staff should also know the location of control valves used to shut off gas flow in case of emergency. Discuss any incident with odors or odors from adjacent laboratories during staff meetings if they are issues.

Any person who detects any gas leakage by smell or alarm from a gas emission detection system shall:

a. Report to the staff of the affected area / office.

b. Wear PPE (refer to the HIRARC form of the job).

c. Closes the main gas source immediately. Closes the main gas outlet associated with the valve immediately disconnected (if necessary).

d. Contact the Security Office and JPPHB.

e. Supervisors with JPPHB representatives are investigating the cause of the leak using a mobile leak gas detector and confirming the leakage point using foam soap.

f. Separate the gaseous incident area (within a minimum radius of 10 meters).

g. Carry out a ventilation operation at a gas leak area such as opening a window.

h. Avoid opening / closing any electrical appliances.

i. Do not try to do anything that may cause burns.

j. Activate the Evacuation Procedure, if any of the following:

(1) Uncontrolled open burning

(2) Involves explosive gas

(3) Any situation that poses any threat to occupants' health and safety

k. JPPHB and ERT took over the emergency situation.

l. For critical situations, inform JBPM and gas suppliers.

m. Continue monitoring the incident until the authorities arrive.

n. Return to work when the area is declared safe by the EC/OSC/ Fire Officer.

o. Once everything is back to normal, fix the damage and the root cause.

p. Return the operation of the facility to its original state.

Utility Outages

199. Planning for utility outages –

a. To pre-plan for utility failure, consider the utilities that the laboratory operations depend on and find our if interruptions are unacceptable. Utility outages that may affect laboratory operations include:

- Electrical power systems
- Backup power system or switching systems
- Compressed air systems
- Ventilation systems (fume hoods, biological safety cabinets, etc.)
- Natural gas system
- Supplied gas systems (medical air, O_2, N_2O, N_2, EtO, etc.)
- Vacuum systems
- Potable water systems (loss or contamination)
- Non-potable water systems (loss or contamination)
- Sewage systems
- Heating systems
- Fire protection systems
- Refrigeration systems (refrigerators, cold rooms, chillers, etc.)
- Lifts
- Communication systems
- Detection and alarm systems (fire alarms, gas leak alarms, etc.)

b. Measures that can mitigate the effects of downtimes on laboratory operations include:

- Backup samples at another facility
- Records backed up at another facility
- Emergency power circuits (if available) for critical equipment
- Emergency devices such as water filters for potable water and surge protectors or Uninterruptible Power Systems (UPS) for electrical power
- Plan the necessary steps to safely shut the process down and resume again
- Plan the necessary actions to prevent uncontrolled reactions
- Service contract for emergency supplies and services.
- Connect incubators, refrigerators and freezers to alarm monitoring services to detect power interruptions and alert the designated person
- Acquire card reader doors and other security systems that typically have a four-hour battery backup
- Prepare flashlights in areas that do not have emergency lighting
- Alarm systems and appropriate responses such as fire alarms
- Establish staff communication channels for catastrophe situations (adverse weather, long-term power outages)
- Safe Chemical Use
- Organize annual safety trainings, drills, or exercises

Biological Spill

200. In event of a biological accidental release/spill, the lab personnel or the researcher identifies the level of emergency (Please refer to the Biological Biosecurity Management Guidelines). If the release of a biological agent controllable, proceed with the clean-up procedure. The general biological spill response procedure is as described below:

a. Notify laboratory staff in the vicinity to prevent the spread of contamination

b. Remove all contaminated PPEs.

c. Get the Biological Spill Kit and wear the appropriate PPE

d. Close door and place the biohazard spill signage on the entry door.

e. Prepare appropriate (disinfectant) in a dilution container.

f. Slowly soak the towels with disinfectant.

g. Using tong, work outside-in, cover spill with disinfectant towels.

h. Allow appropriate contact time.

i. Work outside-in, pick up towels.

j. Dispose towels and waste in biohazard bag.

k. Mop spill area.

l. Remove PPE used during cleanup and put in a biohazard bag to be autoclaved.

m. Decontaminate all waste from the spill.

n. Log and report incident.

o. If any personnel are injured or experiences a potential exposure while handling the spill, they should seek medical attention immediately and report the incident.

201. In the event of a biological release emergency cannot be handled by the lab staff/researcher/student, he/she needs to inform immediately the person in-charge/duty to activate the ERT response, please contact the EC or OSC. The ERT will assess the level of biological spill, isolates the area with red and white striped caution tape and run biological release decontamination.

202. If the ERT determines that the release of biological agents is uncontrollable and external assistance is required, the ERT is required to contact JBPM (Hazmat Team). Activate the Evacuation Procedure if necessary, contact the Security Office and OSHE. OSC will report and hand over the situation to Hazmat Team when they arrive at the scene.

Radioactive Spill / Leakage

203. There are two responses to radiation emergencies depending to the source of the radiation leak.

a. Response Action During Emergency Involving Xray Equipment

As soon the accident is realized, the following action must be taken :

(1) Action to be taken by radiation worker :

(a) Switch the machine off immediately

(b) Perform a radiation survey to confirm that the tube is de energized

(c) Leave everything as it is until details such as position, beam, exposure setting are recorded

(d) Ask any person who may have been exposed to remain at the safe area.

(e) Inform the person in charge of the area so that measures can be taken to restrict entrance to this area

(f) Contact RPO and inform him on what has happened

(g) Do not use the device until it is examined and repaired as necessary by manufacturer or qualified expert

(2) Action to be taken by public/student/researcher/worker:

(a) Promptly evacuate the area as possible.

(b) To go to a designated safe area and wait for RPO to assess the doses received by each people involved

(c) To continue and listen for and follow official instructions given by radiation worker or RPO.

b. Response Action During Emergency Involving Radioactive Sources

As soon the accident is realized, the following action must be taken:

(1) Action to be taken by radiation worker:

(a) Recognize that an abnormal situation which might constitute an emergency has occurred

(b) Avoid touching suspected radioactive item, perform only lifesaving and other critical tasks near a potentially dangerous radioactive source.

(c) Using a survey meter, measure the dose rate around the area and establish a safe barrier

(d) Restrict access and display radiation warning notice

(e) Prepare all emergency equipment required for the rescue.

(f) Detain the persons who have been inside the barrier during the emergency. Obtain their names and telephone numbers so that they can be contacted later if necessary.

(g) Do not leave the area unattended

(h) Call for RPO for further action.

(2) Action to be taken by public/student/researcher/worker:

(a) Promptly evacuate the area as possible.

(b) To go to a designated safe area and wait for RPO to assess the doses received by each people involved

(c) Keep the hands away from the mouth and do not smoke, eat or drink and wash hands, shower and change clothes when instructed by RPO

(d) To continue and listen for and follow official instructions given by radiation worker or RPO.

Security Issues

204. Strategize for ways to prevent and respond to violence, vandalism, unauthorized personnel and suspicious packages. Laboratories are a possible targets for such activities. In general, laboratory security requires students and staff:

- Identify all entry points
- Ensure doors are closed and locked when the lab is unoccupied
- Display identification badges
- Never allow unauthorized personnel to enter the lab
- Do not leave valuable materials and supplies (avoid theft, tampering)
- Properly dispose of hazardous agents that are no longer used and needed

a. Depending on the type of research and materials in use in the laboratory, higher levels of security controls may need to be implemented.

b. The PI, with the approval and support of the department, should come out with policies to increase security. All staff must be reminded of these policies.

Field Works

205. Plan for emergencies that may occur during field laboratory works. Prepare a written safety procedure that takes into account the remoteness of the work and the risks associated with the activities. Minimum considerations include:

- Acquire information and familiarize on potential threats in the area
- Ensure staff and student attended training for first aid, CPR, and medical responseis made available for
- Establish an “In Case of Emergency” communications plan
- Prepare alternative plans for bad weather
- Ensure necessary supplies, equipment, SDSs (or MSDSs) and SOPs
- Verify student coverage prior to participating in laboratory field activities

Spill Kits and First Aid Kits

206. Acquire emergency kits appropriate for the laboratory. Schedule for routine inspection to make sure they are complete and ready for response.

a. Chemical Spill Kits

Many safety equipment suppliers offer spill cleanup kits. The components of the general-purpose spill kit are listed in Table 6. All labs should tailor their kit to their specific works.

Table 6. General Purpose Chemical Spill Kit Contents

Item	Description
Absorbent	Five spill pads, universal for acid, base, oil, solvents
Neutralizer	One 2-kg box baking soda for neutralizing acids
Brush,	One snap together dustpan and whisk broom

Item	Description
dustpan	
Plastic bags	Four yellow hazardous material heavy duty waste bags
Plastic drum	One 19-liter re-useable screw top plastic drum to store kit supplies and hold bagged spill waste
Goggles	One chemical splash protection goggle
Impervious gloves	One pair of gloves (multi-layer construction, impervious to most chemicals)
Lightweight gloves	Eight pairs of powder-free nitrile gloves, various sizes
Forms	Scheduled Collection Notification & Inventory and scheduled waste labels

b. Mercury Spill Kits

Many safety providers offer Mercury spill kits. **Table 7** lists the contents of the Mercury Spill Kit (below):

Table 7. Mercury Spill Kit Contents

Item	Description
Scraper	One plastic scraper
Syringe	One 1 ml/cc syringe to remove visible mercury droplets
Amalgamating powder	One package, Mercury Absorbent Powder to amalgamate micro-droplets
Sponge	One sponge to wipe surfaces after using Mercury Absorbent Powder
Plastic bag	One 9 x 12 resealable bag for waste (holds kit contents)
Gloves	One pair, Nitrile gloves, large size
Forms	Scheduled Collection Notification & Inventory and scheduled waste labels

c. Biological Spill Kit

A basic biological spill kit can be easily prepared, and its contents are listed in **Table 8**. The items selected for the spill kit should be customized to meet the specific needs of each lab. It is the responsibility of the PI to ensure a comprehensive spill kit is readily available and well kept.

Table 8. Biological Spill Kit Contents

Item	Description
Concentrated disinfectant	Select appropriate disinfectant for the infectious agent treated in the laboratory, e.g. sodium hypochlorite.
Dilution container	A container to prepare dilution for the disinfectant
Mechanical device to handle sharps	Suitable device(s) for handling/removing sharps objects such as forceps, autoclavable broom and dustpan.
Absorbent material	Suitable absorbent materials, such as paper towels
Gloves	At least 1 pairs of suitable gloves
Eye or face protection	Suitable eye or face protection, e.g. goggles and mask, or full-face shield
Biohazard autoclave bags	Biohazard autoclave bags for contaminated items

d. Radiation Decontamination Kit

The minimum requirement for radiation decontamination kit is as listed in Table 9 below. User must be trained to before allow to perform any decontamination activities using this kit.

Table 9. Radiation Decontamination Kit

Item Description
Gallon Drum
Disposable Coverall and Shoe Covers
Respirators
Disposable Gloves
Decontamination agents (Radiacwash / Radiaclean)
Radioactive Poly Bags
Tong at least 1.5 m
Shielded container
Radiation warning label and signs
Rope
Sponge mop and scrub brush
1 roll absorbent paper towels

e. First Aid Kits

The lab management / PI must ensure that the first aid kits are stored in a container that prevents them from damage, deterioration, or contamination. Containers must be clearly labeled, readily available, and easily transferred to the location of the injured or ill staff.

(1) At a minimum, kits should include absorbent pads, adhesive bandages, adhesive tape, antiseptic swabs, burn ointment, exam gloves, sterile pads, and triangular bandages. (Refer to Guidelines on First Aid in the Workplace, DOSH 2004). Check frequently for items that need to be restocked, and check the expiration dates of all items at least once a year.

(2) Laboratories using hydrofluoric acid must keep calcium gluconate gel in case of skin contact with hydrofluoric acid. The gel should be kept in the first aid kit (but may also be kept in a spill kit or any location close to the work area and known by all staff). The gel has a relatively short shelf life of only six months, so the PI/laboratory supervisor will have to replace it periodically.

(3) Each PTJ shall update and maintain the first aid kit according to the expiry date of each item and after any item has been used. The Maintenance Schedule Form is as shown in Annex N.

(4) Each PTj must periodically state the status of the First Aid Box Maintenance Schedule Form to their respective ERT.

MOVE IN / MOVE OUT LAB

Lab's Rental Service

207. It is the responsibility of lab tenant to comply with all rules, guidelines and procedures set by PTj and the university related to research laboratory management. Among the common matters to be given attention and complied by lab tenant are as follows:

a. **Access** – Only laboratory users named by the lab tenant can access to the laboratories.

b. **Experiments** – Laboratory users need to ensure that all water supply systems, gases, electricity and others are in good condition to cater for the necessary experimental needs to be done. This is to prevent any possibility of leakage.

c. **Laboratory Info** – Lab tenant needs to provide a list of authorized laboratory users to be pasted outside the laboratory. The name of the lab tenant, coordinator and supervisors of the lab and their contact number must be clearly stated.

d. **Inventories** – Lab tenant is not encouraged to make procurement of laboratory consumables exceeding the need of usage to avoid storage problems. The list of laboratory consumables especially the flammable consumables need to be submitted to the Officer-in-charge at the PTj.

e. **Cleanliness** – Lab tenant is responsible to ensure the cleanliness in the laboratory and surrounding corridors are always clean and tidy.

f. **Emergency** – Lab tenant is responsible to provide safety briefings to the laboratory users especially on steps to be taken in the event of emergency in the laboratory. Emergency evacuation route plan needs to be provided for laboratory user reference.

g. **Neatness** – Users of the laboratory are responsible to ensure that the space in the laboratory is used appropriately and cleaned before leaving the laboratory. This include ensuring all electrical, water and gas are turned off completely and safely.

h. **Accident** – Any accident or injury happened on the laboratory users should be reported promptly and in writing to the UM Security and the Officer-in-charge at the PTj.

i. **Security** – The lab tenant needs to provide laboratory training and awareness to the laboratory users. Laboratory users need to be familiarized with the location and methods of using the emergency equipment such as fire extinguishers and other tools that may be in used during emergencies.

j. **First aid box** – The lab tenant needs to provide first-aid box with proper and adequate drug content on a visible location that is accessible by laboratory user.

k. **Key** – The laboratory's keys are under the responsibility of the laboratory tenant. Duplication of laboratory's keys is allowed and must be submitted to the Officer-in-charge at the PTj and the delivery of key needs to be recorded.

l. **Food** – Laboratory users are not allowed to eat and drink or cook in the laboratory.

m. **Cigarettes/e-Cigarettes** – Laboratory, surrounding areas and universities are non-smoking areas. Smoking is not allowed.

n. **Waste Disposal** – Lab tenant is responsible to ensure any type of experimental waste generated from the laboratory is isolated in a properly labelled container and stored safely prior to disposal. The lab tenant is required to dispose the scheduled waste with the assistance of the assigned Officer-in-charge at the PTj. The wastes disposal process needs to be complied with the Environmental Quality (Schedule Wastes) Regulations 2005 and University procedure.

o. **Application** – Laboratory users need to wear appropriate PPE, clothing, shoes and safety glasses when carry out research work in the laboratory. Purdah is prohibited in the laboratory.

p. **Check/Inspection//Audit** – The PTj and the University may at any time access the laboratory for inspections/audits and review the compliance of laboratory procedures. Self-check/audit by the lab tenant should be done every 3 months and reports need to be submitted to Officer-in-charge at the PTj.

q. **Working Environment** – Lab needs to be in good and healthy environment and facilitated with good air ventilation system. The lab tenant must ensure the entrance/exit and the passageways are not blocked with any obstructions to ensure safe egress during emergency.

r. **Laboratory procedures** – Lab tenant needs to provide laboratory procedure , including safe work procedures and general guidelines to all laboratory users and to be pasted in a visible place outside the lab or near the lab entrance.

s. **Laboratory Equipment** – Lab tenant is responsible to maintain and monitor all laboratory equipment. The PTj is not responsible for the maintenance and supervision of laboratory equipment.

t. **Tagging and Labelling** – Lab tenant is responsible to ensure all laboratory equipment and consumables are marked/tagged and labelled properly based on university settings.

u. **Rest** – Lab users are not allowed to be either asleep or resting in laboratory.

v. **Maintenance** – Civil, mechanical and electrical damages in the laboratory need to be reported to the Officer-in-charge at the PTj. Laboratory tenant is prohibited from doing repair work without the knowledge of PTj and JPPHB.

w. **Renovations** – Application of any renovation works to be implemented must be submitted to PTj for the certificate and approval of JPPHB.

x. **Storage** – Lab tenant is responsible to ensure laboratories with storage is under control and the storage of the consumables in the store is safe and are hindered from any fire hazard and contamination.

y. **Evacuation/Vacation of Laboratory** – The lab tenant is responsible to ensure and manage the disposal or transfer of all lab wastes/consumables in the laboratory upon the evacuation/vacation of laboratory.

LABORATORY EQUIPMENT & FACILITIES

Emergency Washing Equipment

208. Emergency washing equipment is necessary when handling corrosives, strong irritants, and toxic substances that can be absorbed through the skin. Emergency washing facilities must be easily accessible and staff should be able to get to the equipment quickly (within 10 seconds and not more than 50 feet, or closer if access is through a closed door). All emergency equipment must be accessible at all times without requiring a special access or or going through security safeguards.

a. Emergency Eyewashes

An eyewash is required when handling chemicals in such a way that they may splash into eyes to prevent severe eye damage. Laboratory staff must be able to get to eyewash within ten seconds and it should be not more than 50 feet of where chemicals are being used,. Always make sure the paths to eyewashes are unobstructed.

Chemicals can cause blindness or extreme pain, making it impossible for someone in an emergency to identify eyewash on their own. The location and operation of the eyewashes in the area should be known by laboratory staff. It is proposed that staff practice finding the eyewash with their eyes closed. Don't work alone when working with these chemicals.

To ensure that eyewashes are functioning properly, laboratory staff must flush them once a week. Flushing ensures eyewashes to work properly and have a good enough stream of water to wash the eyes of people using them and keep the water clean. The eyewash should be run for about 30 to 60 seconds during the weekly check to ensure that there is no noticeable rust or pollutants in the water. If the eyewash is in a common area, someone should be assigned to perform the task.

b. Emergency Showers

Laboratory staff should be well aware of where the showers are located and how to use them. The staff must be able to get to showers in less than ten seconds. Ensure the path and areas under the shower are unobstructed at all times.

Safety showers should be tested annually by lab users. The equipment should have a tag that displays the most recent test date.

Fire Safety Equipment

209. Fire safety equipment are important and should be make available based on requirements.

a. Fire Extinguishers

(1) Proper Use

Fire extinguishers are provided in all UM buildings. The type(s) of fire extinguishers present in the laboratory should be taught to all laboratory staff. If there is an escape route, people who have been educated in the principles of fire extinguisher use and the dangers involved may try to put out small and incipient fires. Individuals who have not been educated in the use of fire extinguishers should not try to use one in the event of a fire. They, as well as others, could be put in danger if they do so.

Fire extinguishers should be located in easily seen area, wall mounted, and easily accessible.

(2) Types of Fire Extinguishers

The fire extinguishers available in the laboratory should be chosen based on the materials inside or outside the laboratory.

Laboratories that use toxic chemicals should have ABC-rated dry chemical fire extinguishers within 50 feet of the hazard, either along the exit route or in the corridor next to the laboratories. Many fire extinguishers in UM are ABC, which work well on most fires except combustible metal fires. Extinguishers for combustible metal (Class D) are rarely supplied for laboratories unless they are needed..

A CO2 extinguisher can also be requested by laboratories (Class BC). It is not as effective as a dry chemical extinguisher, but easier to clean up.

(3) Maintenance

In UM, the annual maintenance process of fire extinguishers is handled by both JPPHB and PTj as part of the routine building maintenance.

b. Fire Hoses

Only firefighters are allowed to use fire hoses. Fire blankets are not recommended for use in laboratories because they can absorb heat while a victim's clothes are on fire, resulting in more injuries than would otherwise be the case.

c. Flammable Liquid Storage Cabinets

If the laboratories have more than 40 liters of flammable liquids, you must use flammable liquid storage cabinets. The cabinets, however, are not fireproof. They are only intended to protect the contents from high temperatures for a short period of time.

(1) Approved Flammable Liquid Storage Cabinets
Flammable liquids should be kept in a certified flammable liquid storage cabinet and equipped with automatic or self-closing doors.

(2) Label
"Flammable - Keep Fire Away" must be labelled on cabinets.
(3) Capacity
Check manufacturer’s recommendations for storage limits and do not overfill cabinets.

(4) Bottles

Bottles should only be placed on shelves and never be stacked. Ensure all containers are tightly closed.

(5) Containers

Only use containers designed for the storage of flammables. Do not use “improvised” containers even for temporary storage.

(6) Incompatible Chemicals

Never store incompatible chemicals in the cabinet.

(7) Cabinet Doors

Do not prop open cabinet doors unless the mechanism is a designed part of an approved cabinet.

(8) Inappropriate Storage

Do not use tops of cabinets as storage shelves. Combustible materials should not be stored on or beside flammable liquid storage cabinets.

d. Flammable Storage Refrigerators/Freezers

Flammable chemicals or chemical mixtures that require surrounding of low temperature must be kept in flammable storage refrigerators or freezers. These refrigerators and freezers are specially designed with non-sparking interiors. Explosion-proof refrigerators are designed to prevent ignition of flammable vapors or gases that may be present inside and outside the refrigerator. This type of refrigerator must be placed in locations where a flammable atmosphere may develop at some time in the room. All refrigerators and freezers must be prominently labelled with a warning sign indicating whether it can be used for flammable or non-flammable storage.

Laboratory Signs

210. Laboratory signage is important as it provides information to staff, students and visitors with regarding potential laboratory hazards and risks, required precautions for entry, and contact information. This signage is a part of the University’s hazard communication and it more standardized and recognizable. It is also very useful to emergency responders and facilities management staff during an emergency.

a. Caution Sign

A standard Laboratory Caution Sign must be displayed at each lab entrance. The sign aims to alert emergency responders and visitors to potential hazards in the lab and also coto comply with regulatory requirements.

b. Emergency Procedures

Laboratories must post the Emergency Procedures in an easily noticeable position in the facility. Include specific emergency procedures and phone numbers for several emergency situations. Provide contact information for the PI and lab staff in case of an emergency.

c. Floor Plan

Laboratories should have a floor plan that shows the escape route(s), as well as the location of spill kits, fire extinguishers, and other protection equipment. If hazardous substances are used in a designated area, it is required to show the designated area in the floor plan.

d. Emergency/Safety Equipment Location Signs

Signs for location of exit routes and safety equipment such as safety showers, eyewash stations, fire extinguishers, first aid kits, and flammable storage cabinets must be posted in and around the laboratories.

e. Hazards Warning Signs

If there are special or unusual hazards present, warning signs and labels should be posted clearly. Depending on the hazardous level, these signs may be mandatory.

f. Gas Emergency Shut Off Valve

Post a sign indicating the present of emergency shut-off valve for gas supply systems if the laboratory has one.

Laboratory General Ventilation

211. Laboratory should be well designed with proper ventilation. Some basic requirements are -

a. The laboratory air pressure should be negative to the corridor to prevent any accidental release of hazardous vapours, including from the operation of lab apparatus, *i.e.* gas chromatographs, liquid chromatography, vacuum pumps, from being released into the corridor and the building.

b. The laboratory ventilation should be designed by competent engineer (PE) and should be periodically checked and tested. Supply and exhaust vents should not be blocked.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

212. Staff and student safety and health is one of the University concerns, at it is important to ensure that they are adequately protected to an acceptable level risk of laboratory hazards which existed due to the nature of work involved. Personal protective equipment is any equipment that is designed and to be worn by a person at workplace to protect oneself against any health or safety risks. This means it provides a safe–person approach offering protection the user only. Hence it is always better to control the hazard at the source through hierarchy of control and adoption of a safe system of work. The use of PPE should be used as the last option and it is the last line of defence/protection for worker. The decision to use PPE should be based on systematic assessment, such as using hazard assessment tools include Risk Assessment and/or Job Safety Analysis.

213. PPE must be made available to laboratory staff, students and other users to reduce exposure risk any hazards (biological, chemical and radioactive substances) in the lab. Basic PPE includes gloves, lab coats, goggles, face shields, aprons, etc. It is the responsibility of the PI, HoD and/or Head of PTj to provide proper PPE to the lab staff and those under their supervision. The lab staff and users are responsible to follow the procedure and instructions, to wear and maintain the PPE properly.

214. PPE should be worn at workplace, and not outside the lab — staff and students should be trained to their PPE before leaving the lab to enter common/public areas.

Types of PPE

215. Basic PPE are made available in all laboratories. However, some laboratories required specialized PPE and hazard assessment can help identify their requirements.

a. **Head Protection**

PPE includes headgears, safety/hard hats should be made available for any activities with the risks of falling objects to the head. Safety check for head protection equipment should include checking for dents, cracks or deformities on the shell and connections are tightened inside. The PPE should be store away from direct sunlight, should be replaced if there is any incident of any kind of impact before, even if there is no visible damage.

b. **Face and Eye Protection**

PPE includes face shields and safety goggles should be used for any task that has the possibility of risk to vision and injury to face or eyes (such as splashes of toxic liquids, burns, etc. Safety equipment should be checked prior use, and ensure that there are in good conditions, no cracks or deformities, strap is in good working order, firm sealto the cheek and forehead.

All persons working in chemical laboratories must wear approved safety glasses/goggles at all times. Safety glasses are required when working with hazardous condition, such as flying particles/debris and sparks, and as recommended by SDS.

Purdah/niqab or any face veil is not allowed in laboratories as it is not approved PPE and can be a hazard. Use only accepted PPE for face and respiratory protection such as goggles, approved respirators and face shields. Staff/students wearing *tudungs*/head scarves must be tugged inside (beneath) the lab coat. Long hair should be tied.

c. **Respiratory Protection**

Respirators should be used for activities where there is a possibility of inhalation of harmful materials including fine dust particles. Mask or respirator selection for any chemical item used should follows the recommendation of the relevant SDS. Prior to use, the the equipment should be fit-tested and proper training should be given to the staff/users before wearing one.

d. **Hands Protection**

Safety gloves should be used when there are risks of injury to hand and skin burns, absorption of harmful substances, cuts, fractures or amputations. All hand protection equipment should be inspected prior to use to ensure that they fit properly (no spaces/not loose), and free from tears/cuts, burns and chemical residue. Replace the PPE if any sign of damage or contamination observed.

Selection of type of suitable gloves is critical and should be based on HIRARC or JSA requirements.

Gloves must be worn when handling chemicals or any hazardous materials. Selection of gloves must follow the recommendation of the relevant SDS. When unsure, do not guess – ask your supervisor or PI.

Strategies to reduce the risk of hand contact with hazardous chemicals while working –

(1) Always use techniques that can reduce splashing and minimize contact with the chemicals.

(2) Always check the conditions of your gloves, particularly disposable gloves. Change it when contaminated with high contact hazards materials.

(3) Change disposable gloves frequently and wash your hands whenever you remove gloves.

(4) Consider double gloving in situations where practical considerations may limit a ‘best’ glove selection.

(5) Reusable gloves provide better forearm protections and puncture resistance and are most appropriate for Contact Protection when working with

chemicals that have a Very High or High contact hazard. They are recommended for all work requiring Immersion Protection.

(6) Be aware of conditions that may affect your risk of contact hazards and adjust protection as needed.

Selection of suitable gloves is important when dealing with electricity, materials that are mechanical hazard, have extreme temperature (hot/cold), and the potential risks of laceration by sharp objects.

When wearing protective gloves, you should not be handling switches, handles, plugs and other equipment, door knobs, telephones in laboratories to avoid contamination other surfaces.

e. **Body Protection**

Labcoats, coverall, safety vests, aprons should be used for tasks with risk of body injuries from extreme temperatures, flames and sparks, toxic chemicals, insect bites and radiation. These PPE should be maintained, clean and free from cuts and burns. Always get a good fit to ensure proper protection.

The most commonly used in laboratory is a laboratory coat (lab coat). Staff or students without a lab coat should not be allowed to work in laboratories. This applies to ALL including visitors. Wear laboratory coats properly and it should be buttoned/fastened. Laboratory coats must be kept clean and in safe/good condition. Laboratory coats should not to be worn outside of the labs, especially in common corridors, canteen, staff rest area to avoid cross contamination.

f. **Foot Protection**

Safety boots should be used when work activities has the risks of serious foot and leg injuries from falling or rolling objects, hot substances and electrical hazards.. Use boots with slip-resistant soles that protect against compression and impact. In laboratory, slippers, sandals, open-top shoes are not allowed.

g. **Hearing Protection**

Ear plugs and ear muffs should be used for noisy areas or work activities that have the potential of causing loss of hearing and hearing problems. The PPE must fit the person and ear canal properly. The selection should be based the needs and suitability.

h. General PPE for Laboratory

Approriate PPEshould be used and worn at all times when working with laboratory hazards. The hazard and risk assessment will determine the types of PPE required for each work activities. The minimum PPE requirements to work in any laboratories include:

(1) lab coat,

(2) fully enclosed shoe,
(3) safety glasses,
(4) gloves

216. However, the selection of the types of PPE needs to comply with the specific needs of the work and laboratory requirements. The supervisor and PI needs to determine the types of risks and hazards for their work or research activities, and make the necessary acquisition. For example, two biological labs (Biosafety Level 1 and 2) have different levels and types of risks, and the PPE used will reflected as they need types of PPE used to follow the area-based hazards, such as eye and skin exposure to biological agents and chemicals.

217. It is recommended that all labs to establish a designate temporary storage area for PPE (i.e., lab coats and other PPE) as the PPE are not being worn outside the lab.

218. Washing of lab coats, apron, etc should be done separately for personal laundry to avoid any safety and health issue arises from possible cross contamination.

Training for Personal Protective Equipment

219. PPE training should be given to all staff, students and other lab users. The training should include the selection, proper use, limitations, care, and maintenance of PPE. Training can be conducted in formal classroom style, small groups, in research group meeting, or even one-on-one training if required. Mandatory topics to be covered in the training include:

a. When PPE must be worn.

b. What PPE is necessary to carry for work activities, i.e. procedure or experiment.

c. How to properly put on, take off, adjust, and wear PPE.

d. Proper cleaning, care, maintenance, useful life, limitations, storage and disposal of the PPE

220. Effective protection can only be achieved through using the suitable PPE (for the hazards) and has to be correctly fitted, properly used and properly maintained PPE. Care should be taken with PPE usage to ensure that the wearer need to understand that he/she may has some extent of restricted mobility, or visibility, or by requiring additional weight to be carried when doing their work.

221. The annual or periodical laboratory safety review to be carried out to ensure the training requirements is updated and current.

222. It is the responsibility of the Principal Investigator, Lab Manager and HoD/Head of PTj to ensure laboratory staff and user to receive the appropriate PPE training when working in laboratories with PPE.

Disposal of Personal Protective Equipment

223. The disposal of PPE should be following the established procedures. For example, gloves contaminated with chemicals, highly-toxic chemicals, and mercury and higher biological materials should be disposed into appropriate hazardous waste containers following the lab waste (scheduled waste) disposal procedure.

224. PPE contaminated by radioactive materials must strictly follow the procedures by the Radiation Protection Unit.

MEDICAL SURVEILLANCE

225. **Medical Surveillance for Working with Chemical Materials**

a. **Components of Medical Surveillance Programme**

The components of Medical Surveillance Programme under the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations, 2000 include:

(1) Pre-employment and pre-placement medical examination.

(2) Biological monitoring and biological effect monitoring.

(3) Health effects monitoring.

(4) Investigation of occupational disease and poisoning including workplace inspections.

(5) Notification of occupational disease and poisoning.

(6) Assist in disability assessment.

(7) Return to work examination after medical removal protection.

(8) Record keeping and monitoring.

b. **Duties of Employer**

(1) Carry out health surveillance programme as required by the assessment report under USECHH Regulations.

(2) Health surveillance programme shall be conducted during the working hours and the costs shall be borne by the employer.

(3) Appoint an Occupational Health Doctor, (OHD) to conduct occupational medical surveillance programme.

(4) Allow and assist the OHD to visit the workplace to investigate and manage occupational disease and poisoning including access to relevant monitoring and other health related data.

(5) Co-operate with the OHD in medical removal protection of the worker.

(6) During the period of medical removal, the worker may be allowed to do other work that will not expose him to the hazardous chemical.

(7) Notify occupational disease and poisoning to OSHE.

(8) Notify the workers concerned regarding monitoring of exposure levels of chemicals hazardous to health including occupational disease and poisoning.

(9) Allow the employee access to occupational medical surveillance records.

(10) Ensure the workplace hygiene is improved, is safe and healthy and does not place the worker at increased risk of material impairment to health from exposure to chemical hazardous to health. Before allowing the worker to work in the same place so as to ensure the disease or poisoning does not reoccur.

(11) Record Keeping of diseases and accidents.

(12) Provide Employee Medical Book.

c. **Duties of Employee**

(1) Undergo training on importance of preventing occupational poisoning and disease.

(2) Report early symptoms and signs of disease (including self-examination) to the OHD and management.

(3) Comply and co-operate in the Occupational Medical Surveillance Programme, as required under USECHH.

(4) To take proper care of the Employee Record Book and to present it to OHD for Occupational Medical Surveillance record purposes.

d. **Chemicals for Which Medical Surveillance Is Appropriate.**

SCHEDULE II

(Subregulation 27(3))

(Chemicals for which medical surveillance is appropriate)

1. 4-Aminodiphenyl
2. Arsenic And Any Of It Compound
3. Asbestos (All Forms Except Crocidolite)
4. Auramine, Magenta
5. Benzidine
6. Beryllium
7. Cadmium And Any Of Its Compound
8. Carbon Disulphide
9. Disulphur dichloride
10. Benzene including benzol
11. Carbon Tetrachloride
12. Trichloroethylene
13. n–Hexane
14. bis (Chloromethyl) ether
15. Chromic Acid
16. Chromium, metal and inorganic compounds, e.g. Water-Soluble Cr VI compounds, Insoluble Cr VI compounds
17. Free crystalline silica
18. Isocyanates
19. Lead (including organic lead compounds)
20. Manganese
21. Mercury
22. Mineral oil including paraffin
23. b-Naphthylamine
24. 1-Naphthylamine and its salts
25. Orthotolidine and its salts
26. Dianisidine and its salts
27. Dichlorobenzidine and its salts
28. 4-Nitrodiphenyl
29. Nitro or amino derivatives of phenol and of benzene or its homologues
30. Nitrous fumes. Chromate or dichromate of potassium, sodium ammonium or zinc
31. Pesticides (organophosphates)
32. Pitch
33. Tar, bitumen and creosote
34. Vinyl chloride monomer (VCM)
35. Nickel sulfide roasting, fume and dust as nickel

***Note**: Please refer Guidelines on Medical Surveillance by Department of Occupational Safety & Health, Ministry of Human Resources*

226. **Medical Surveillance for Working with Biological Materials**

a. **General Awareness**

(1) All employer and employees in research laboratories working with, or who may be exposed to, potentially infectious agents, including recombinant viral vectors, must be aware of signs or symptoms consistent with diseases caused by these agents, their parental strains and materials present in their laboratory.

(2) In some cases medical evaluations, vaccinations and/or other medical surveillance is required.

(3) Laboratory-specific training must include hazard communication related to the risks of these agents, anticipated signs/symptoms associated with these agents to facilitate recognition of potential occupational illnesses, and procedures to follow if a potential exposure has occurred.

(4) For certain activities, medical surveillance must be undertaken prior to working with biological agents. Examples include laboratories working with human pathogens, such as HIV or Zika virus, or with agents for which vaccination may offer protection.

(5) All personnel must be made aware by their supervisors that certain medical conditions increase their risk of potential health problems when working with pathogenic microorganisms and/or animals. These conditions include pregnancy, immunosuppression, animal related allergies, and chronic skin conditions.

b. **Vaccinations**

Personnel to be offered vaccinations to protect them from workplace hazards. Examples include:

(1) Hepatitis B vaccine for all workers with reasonable expectation of exposure to human blood or other potentially infectious materials (OPIM), which includes human and nonhuman primate cell lines, including those acquired from commercial sources.

(2) Tdap (Tetanus, Diphtheria, Pertussis) vaccination, which is highly effective for the prevention of diphtheria, tetanus and pertussis, should be offered to personnel working with pertussis toxin (PT) or handling animals.

c. **Post Exposure Surveillance**

(1) Exposures or potential exposures should be reported to the supervisor/PI/HOD and OSHE.

(2) Affected individuals should refer to the Occupational Health Clinic (OHC) for further medical evaluations. The medical professionals at OHC will determine the need for post-exposure treatment, and continued medical surveillance.

(3) Employer must allow and assist the OHD to investigate and manage occupational disease and poisoning including access to relevant monitoring and other health related data.

(4) Employer must notify occupational disease and poisoning to OSHE and keep record of diseases and accidents.

SAFETY TRAINING

Laboratory Safety Training

227. The Universiti Malaya policy requires the PTj and Departments are to ensure that all employees, students and visitors are safe at work place. Hence, the Principal Investigators (PIs), Researchers, Laboratory Supervisors, Officers In-Charge (PIC) are responsible to ensure that all staff, students and other lab users receive adequate training and understand the hazards present in their work area. Training must be conducted prior to the laboratory users are allowed to use the laboratories, and work assignments involving new hazards.

228. The basic Laboratory Safety Training Module has been developed and can be accessed at UM platform . PTj is required to comply to the latest lab safety training processes as stated in Process Flow on Lab Safety Training

229. Each PTj / Department must establish method for tracking the training new staff and new laboratory users (including students and visitors) before working in the laboratories with hazardous chemicals and other hazards in the laboratory. All visitors must receive adequate training to ensure that they understand and aware of the hazards and to ensure safety for themselves and others while in the work area.

230. Lab users will need to retake the lab safety training according to the timeframe as stated in the latest Lab Safety Training Guideline. This also applies if the lab users demonstrate that they fail to adhere to lab safety standards/procedures or did not understand the initial training.

231. PTj is allowed to establish additional / advanced safety training module (in conjunction with OSHE) for their staff. All trainings conducted by PTj has to be recorded and kept as per para #230 . Additional specific training may be required for specialized research laboratory that is not within the scope of basic laboratory safety training, for example, animal research, biosafety labs, clinical research, funded research, etc. Such trainings are the responsibility of the Departments. Laboratories and the PIs to design, develop and conduct such trainings.

Safety Training Records

232. Each Department is required to develop a matrix describing the recommended training for each laboratory staff and users (including students and visitors).

233. Each PTj or Departments are required to maintain the training records for all courses attended by the staff and laboratory users for a period of their employment and for a period stipulated by the law.

Process Flow on Laboratory (Lab) Safety Training (Basic Training)

Responsibility	Process Flow	Interface
	Start	
Lab User	Inform Lab Admin the date of entry lab	
Lab Admin	1) Register the lab user for lab safety training 2) Inform lab user the date of training	
Lab User	Lab user are required to attend the lab safety training according to the schedule 1) read and understand the lab safety training module 2) take lab safety quiz within the stipulated time	www. atrium.um.edu.my
Lab User	Test (Fail → return to Register the lab user for lab safety training; Pass → continue)	
Lab User	Receive an e-certificate (valid in 2 years)	UMTouch
Lab User	Present the e-certificate to the Lab Person In Charge (PIC) prior to entering the Lab	
	End	

A.

APPENDICES

Seventh Schedule
[Subregulation 6(1)] of Prevention and Control of Infectious Diseases Act 1988

SEVENTH SCHEDULE

[Subregulation 6(1)]

Category of organisms according to Risk Group

A Risk Group is defined by criteria developed by the World Health Organization based on the pathogenicity of the organism, the mode and relative ease of transmission, the degree of risk to both an individual and a community and the reversibility of the disease, through the availability of known and effective preventive measures and treatment, as follows:

Risk Group 1: Organism, which is unlikely to cause disease in a healthy individual, plant or animal. For the purpose of these Regulations, all organisms not listed in Risk Group 2, 3 and 4 falls under Risk Group 1.

Risk Group 2: Organism, which is known to cause disease in a healthy individual. Infectious risk is via direct contact, ingestion or inhalation. Effective treatment, preventive and control measures are readily available and can be implemented to control disease transmission. Risk of spread to a community is limited

Risk Group 3: Organism, which may be an exotic or indigenous agent with potential in transmitting disease mainly via aerosol. Disease caused is severe and may result in death. It could present a risk if spread in the community, however effective treatment, preventive and control measures are available.

Risk Group 4: Organism, which may be exotic agent or new agent usually able to cause life-threatening human disease. The infectious disease is readily transmissible from one individual to another. Infectious disease is transmitted via aerosol or it may not be known. Effective treatment, preventive and control measures are not available. Any newly discovered organism, which has not yet been categorized under these Regulations falls under Risk Group 4.

Note: This is not a complete list. *For the purpose of these Regulations, any organism not listed in Risk Group 2, 3 or 4, should not be classified in Risk Group 1 until its characteristic and pathogenicity are verified in consultation with the Expert Committee on Prevention and Control of Infectious Disease, Ministry of Health, Malaysia.*

BACTERIA, CHLAMYDIA, MYCOPLASMA AND RICKETTSIA

Risk Group 2

-- *Acinetobacter baumannii (Acinetobacter calcoaceticus)*
-- *Acinetobacter Iwoffi*
-- *Actinobacillus actinomycetemcomitans*
-- *Actinomadura madurae*
-- *Actinomadura pelletieri*
-- *Actinomyces spp.* including:
 - **--** *Actinomyces gerencseriae*
 - -- *Actinomyces israelii*
 - -- *Actinomyces pyogenes (Corynebacterium pyogenes)*

-- *Aeromonas hydrophila*
-- *Afipia spp*
-- *Agrobacterium radiobacter*
-- *Alcaligenes spp.*
-- *Amycolata autotrophica*
-- *Archanobacterium haemolyticum (Corynebacterium haemolyticum)*
-- *Arizona spp* – all serotypes
-- *Bacillus cereus*
-- *Bacteroides spp.* including:
 - -- *Bacteroides fragilis*

-- *Bartonella bacilliformis (Rochalimaea bacilliformis)*
-- *Bartonella quintana (Rochalimaea quintana)*
-- *Bartonella henselae (Rochalimaea henselae)*
-- *Bartonella vinsonii (Rochalimaea vinsonii)*
-- *Bordetella bronchiseptica*
-- *Bordetella parapertussis*
-- *Bordetella pertussis*
-- *Borrelia spp.* including:
 - -- *Borrelia burgdorferi*
 - -- *Borrelia duttonii*
 - -- *Borrelia recurrentis*

-- *Brucella ovis*
-- *Burkholderia spp.* including:
 - -- *Burholderia cepacia*
 - -- *Burholderia mallei (Pseudomonas mallei)*
 - -- *Burholderia pseudomallei (Pseudomonas pseudomallei*

-- *Campylobacter spp.* including:
 - -- *Campylobacter coli*
 - -- *Campylobacter fetus*
 - -- *Campylobacter jejuni*

-- *Capnocytophaga spp.*
-- *Cardiobacterium hominis*
-- *Chlamydia pneumoniae*
-- *Chlamydia psittaci (*non avian strains*)*
-- *Chlamydia trachomatis*
-- *Citrobacter spp.*
-- *Clostridium spp.* including:
 - -- *Clostridium botulinum*
 - -- *Clostridium chauvoei*
 - -- *Clostridium haemolyticum*
 - -- *Clostridium histolyticum*
 - -- *Clostridium novyi*

-- *Clostridium perfringens*
-- *Clostridium septicum*
-- *Clostridium tetani*

-- *Corynebacterium spp.* including:
-- *Corynebacterium diphtheriae*
-- *Corynebacterium minutissimum*
-- *Corynebacterium pseudotuberculosis*
-- *Corynebacterium renale*

-- *Dermatophilus congolensis*
-- *Edwardsiella tarda*
-- *Enterobacter spp.* including:
-- *Enterobacter aerogenes / cloacae*

-- *Enterococcus spp.*
-- *Erysipelothrix rhusiopathiae*
-- *Escherichia coli* – all enteropathogenic, enterotoxigenic, enteroinvasive and strain bearing K1 antigen, including E. coli O157:H7 or O103
-- *Flavobacterium meningosepticum*
-- *Fluoribacter bozemanae (*formerly known as *Legionella)*
-- *Francisella tularensis (Type B)*
-- *Fusobacterium spp.* including:
-- *Fusobacterium necrophorum*

-- *Gardnerella vaginalis*
-- *Haemophilus spp.* including:
-- *Haemophilus ducreyi*
-- *Haemophilus influenzae*

-- *Helicobacter pylori*
-- *Klebsiella spp*. including:
-- *Klebsiella pneumonia*
-- *Klebsiella oxytoca*

-- *Legionella spp.* including:
-- *Legionella pneumophila*

-- *Leptospira interrogans* – all serotypes
-- *Listeria ivanovii*
-- *Listeria monocytogenes*
-- *Moraxella catarrhalis*
-- *Moraxella lacunata*
-- *Morganella morganii*
-- *Mycobacterium spp. (*except those listed in Risk Group 3*)* including*:*
-- *Mycobacterium africanum*
-- *Mycobacterium avium / intracellulare*
-- *Mycobacterium asiaticum*
-- *Mycobacterium bovis (BCG* vaccine strain*)*
-- *Mycobacterium chelonei*
-- *Mycobacterium fortuitum*
-- *Mycobacterium kansasii*
-- *Mycobacterium leprae*
-- *Mycobacterium malmoense*
-- *Mycobacterium marinum*
-- *Mycobacterium microti*
-- *Mycobacterium paratuberculosis*
-- *Mycobacterium scrofulaceum*
-- *Mycobacterium simiae*
-- *Mycobacterium szulgai*
-- *Mycobacterium ulcerans*
-- *Mycobacterium xenopi*

-- *Mycoplasma caviae*
-- *Mycoplasma hominis*
-- *Mycoplasma pneumoniae*
-- *Neisseria elongata*
-- *Neisseria gonorrhoeae*
-- *Neisseria meningitidis*
-- *Nocardia spp.* including:
    --*Nocardia asteroids*
    --*Nocardia brasiliensis*
    --*Nocardia farcinica*
    --*Nocardia nova*
    --*Nocardia otitidiscaviarum*
    --*Nocardia transvalensis*
-- *Pasteurella spp.* including*:*
    --*Pasteurella multocida (*except resistant strains listed in Risk Group 3*)*
-- *Peptostreptococcus spp.* including:
    --*Peptostreptococcus anaerobius*
-- *Plesiomonas shigelloides*
-- *Porphyromonas spp.*
-- *Prevotella spp*
-- *Proteus mirabilis*
-- *Proteus penneri*
-- *Proteus vulgaris*
-- *Providencia spp*. including:
    --*Providencia alcalifaciens*
    --*Providencia rettgeri*
-- *Pseudomonas aeruginosa*
-- *Rhodococcus equi*
-- *Rochalimaea spp. (*see *Bartonella spp.)*
-- *Salmonella spp.* including*:*
    --*Salmonella arizonae*
    --*Salmonella.cholerasuis*
    --*Salmonella enteritidis*
    --*Salmonella gallinarum-pullorum*
    --*Salmonella meleagridis*
    --*Salmonella paratyphi, A, B, C*
    --*Salmonella typhi*
    --*Salmonella typhimurium*
-- *Serpulina spp.*
-- *Serratia liquefaciens*
-- *Serratia marcescens*
-- *Shigella boydii*
-- *Shigella dysenteriae (*all serotypes)
-- *Shigella flexneri*
-- *Shigella sonnei*
-- *Sphaerophorus necrophorus*
-- *Staphylococcus aureus*
-- *Stenotrophomonas maltophilia*
-- *Streptobacillus moniliformis*
-- *Streptococcus spp.* including:
    --*Streptococcus pneumoniae*
    --*Streptococcus pyogenes*
    --*Streptococcus suis*
-- *Treponema spp.* including:
    --*Treponema carateum*
    --*Treponema pallidum*

    --*Treponema pertenue*
-- *Ureaplasma urealyticum*
-- *Vibrio spp*. including:
    --*Vibrio cholerae*
    --*Vibrio parahemolyticus*
    --*Vibrio vulnificus*
-- *Yersinia spp (*except *Yersenia pestis*, ilsted in Risk Group 3*)*
    --*Yersinia enterocolitica*
    --*Yersenia pseudotuberculos*

Risk Group 3

-- *Bacillus anthracis*
-- *Brucella spp.* (except *Brucella ovis, listed in Risk Group 2*)
    --*Brucella abortus*
    --*Brucella canis*
    --*Brucella melitensis*
    --*Brucella suis*
-- *Burkholderia (Pseudomonas) mallei*
-- *Burkholderia (Pseudomonas) pseudomallei*
-- *Chlamydia psittaci* (avian strains)
-- *Coxiella burnetii*
-- *Ehrlichia spp*. including:
    --*Ehrlichia sennetsu (Rickettsia sennetsu)*
-- *Eikenella corrodens*
-- *Francisella tularensis* (Type A)
-- *Mycobacterium bovis* (except *BCG* strain, *see Risk Group 2*)
-- *Mycobacterium tuberculosis* (multi-drug resistant strains)
-- *Pasteurella multocida* Type B -*"buffalo"* and other virulen strains
-- *Rickettsia spp.* including:
    --*Rickettsia akari*
    --*Rickettsia australis*
    --*Rickettsia canada*
    --*Rickettsia conorii*
    --*Rickettsia prowazekii*
    --*Rickettsia rickettsii*
    --*Rickettsia sennetsu* (see *Ehrlichia sennetsu*)
    --*Rickettsia siberica*
    --*Rickettsia tsutsugamushi*
    --*Rickettsia typhi (Rickettsia mooseri)*
-- *Yersinia pestis*

Risk Group 4

NONE

VIRUSES AND PRIONS

Risk Group 2

-- *Adenoviridae*
- -- *Adenoviruses*, all serotypes

-- Arenaviridae
- -- Lymphocytic choriomeningitis virus (LCM); non-neurotropic strains; *Ippy, Mobala*
- -- *Tacaribe virus complex: Ampari, Latino, Parana, Pichinde, Tacaribe, Tamiami*
- -- Virus *Hepatitis delta*

-- Astroviridae
- -- Human a*strovirus*

-- Bunyaviridae

Genus: *Bunyavirus*
- -- *Bunyamwera virus*, California encephalitis *group*, including *LaCrosse* virus

Genus: *Phlebovirus*

all species, except Rift Valley fever virus (see Risk Group 3), includes :
- -- Rift Valley fever virus strains MP-12, Sandfly fever virus, Toscana, *Uukuvirus*

Genus: *Nairovirus*
- -- *Hazara virus, Dugbe virus*

-- *Caliciviridae*

all viruses including *Norwalk virus, Sapovirus* and *Hepatitis E virus*

-- Coronaviridae

Human *coronavirus*, (serotype 229E and OC43), except *SARS coronavirus,* (see Risk Group 3*)*

-- Flaviviridae

Genus: *Flavivirus* (Group B Arbovirus)
- *-- Dengue virus serotypes 1, 2, 3, and 4*
- -- Yellow fever virus vaccine strain *17D*

Genus: *Hepacivirus*
- -- Hepatitis C virus

-- Hepadnaviridae
- -- Hepatitis B virus

-- *Herpesviridae*

all Herpesviruses, except *Herpesvirus simiae (*Herpes B, see Risk Group 4*):*
- *-- Cytomegalovirus*
- -- Virus *Epstein Barr*
- -- *Herpes simplex* type 1 and 2
- *-- Herpes varisela-zoster*
- -- Human herpesvirus type 6 (HHV 6)
- -- Human herpesvirus type 7 (HHV 7)
- -- Human herpesvirus type 8 (HHV 8)

-- *Flaviviridae* - Group B Arbovirus

Genus: *Flavivirus*
- -- *Japanese encephalitis virus*, yellow fever virus (wild type), *West Nile fever*, *St. Louis encephalitis virus, Murray Valley encephalitis virus*, *Ntayavirus group*: *Israel turkey Meningitis virus*
  Modoc virus group: Sal Vieja viirus, San Perlita virus Tentative

species: Rocio, Spondweni, Wesselsbron
Tick-borne encephalitis virus group: *Hanzalova, Absettarov, Hypr, Kumlinge, Louping Ill, Negishi, Powassan*

-- *Orthomyxoviridae*
-- *Influenza virus type* A, B and C except Influenza A, H5N1
-- other *tick-borne orthomyxovirus* such as *Dhori* and *Thogoto*

-- *Papillomaviridae*
Genus: Papillomavirus
All Human *papilloma* viruses

-- Paramyxoviridae
Genus: *Paramyxovirus*
-- all isolates including Human *parainfluenza* viruses types 1, 2, 3 and 4, and *Newcastle* disease virus
Genus: *Pneumovirus*
-- all isolates including Respiratory Syncytial virus
Genus: *Morbillivirus*
-- all isolates including measles virus
Genus: *Rubulavirus*
-- *Mumps* virus
Genus: *Metapneumovirus*
-- Human metapneumovirus

-- *Parvoviridae*
Genus: *Parvovirus*
-- all isolates including Human *parvovirus (B19)*

-- *Picornaviridae*
Genus: *Aphthovirus*
Genus: *Cardiovirus*
Genus: *Enterovirus*
-- *Coxsackie virus* types A and B
-- *Echoviruses*
-- Polioviruses
-- *Enterovirus serotypes* 68 – 71 Genus:
Rhinoviruses
Genus: *Hepatovirus*
-- *Hepatitis A*

-- *Polyomaviridae*
-- all isolates including *BK* and *JC viruses*, *Simian virus 40 (SV 40)*

-- *Poxviridae*
-- all type, except *Monkeypox virus* and restricted *poksvirus such as Alastrim, Smallpox,* and *Whitepox (see Risk Group 3 and 4);* includes viruses:
-- *Buffalopox, Cowpox,* nodule *Milker's, Molluscum contagiosum, Orf, Vaccinia, Yabapox* and *Tanapox*.

-- *Reoviridae*
Genus: *Coltivirus*
-- all type including *Colorado* tick fever virus Genus:

Rotavirus
-- all Human *rotaviruses*
Genus: all isolates of *Orthoreovirus* and *Orbivirus*

-- *Rhabdoviridae*
Genus: *Lyssavirus*
-- *Rabies* virus "fixed" virus / vaccine strains)
Genus: *Vesiculovirus*
-- *stomatitis Vesicular* virus – laboratory adapted strains including VSV-Indiana, San Juan and Glasgow, Piry, Chandipura

-- *Togaviridae*
Genus: *Alphavirus* - Group A arboviruses
-- *Bebaru*, *Barmah forest* virus, *Chikungunya, O'nyong-nyong, Ross river* virus, *Semliki forest* virus, Sindbis, Venezuelan equine encephalomelitis vaccine strains TC-83 only.
Genus: *Rubivirus*
-- *Rubella virus*

Risk Group 3

-- *Arenaviridae*
-- *Flexal, Mopeia*
-- Lymphocytic coriomeningitis virus (LCM) (neurotropic strains)

-- *Bunyaviridae*
Genus: *Hantaviruses*
-- *Hantaan* virus (*Korean haemorrhagic fever*), *Seoul*, *Sin Nombre virus*, *Belgrade, Puumala* and unclassified Bunyaviruses
Genus: *Nairovirus*
-- *Bhanja*
Genus: *Phlebovirus*
-- *Rift Valley* fever virus

-- *Coronaviridae*
-- *SARS* Coronavirus

-- *Paramyxoviruses*
Genus: *Henipah*
-- *Hendra* (Equine *morbillivirus*), *Nipah* virus, *Nipah-like* viruse

-- *Orthomyxoviridae*
-- Influenza A, H5N1.

-- *Poxviridae*
-- *Monkeypox virus*

-- *Prions*
-- Transmissible *spongioform encephalopathies* (TME) agents: *Bovine spongioform encephalopathy* (BSE), *Creutzfeldt-Jacob disease* (CJD), Variant *Creutzfeldt-Jacob* disease, *Fatal familial* insomnia, *Gerstmann- Straussler-Scheinker syndrome* and *Kuru*

-- *Togaviridae* – Group A a*rboviruses* Genus:
Alphavirus

-- Semliki Forest virus, Getah, Mayaro, Middleburg, Ndumu
-- Eastern equine encephalomyelitis, *Western equine encephalomyelitis*, Venezuelan equine encephalomyelitis virus (except the vaccine strains TC-83), *Sagiyama, Tonate, Mucambo*

-- *Retroviridae*
- -- Human *immunodeficiency* virus (HIV) types 1 and 2
- -- Human *T cell lymphotropic* virus (HTLV and 2))
- -- *Simian immunodeficiency* virus (SIV)

-- *Rhabdoviridae*
- -- *Rabies virus* (virus *Street*)

-- *Unclassified viruses*
- -- Chronic infectious neuropathic agents (CHINAs)

Risk Group 4

-- *Arenaviridae*
Genus: *Arenaviruses*
- -- *Lassa, Guanarito, Junin, Machupo* and *Sabia*

-- *Bunyaviruidae*
Genus: *Nairovirus*
- -- *Crimean-Congo hemorrhagicafever virus*

-- *Filoviridae*
- -- all *Ebola* virus and *Marburg* virus

-- *Flaviridae* (*Togaviruses*) – Group B arbovirus
- -- *Tick-borne encephalitis virus complex including Central European encephalitis, Kyasanur Forest disease, Omsk hemorrhagic fever, and Russian spring-summer encephalitis viruses*

-- *Herpesviruses* (*alpha*)
- -- *Herpesvirus simiae* (*Herpes B* or *Monkey B* virus)

-- *Poxviridae*
- --*Variola major, variola minor, whitepox, alastrim (*Importation of organisms including *alastrim, smallpox (variola)* and *whitepox is strictlt prohibited).* All activities, including storage *variola* and *whitepox*, are ristricted to a single facility *(World Health Organization Collaborating Center for Smallpox Research, Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America).*

-- *Hemorrhagic fever agents and viruses as yet undefined.*

PARASITE

Risk Group 2

-- *Acanthamoeba spp*
-- *Ancylostoma* human hookworms including:
  -- *Ancylostoma duodenale, Ancylostoma. ceylanicum*
-- *Angiostrongylus spp.*
-- *Anisakis simplex*
-- *Ascaris spp.* including*:*
  -- *Ascaris lumbricoides, Ascaris suum*
-- *Babesia spp.* including:
  -- *Babesia divergens, Babesia microti*
-- *Balantidium coli*
-- *Blastocystis hominis*
-- *Brugia filaria* worms including:
  -- *Brugia malayi, Brugia timori*
-- *Capillaria spp.*
-- *Coccidia*
-- *Contracaecum osculatum*
-- *Cryptosporidium spp*. including:
  -- *Cryptosporidium parvum*
-- *Cyclospora spp* including:
  -- *Cyclospora cayetanensis*
-- *Cysticercus cellulosae* (hydatid cyst, larva of *Taenia solium*)
-- *Dicrocoelium dendriticum*
-- *Dientamoeba fragilis*
-- *Dracunculus medinensis*
-- *Entamoeba histolytica*
-- *Enterobius vermicularis*
-- *Enterocytozoon bieneusi*
-- *Fasciola gigantica*
-- *Fasciola hepatica,*
-- *Fasciolopsis buski*
-- *Giardia spp*. including:
  -- *Giardia lamblia (Giardia intestinalis)*
-- *Heterophyes spp.*
-- *Hymenolepis diminuta*
-- *Hymenolepis nana*
-- *Isospora belli*
-- *Leishmania* spp. (mammalian) except *Leishmania braziliensis* dan *Leishmania donovani* (see Risk Group 3) including species:
  -- *Leishmania ethiopia, Leishmania major, Leishmania mexicana, Leishmania peruvania, Leishmania tropica*
-- *Loa loa* filaria worms
-- *Mansonella spp*. such as
  -- *Mansonella ozzardi, Mansonella perstans, Mansonella streptocerca*
-- *Metagonimus spp.*
-- *Microsporidium spp.*
-- *Naegleria spp.* except *Naegleria fowleri,* (see Risk Group 3)
-- *Necator* human hookworms including:
  -- *Necator. americanus*
-- *Onchocerca* filaria worms including, *Onchocerca volvulus*
-- *Opisthorchis felineus*
-- *Opisthorchis sinensis (Clonorchis sinensis)*

-- *Opisthorchis viverrini (Clonorchis viverrini)*
-- *Paragonimus spp* including:
    -- *Paragonimus westermani*
-- *Plasmodium spp*. (human and simian) including:
    -- *Plasmodium cynomologi, Plasmodium falciparum, Plasmodium malariae, Plasmodium ovale, Plasmodium vivax*
-- *Sarcocystis suihominis*
-- *Schistosoma spp*. including:
    -- *Schistosoma haematobium, Schistosoma intercalatum, Schistosoma japonicum, Schistosoma mansoni, Schistosoma mekongi*
-- *Strongyloides spp*. including:
    -- *Strongyloides stercoralis*
-- *Taenia saginata*
-- *Taenia solium*
-- *Toxocara spp*. including:
    -- *Toxocara canis*
-- *Toxoplasma spp*. including:
    -- *Toxoplasma gondii*
-- *Trichinella nativa*
-- *Trichinella nelsoni*
-- *Trichinella pseudospiralis*
-- *Trichinella spiralis*
-- *Trichomonas vaginalis*
-- *Trichostrongylus spp*. including, *Trichostrongylus orientalis*
-- *Trichuris trichiura*
-- *Trypanosoma brucei sub-spp.* except *Trypanosoma brucei rhodesiense* and *Trypanosoma cruzi* (see Risk Group 3) including *Trypanosoma brucei gambiense*
-- *Wuchereria bancrofti* filaria worms

Risk Group 3

-- *Echinococcus spp.* such as:
    -- *Echinococcus granulosis, Echinococcus multilocularis, Echinococcus vogeli*
-- *Leishmania braziliensis,*
-- *Leishmania donovani*
-- *Naegleria fowleri*
-- *Trypanosoma brucei rhodesiense*
-- *Trypanosoma cruzi*

Risk Group 4

NONE

FUNGI

Risk Group 2

-- *Asperigillus fumigatus*
-- *Asperigillus flavus*
-- *Candida albicans*
-- *Candida tropicalis*
-- *Cryptococcus neoformans var neoformans (Filobasidiella neoformans var neoformans)*
-- *Cryptococcus neoformans var gattii (Filobasidiella bacillispora)*
-- *Dactylaria galopava (Ochroconis gallopavum)*
-- *Emmonsia parva var parva*
-- *Emmonsia parva var crescens*
-- *Epidermophyton spp*. Including:
    -- *Epidermophyton floccosum*
-- *Exophiala (Wangiella) dermatitidis*
-- *Fonsecaea compacta*
-- *Fonsecaea pedrosoi*
-- *Madurella grisea*
-- *Madurella mycetomatis*
-- *Microsporum spp*
-- *Neotestudina rosatii*
-- *Penicillium marneffei*
-- *Scedosporium apiospermum (Pseudallescheria boydii)*
-- *Scedosporium proliferans (inflatum)*
-- *Sporothrix schenckii*
-- *Trichophyton spp.* including:
    -- *Trichophyton rubrum*

Risk Group 3

-- *Blastomyces dermatitidis (Ajellomyces dermatitidis)*
-- *Cladophialophora bantiana (Cladosporium bantianum, Xylohypha bantiana)*
-- *Cladosporium trichoides*
-- *Coccidioides immitis*
-- *Histoplasma capsulatum spp.* including:
    -- *Histoplasma capsulatum var capsulatum*
    -- *Histoplasma capsulatum var farcinimosum*
    -- *Histoplasma. capsulatum var. duboisii*
- -*Paracoccidioides braziliensis*

Risk Group 4

NONE

Guideline on Completing Biological Risk Assessment

PIs must conduct risk assessment (Biological Risk Assessment Form, UM/IBBC/ANNEX 1) in relation to the activity proposed to be carried out and putting in place the appropriate measures. The biological risk assessment should be communicate to the personnel involved to the hazards of working with infectious agents and to the need for developing proficiency in the use of selected safe practices and containment equipment.

To conduct the laboratory/work activity based risk assessment shall consist of the following elements:-

1) Prepare all information necessary for risk assessment (eg: Pathogen safety data sheet, process flow chart, operation manual, accident records, etc)
2) Identify the personnel involve in the project (risk assessment team(s)) and describe each respective roles or job duties
3) Open an electronic copy of **Biological Risk Assessment Form - UM/IBBC/ANNEX 1** and complete the details of at the top of worksheet.

WORK INVENTORY FORM			
Complete address where work will be performed: **(Specify the Bldg BLOCK & FLOOR)**	*Eg: Research Laboratory 1* *Department of Medical Microbiology* *Faculty of Medicine* *University of Malaya*	**IBBC registration no:**	**Eg:** UMIBBC/NOI/D/XXXX/XXX-004/2017
		Name of PI:	Name of the lead scientist who takes direct responsibility for the technical and/or scientific direction of a project, the relevant course coordinator and service laboratory director
Project Name:	*Eg: Dengue Serology Testing*	**Conducted By:** **Date:**	Name of personnel who is responbonsible in conducting the risk assessment
Name of Biological Agent:	*Ex: Dengue Virus*	**Reviewed and Approved By:** **Date:**	Name of person who reviewed and approved the risk assessment. Date of approvel.

EXAMPLE:

4) Register the work processes or experiments and a listing of work activities (from beginning to end point for each process) with information on hazardous materials used and the location where the activity is performed. Prioritize the most critical process and activities involved in the experiment.

UM/IBBC/ANNEX 1

BIOLOGICAL RISK ASSESSMENT FORM

No	Work Process	Act No	Work Activities
1.	Receiving suspected blood sample and blood sample preparation for diagnostic testing	1.1	Receiving blood sample tubes (in secondary or outer container) sent from blood collection clinic , etc
		1.2	Register the samples
		1.3	Transferring blood sample tubes out from the external parcel/box/container for processing.

EXAMPLE:

5) Hazard Identification
   a. Identify what hazards, in addition to biological, are associated with each work activity.
   b. Enter the hazard in column 2 (activities), second page of the Risk Assessment worksheet.

6) Risk Evaluation
   a. Upon identifying the hazard(s), state the possible corresponding outcome related to human (injury, death/ ill-health) contribute by the hazards, column 3.
   b. Consider any current/existing controls measures in related to the work activity, record this in column 5 **(Likelihood score – Existing Risk Control)**

c. Refer to classification table for scoring severity (table 1) and scoring likelihood (table 2).
    - Assessing the severity rating that relates to how severe is the possible injury, death/ ill-health
    - Determine the likelihood occurrence arising from identified hazard(s) by considering the existing controls
d. Record the value for the severity in column 4 and likelihood in column 6. Estimate the risk levels of the activity in related to the hazards identified. Risk level are deduced from risk scoring of severity and likelihood (severity x likelihood). Use the 5 X 5 risk matrix (table 3) below as a guide to assess the level.
e. Determine the acceptable level of the risk acceptability of risk)

Table 2: Scoring

Score	Impact to human	Impact to community	Impact to environment
1 (Insignificant) Negligible	Not likely to cause harm or injury	Does not lead to disease in human or animal	No impact to environment
2 (Minor) Slight	Injury of ill-health requiring 1st aid treatment only. Discomfort is temporary and reversible	May infect lab worker but is not serious. Not community risk	No impact to environment
3 (Moderate)	Injury require medical treatment	May infect lab worker but not infectious or May spread but prophylaxis is available e.g: normal flu	May have impact that take weeks to reverse
4 (Major) High	Serious injury or long term life threatening occupational disease (e.g: cancer)	High risk of spreading to community but affective prophylaxis or treatment is available.	Great impact to environment and may take years to reverse
5 (Catastrophic) Very high	Fatality disease or injury	Readily infect lab worker and transmittable to human or animal. No effective treatment is available	Irreversible e.g:

Table 2: Scoring Likelihood

LEVEL	DESCRIPTON	LIKELIHOOD – DESCRIPTION
1	Remote (very unlikely)	Never happen in a lifetime due to robust existing control and no risk
2	Unlikely	May occur at some time
3	Possible	Possible or known to occur
4	Likely (Frequent)	Will probably occur in most circumstances or at constant interval
5	Most likely (very frequent)	Is expected to occur in most circumstances

Table 3: 5 X 5 Risk

LIKELIHOOD	SEVERITY(S)				
	1	2	3	4	5
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

EXAMPLE:

Laboratory:	**Laboratory 1, Diagnostic Virology Laboratory**	**Conducted By:** **Date:**	
Work Process:	**Receiving suspected blood sample and blood sample preparation for diagnostic testing**	**Reviewed and Approved By:** **Date:**	

Act No	Hazard/Threat Identification	Risk Evaluation						Risk Control & Mitigation						
		Severity Score		Likelihood Score		Risk Level Score (S x L)								
	Activities	Possible Injury/ ill-Health	(S)	Existing Risk Control (if any)	(L)		Proposed Risk Controls	(S)	(L)	Final Risk Level Score (S x L)	Person-in-Charge	Due Date	Remarks
1.1	Receiving blood sample tubes (in secondary or outer container) Register the samples	Exposure to contaminated tubes surface or container	4	PPE (lab coat) when receiving opening container	1	4							
1.2	Register the samples	Incorrect sample ID & Information	3	Bar Code Inventory system	1	3							
1.3	Transferring blood sample tubes out from the external parcel/box/container for processing. Collecting the blood from patients **Discovered** (a) Breakage of blood tube => sharp injury (percutaneous) => direct contact with blood sample	- Sharp injury and blood borne infection (Dengue or others	4	PPE (lab coat) when receiving opening container	3	12							

7) Determine if the risks are acceptable

  a. Based on the risk level, the risk assessor, team, working with management and other stakeholders, should determine if the assessed risk is acceptable to the facility, laboratory, individuals working in the facility, and the community (refer table 4 Acceptability of risk) .

  b. For a risk that is determined to be unacceptable, risk control must be put in place and to determine which mitigation measures are appropriate

  c. Control measures are derived from the hierarchy of control measures below:
     - Elimination
     - Substitution
     - Engineering controls
     - Administrative controls
     - Standard Operating Procedure (SOP)
     - Personal protective equipment (PPE)

  d. An effective and practicable risk controls must be implemented to reduce risk to **Reasonably Acceptable Level.**

Table 4: Acceptability of Risk

RISK	DESCRIPTION	RISK ACCEPTABILITY	RECOMMENDED ACTION
15 - 25	**HIGH RISK**	**Not Aceptable**	A **HIGH** risk requires immediate action to control the hazard as detailed in the hierarchy of control. Actions taken must be documented on the risk assessment form including date for completion. Work shall not start.
5 - 12	**MEDIUM RISK**	**Tolerable**	A **MEDIUM** risk requires a planned approach to control the hazard interim control measures may be implemented while longer term measures are being establish and to ensure that the risk level is reduce to as low as reasonably practicable within a define period. It is acceptable to start the work activities and actions taken must be documented on the risk assessment form including date for completion.
1 - 4	**LOW RISK**	**Acceptable**	A risk identified as **LOW** may be considered as acceptable and further reduction may not be necessary. However, if the risk can be resolved quickly and efficiently, control measures should be implemented and recorded.

8) Estimate the reduction in severity (enter in column 9) and likelihood (enter in column 10) provided by the control(s). Determine the final risk level score (column 11).
9) Identify a person that will be responsible to implement the controls and enter the name at column 12 and estimate the due date of the controls to be implemented.
10) Completed work activity risk assessments must be reviewed and approved by PI and be reviewed
    a. once every two years, or;
    b. upon occurrence of accidents, near misses, dangerous acts, or;
    c. when there are changes in work processes, technologies or workplace condition / layout,
11) On completion of the form, the original form must be submitted to IBBC secretariat for the NOI submission. A copy of the complete document is placed in the file and should be clearly identifiable and accessible to the users.
12) The risk assessment should be fully and systematically documented and communicated to the laboratory personnel. Understanding any limitations that influenced a risk assessment is essential for transparency of the process that is important in decision making. The formal document and record should indicate any constraints, uncertainties, and assumptions and their impact on the risk assessment.

Refer to sample template for work activity risk assessment for laboratory handling biological material

ANNEX C TO
UM LSG

Autoclave Use Log

No.	Date	Time	Name	Signature	Remarks

AUTOCLAVE JOB SAFETY ANALYSIS SHEET

AUTOCLAVE				
JOB SAFETY ANALYSIS				
Name				
Matrix No.			**Date**	
Subject			**Subject Code**	
Lecturer				
No.	**Job steps**	**Hazards**	**Harm**	**Risk Controls**
1.				
2.				
3.				
4.				
5.				
6.				

No.	Scenario	Hazards	Harm	Risk Controls
7.				
8.				
9.				
10.				

Declaration

Hereby, I ……………………………………… have attended the training on the use of autoclave equipment with the person in charge/ lab supervisor, ………………………………………….. on ………………… . I have also completed the Job Safety Analysis sheet and submitted on time prior to the usage of the equipment. I have read, understand and will follow the safety work procedures according to the Laboratory Safety Guidelines for Autoclave.

Checked and supervised by,

……………………………..
Name :
Date :

……………………………..
Name :
Date :

ANNEX E TO UM LSG

AUTOCLAVE MAINTENANCE LOG

No.	Date	Maintenance Remarks	Technician's Name	Signature	Checked

ANNEX F TO
UM LSG

BOILER USE LOG

No.	Date	Name	Time In	Time Out	Signature

ANNEX G TO
UM LSG

BOILER MAINTENANCE LOG

No.	Date	Maintenance Remarks	Technician's Name	Signature	Checked

ANNEX H TO UM LSG

BOILER IMPLEMENTATION OF TOOLS RECORD

Tagging No. :
Name of Equipment :
Location :
Supplier :
Bought on :
Purpose of Equipment :

Please tick (/) and write the date of newly implementer or serviced tools of boiler in the ledger below.

Monthly Implementation							
1.							
2.							
3.							
4.							
5.							
Annual Implementation							
1.							
2.							
3.							
4.							
5.							
Implementation / Services							
1.							
2.							
3.							
4.							
5.							

CENTRIFUGE JOB SAFETY ANALYSIS SHEET

CENTRIFUGE				
JOB SAFETY ANALYSIS				
Name				
Matrix No.			**Date**	
Subject			**Subject Code**	
Lecturer				
No.	**Job steps**	**Hazards**	**Harm**	**Risk Controls**
1.				
2.				
3.				
4.				
5.				
6.				

No.	Scenario	Hazards	Harm	Risk Controls
7.				
8.				
9.				
10.				

Declaration

Hereby, I……………………… have attended the training on the use of centrifuge equipment with the person in charge/ lab supervisor, ………………………………………….. on ………………… . I have also completed the Job Safety Analysis sheet and submitted on time prior to the usage of the equipment. I have read, understand and will follow the safety work procedures according to the Laboratory Safety Guidelines for Centrifuge.

Checked and supervised by,

……………………………..
Name :
Date :

……………………………..
Name :
Date :

ANNEX J TO UM LSG

CENTRIFUGE USE LOG

No.	Date	Time	Name	Signature	Lab Supervisor's Signature

CENTRIFUGE MAINTENANCE LOG

No.	Date	Maintenance Remarks	Technician's Name	Signature	Checked

EXAMPLES OF PERSONAL PROTECTION EQUIPMENT (PPE)

Equipments	Descriptions
Fire extinguisher 	This tool should be ensured to be in good condition and not expired. It should be placed in a conspicuous place and labelled properly.
First-aid kits 	First-aid kit should be located at the place that is easily accessible. It should at least contain the following items : i. Triangular bandages ii. Sterile gauze pads iii. Elastic bandage iv. Pairs of gloves (disposable/non sterile) v. Stainless steel bandage scissors vi. Adhesive tape vii. Alcohol prep pads viii. Antiseptic liquid ix. Wound Plaster x. Safety pins for triangular bandages xi. Tweezers xii. Cotton buds xiii. Inventory of box contents
Safety boots  	Safety boots must be appropriate to the needs of the physical properties of chemical.

Laboratory coat 	Laboratory coat must be appropriate to the needs of the physical properties of chemical.
Sawdusts   Saw dusts should be placed in appropriate containers	This material should be provided in quantities appropriate to the type of chemicals in the laboratory. This is to control spillage in the event of chemical spills.

Rubber gloves  	Rubber gloves must be appropriate to the needs of the physical properties of chemical.
Safety mask  	Safety mask must be appropriate to the need of the physical properties of chemical.
Safety goggles 	Safety goggles must be appropriate to the needs of the physical properties of chemical.
Shovels 	Shovel is used to collect chemical wastes during a chemical spillage and have to ensure is provided in the laboratory.

Compatibility Chart for Chemical Mixtures

Reactivity Group No.	Reactivity Group Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106
1	Acids, Mineral, Non-oxidizing	1																																							
2	Acids, Mineral, Oxidizing		2																																						
3	Acids, Organic		G, H	3																																					
4	Achohol and Glycols	H	H, F	H,P	4																																				
5	Aldehydes	H, P	H, F	H, P		5																																			
6	Amides	H	H, GT				6																																		
7	Amines, Aliphatic and Aromatic	H	H, GT	H		H		7																																	
8	Azo compounds, Diazo compounds and Hydrazines	H, G	H, GT	H, G	H, G	H			8																																
9	Carbamates	H, G	H, GT						G, H	9																															
10	Caustics	H	H	H		H				H, G	10																														
11	Cyanides	GT, GF	GT, GF	GT, GF					G			11																													
12	Dithiocarbamates	H, GF, F	H, GF, F	H, GF,		GF, GT		U	H, G				12																												
13	Esters	H	H, F						H, G		H			13																											
14	Ethers	H	H, F												14																										
15	Fluorides, Inorganic	GT	GT	GT												15																									
16	Hydrocarbons, Aromatic		H, F														16																								
17	Halogenated Organics	H, GT	H, GT, P					H, GT	H, G		H, GF	H						17																							
18	Isocyanates	H, G	H, GT, P	H, G	H, P			H, P	H, G		H, P, G	H, G	U						18																						
19	Ketones	H	H, F						H, G		H	H								19																					
20	Mercaptans and other Organic Sulfides	GF, GT	H, GT, F						H, G									H	H	H	20																				
21	Metals, Alkali and Alkaline Earth Elemental	GF, H, F	GF, H, F	GF, H, F	GF, H, F	GF, H, F	GF, H	GF, H	GF, H	GF, H	GF, H	GF, H	GF, GT, H	GF, H								21																			
22	Metals, other Elemental Alloys as powders, vapors or sponges	GF, H, F	GF, H, F	GF					GT, H, F	U	GF, H							H, E	GF, H		GF, H, F		22																		
23	Metals, other Elemental Alloys as sheets, rods, moldings, etc.	GF, H, F	GF, H, F						H, F, G									H, F						23																	
24	Metals and Metal compounds, Toxic	S	S	S			S	S			S														24																
25	Nitrides	GF, H, F	H, F, E	GF, H	GF, H, E	GF, H			U	H, G	U	GF, H	GF, H	GF, H				GF, H	U	GF, H	GF, H	E				25															
26	Nitriles	H, GT	GT, H, F	H							U											H, P			S	GF, H	26														
27	Nitro compounds, Organic		GT, H, F			H					H, E											GF, H, E				GF, H, E		27													
28	Hydrocarbons, Aliphatic, Unsaturated	H	H, F			H																	H, E						28												
29	Hydrocarbons, Aliphatic, Saturated		H, F																											29											
30	Peroxides and Hydroperoxides, Organic	H, G	H, E		H, F	H, G		GT, H	H, F, E	GT, H, F		GT, H, E	GT, H, E					H, E	H	GT, H, F	H, E	H, G	H, G		H, G	GF, H, E	GT, H, P		H, P		30										
31	Phenols and Cresols	H	H, F						H, G										H, P			GF, H				GH, H					H	31									
32	Organophosphates, Phosphothioates, Phosphodithioates	GT, H	GT, H						U		H, E											H									U		32								
33	Sulfides, Inorganic	GT, GF	GT, H, F	GT		H			E										H												GT, H			33							
34	Epoxides	H, P	H, P	H, P	H, P	U		H, P	H, P		H, P	H, P	U								H, P	H, P	H, P		H, P	H, P					H, P	H, P	U	H, P	34						
101	Combustible and Flammable materials, Miscellaneous	H, G	GT, H, F																				H, G, F			GF, H, F					GT, H, F					101					
102	Explosives	H, E	H, E	H, E					H, E		H, E			H, E								H, E	H, E	H, E	E	E					H, E	H, E		H, E	H, E	H., E	102				
103	Polymerizable compounds	P, H	P, H	P, H					P, H		P, H	P, H	U									P, H	P, H	P, H	P, H	P, H					P, H	P, H		P, H			H, E	103			
104	Oxidizing Agents, strong	GT, H		GT, H	H, F	H, F	GT, H, F	GT, H, F	H, E	GT, H, F		GT, H, F	GT, H, F	H, F	H, F		H, F	GT, H	GT, H, F	H, F	GT, H, F	H, F, E	H, F, E	H, F		H, F, E	GT, H, F	H, E	H, F	H, F	H, G	H, F	GT, H, F	GT, H, F	H, G, F	H, G, F	H, E	GT, H, F	104		
105	Reducing Agents, strong	GF, H	GT, H, F	GF, H	GF, H, F	GF, H, F	GF, H	GF, H	GF, H				GT, H	H, F				H, E	GF, H	GF, H	GF, H						GF, H	H, E			H, E	GF, H	GF, GT		H	GF, H	H, E	GF, H, P	H, F, E	105	
106	Water and mixtures containing water	H	H						G										H, G			GF,	GF,		S	GF,								GF, GT						GF, GT	106

Reactivity code	Consequence
H	Heat generation
F	Fire
G	Innocous non-flammable gas generation
GT	Toxic gas generation
GF	Flammable gas generation
E	Explosion
P	Violent polymerization
S	Solubilazation toxic substance
U	Maybe hazardous but unknown

Example	
H, F, GT	Heat generation, fire and toxic gas generation

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107
																						H	H			H																
107	Water reactive substances	E	X	T	R	E	M	E	L	Y		R	E	A	C	T	I	V	E		D	O		N	O	T		M	I	X	!	!	!									107
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107

NOTES:

1. Source from EPA-600/2-80-076, April 1980. A method determining the compatibility of chemical mixtures.
2. This chart can be used to identify hazards that can be expected when chemical wastes are mixed.
3. This list is not an exhaustive list as there are different activities of the thousands of compounds that may be encountered.
4. Any blanks that appear in the chart does not mean that the mixture cannot result in a hazard occurring.
5. Detailed information on hazards involved in handling and disposing of any given waste should be obtained from the waste generator

SCHEDULED WASTES OF POTENTIAL INCOMPATIBILITY

The mixing of a waste in Group A with a waste in Group B may have the following potential consequences:

Group 1-A	*Group 1-B*
Alkaline caustic liquids Alkaline cleaner Alkaline corrosive liquid Caustic wastewater and other corrosive alkalies	Acid sludge Chemical cleaners Electrolyte, acid Etching acid, liquid or solvent Lime sludge Pickling liquor and other corrosive acid Spent acid Spent mixed acid

Potential consequences: Heat generation, violent reaction

Group 2-A	*Group 2-B*
Asbestos Berryllium Unrinsed pesticide containers Pesticides	Solvents Explosives Petroleum Oil and other flammable wastes

Potential consequences: Release of toxic substances in case of fire or explosion

Group 3-A	*Group 3-B*
Aluminium Berryllium Calcium Lithium Magnesium Potassium Sodium Zinc powder and other reactive metals and metal hydrides	Any waste in Group 1-A or 1-B

Potential consequences: Fire or explosion; generation of flammable hydrogen gas

Group 4-A	*Group 4-B*
Alcohols	Any concentrated waste in Group 1-A or 1-B Calcium Lithium Metal hydrides Potassium Sodium Water reactive wastes

Potential consequences: Fire, explosion or heat generation; generation of flammable toxic gases

Group 5-A	*Group 5-B*
Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons and other reactive organic compounds and solvents Unsaturated hydrocarbons	Concentrated Group 1-A or 1-B wastes Group 3-A wastes

Potential consequences: Fire, explosion or violent reaction

Group 6-A	*Group 6-B*
Spent cyanide and sulphide solution	Group 1-B wastes

Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulphide gas.

Group 7-A	*Group 7-B*
Chlorates and other strong oxidizers Chlorites Chromic acid Hypochlorites Nitrates Nitric acid Perchlorates Permanganates Peroxides	Organic acids Group 2-B wastes Group 3-B wastes Group 5-A wastes and other flammable and combustible wastes

Potential consequences: Fire, explosion or violent reaction

ANNEX O TO UM LSG

FIFTH SCHEDULE

(Regulation 11)
ENVIRONMENTAL QUALITY ACT 1974

ENVIRONMENTAL QUALITY (SCHEDULED WASTES) REGULATION 2005

INVENTORY OF SCHEDULED WASTES AS AT: ....

* Date	* Waste Category Code	* Name of Waste	* Quantity Generated (Metric Tonnes)	*Waste Handling		
				Method[b]	Quantity in Metric Tonnes	Place[c]

Note:
* Inventory of the current generation of scheduled wastes

a. Date when the scheduled wastes are first generated
b. Stored, processed, recovered for materials or product from such scheduled wastes, incinerated, exchanged or other methods (specify)
c. Give name and address of the facility

I hereby declare that all information given in this form is to the best of my knowledge and belief true and correct in all respect.

Name of Reporting Officer: ....
Designation: ....
Signature: .... Date: ....
I.C. Number: ....

ANNEX P TO
UM LSG

FIRST AID BOX MAINTENANCE FORM

Date:
Location:

No.	Content	Total	Date Used	Date Expired	Current Total
	EXAMPLE				
1.	*Triangular bandage*	*5*	*1/10/2017*		*4*

Prepared by
Name: **Stamp & Position:**

B.

SOP FOR CHEMICALS

SOP 1: CHEMICAL SPILL

STANDARD OPERATING PROCEDURE

UNIVERSITY OF MALAYA

CHEMICAL SPILL

TYPE OF SOP:

Process ■ Hazardous chemicals ☐ Hazard Class ☐

1. HAZARD OVERVIEW

A chemical spill in the laboratory can be something which is minor and can be easily contained, or a serious incident in the form of a major spill. The latter pose high hazard risk to the laboratory workers and the environment, and often requires the help of experts/experienced personnel.

Prompt response by laboratory personnel is important to limit the consequences of a chemical spill. Certain chemicals found in the laboratory can be dangerous or hazardous when spilled. Review the SDS of the chemicals to understand the properties of the spilled substance, especially its hazardous property, and put on the necessary protective gears before one attempts to clean it up.

2. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Refer to main section on PPE in the safety handbook

3. ENGINEERING/VENTILATION CONTROLS

For indoor chemical spill, if one decides to clean up the spill, make sure the room where the chemical spill happened is well ventilated to prevent saturation of chemical vapour and displacement of O_2 in the room.

4. SUPPLIES

Emergency spill kit set comprising basic PPEs and different types of absorbent for different types of spill. Specifically:

- Safety goggles
- Hand gloves
- Absorbent materials (sponges, pads)
- Vermiculite (to absorb organic materials)
- Acid neutraliser
- Base neutraliser
- pH paper
- Plastic container for waste materials
- Plastic scraper to transfer waste into container
- Warning signs and barriers

5. INCIDENT PROCEDURES

Assess the scale of the spill and extent of danger. If it is within your means, help contaminated or injured persons to evacuate the spill area. Keep others from entering contaminated area. Course of action depends on:

a. Size of chemical spill

i. Minor spill (10 mL up to 1 L)

- Inform laboratory principal investigator immediately. If personnel are trained to handle the situation and the assessed risk done based on the SDS of the chemical spilled is not greater than normal laboratory operation, put on the appropriate personal protective equipment, and cover the spill with suitable spill absorbent. Make sure the room is well ventilated to avoid displacement of O_2 in confined space
- When the reaction stops/neutralises (if relevant), clean the area thoroughly using sponge, towels and/or scraper, and transfer the waste into a labelled container.
- Any contaminated equipment and clothing should be thoroughly cleansed on site.
- Inform PTj safety committee and file incident report.
- *NOTE: In the event a chemical spill causes injury and requires external intervention such as medical assistance and/or others, such incidents should be treated as major spill regardless of the volume.*

ii. Major spill (> 1L)

- Inform laboratory principal investigator, head of PTj and PTj safety committee immediately. PTj assess the situation and determine the next course of action. If spill containment is beyond the ability of PTj personnel, inform OSHE UM at 03-7967 7925, and contact 999 or Fire and Rescue department at +603-8892 7600 for assistance
- Switch off ignition sources in the area, if there is any.
- If there is any victim in the incident, isolate the contaminated individuals and treat as per SDS.
- Notify others who are in the close vicinity to evacuate the area.
- Close the doors and keep the area away from any non-emergency response personnel.
- You are encouraged to remain there, but stay at a safe distance, to receive and direct safety personnel when they arrive.

b. Type of Chemical Spill

- **Organic materials/solvent** – absorb spill using vermiculite or any suitable commercially available absorbent. Spent vermiculite or absorbent should be transferred into a labelled bag or container for waste disposal.
- **Acid spill** - neutralize acid spill with sodium carbonate or bicarbonate. Be careful of potential violent reaction especially if the spill is made up of concentrated acid. Since CO_2 (g) is produced during the neutralization, it is important to make sure the room is well ventilated to avoid displacement of O_2 in confined space.
- **Alkali spills** – preferably neutralize with weak acids such as boric acid, citric acids etc. Do not neutralize a strong base with strong acid as the reaction could be highly exothermic.
- **Mercury spill** should be addressed using special equipment such as mercury spill kit or mercury sponge. Once the mercury is contained it should be clearly labelled and submitted for waste disposal.

6. INCIDENT REPORTING

- For minor spill, incident should be recorded in laboratory incident log book, and laboratory principal investigator should be notified.
- For major spill, incident must be reported to principal investigator, department/faculty office, and OSHE UM. Incident should be recorded in laboratory incident log book as well.

7. DETAILED PROTOCOL

- Do not attempt to clean up chemical spill if you are not sure of the procedure. Get help from others or lab principal investigator.
- Read SDS, understand the risk hazards of the chemicals involved and take note of the precautionary measures.
- Always put up the required PPE when attempting to clean up chemical spill.

SOP 2: WORKING WITH ACID

UNIVERSITY OF MALAYA

STANDARD OPERATING PROCEDURE

WORKING WITH ACID

TYPE OF SOP:

Process ☐ Hazardous chemicals ☐ Hazard Class ■

1. HAZARD OVERVIEW

Acids are corrosive substances which can be in solids, liquids or gaseous state, and when in contact, it can cause severe damage to living tissues. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, in the gastrointestinal tract in the event of accidental ingestion.

Mixing water and acid – **Always add acid to water, and never the opposite**
Acid dilution is an exothermic process where heat is generated when strong acids mix with water.
Addition of water to acid results with formation of an extremely concentrated solution of acid initially, and this generates a huge amount of heat which is usually high enough to boil the solution violently, resulting in splashing of the corrosive solution.
On the contrary, if acid is added to water, the solution formed would be dilute and the heat generated is minimal, usually insufficient to boil the solution.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

This SOP is applicable to all acid solutions, both mineral and organic. Some examples of acids include:

Hydrochloric acid	Hydrobromic acid
Sulphuric acid	Nitric acid
Acetic acid	Formic acid

Concentrated acids are most likely to cause immediate pain when they come in contact with the body.
By itself, concentrated aqueous solutions of inorganic acids are inflammable. However, combustion can occur when acid is mixed with certain chemicals, especially with strong reducing agents or with certain combustible materials.
Acid is also known to react with many metals to produce highly flammable hydrogen gas.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Refer to section on PPE in the relevant Safety Data Sheet / safety handbook

4. ENGINEERING/VENTILATION CONTROLS

Whenever possible, acids should be handled and used in a certified laboratory chemical fume hood with the sash placed at a suitable position to protect the operator. Fume hood should be periodically inspected to ensure it is in good working condition.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Acids should only be used in laboratories, which are equipped with eye wash.
It is important to ensure that all strong corrosives are stored separately from incompatible chemicals such as bases and reducing agents. Further information and substance-specific storage guidance can be obtained in the safety data sheet (SDS) documentation of the chemical.
In view of the corrosive properties of these materials and the fire hazard risk that it poses, following considerations are applicable in the selection of a storage site and handling of acids:

- A relatively cool and dry environment free from extremes temperature
- Acids and bases should be stored separately and in a manner which is consistent with its properties.
- Acids should be stored in dedicated cabinet
- The use of bottle carriers (eg. Winchester bottle carrier or basket) when transporting materials is highly encouraged.
- To prepare/ dilute acid, always mix acid into water and never the reverse.

6. SPILL AND INCIDENT PROCEDURES

Assess the scale of the spill and extent of danger. If it is within your means, help contaminated or injured persons to evacuate the spill area. Keep others from entering contaminated area. Course of action depends on the size and type of acid spillage:

a. Minor spill (10mL up to 1 L)

- Inform laboratory principal investigator immediately. If personnel are trained to handle the situation and the assessed risk is not greater than normal laboratory operations, put on the appropriate personal protective equipment, and cover the spill with sodium carbonate, bicarbonate or with suitable absorbent (if available). Be careful of potential violent reaction especially if the spill involves concentrated acid. Make sure the room is well ventilated to avoid displacement of O_2 in confined space, especially when carbonate or bicarbonate is used to neutralize the spill.
- When reaction stop/neutralized, place all the waste in a labelled container and clean the area with damp sponge or paper towels. Arrange for chemical waste pick-up.
- Inform PTj safety committee and file incident report.
- *<u>NOTE:</u> In the event a chemical spill causes injury and requires external intervention such as medical assistance and/or others, such incident should be treated as major spill regardless of the volume.*

b. Major spill (> 1L)

- Inform laboratory principal investigator, head of PTj and PTj safety committee immediately. PTj assess the situation and determine the next course of action. If spill containment is beyond the ability of PTj personnel, inform OSHE UM at 03-7967 7925, and contact 999 or Fire and Rescue department at +603-8892 7600 for assistance
- Notify others who are in the close vicinity to evacuate the area.
- Close the doors and keep the area away from any non-emergency response personnel.
- You are encouraged to remain there, but stay at a safe distance, to receive and direct safety personnel when they arrive.

c. Chemical spill on body or clothes

- Quickly remove the clothing and rinse the body or affected skin with plenty of water in an emergency shower for ≥ 15 minutes.
- Notify principal investigator of the laboratory / lab supervisor, and inform the incident to the department/faculty main office, as well as OSHE UM at 03-7967 7925.
- Seek medical attention (provide SDS) if there are signs of burn blisters or tissue damage.

- If necessary, contact 999 or UMMC Ambulance Hotline at 03-7949 2500 for emergency medical assistance.

d. Chemical splash into eyes

- Immediately get help to rinse the eye with water at the emergency eyewash station for not less than 15 minutes. Note that it is going to be very painful, but you need to forcibly hold the eye open in order to properly rinse the eye and remove as much chemicals as possible.
- Notify principal investigator of the laboratory / lab supervisor, and inform the incident to the department/faculty main office, as well as OSHE UM at 03-7967 7925.
- Seek medical attention (bring SDS).
- If necessary, contact 999 or UMMC Ambulance Hotline at +603-79492500 for emergency medical assistance.

7. DECONTAMINATION

Equipment or bench contaminated with acid should be treated with sodium bicarbonate and water. Wear proper PPE during the decontamination procedure.
Any contaminated disposables should be disposed of as hazardous waste.

8. WASTE DISPOSAL

- Store hazardous waste in closed containers, preferably with secondary containment in a designated location.
- Waste containers have to be labelled using the appropriate Scheduled Waste labels issued by JPPHB, University of Malaya. Waste generator has to provide details of the waste; including the date when the waste is first generated, laboratory, location, name of waste generator, and preferably the main content of the waste.
- Acid waste must not be left accumulated in the lab for a long period of time and should be disposed routinely
- Do not discharge acids into the drains or environment.

9. SAFETY DATA SHEET (SDS)

SDS of every acid used must be made available and accessible all the time.

10. DETAILED PROTOCOL

- It is recommended not to work alone in the laboratory particularly after office hour
- Always put up the required PPE when handling acids
- Concentrated acids should be handled only in chemical fume hood
- When diluting acid, always pour acid into water and not the reverse
- Unless necessary, do not mix concentrated acids
- Unless it is absolutely necessary, do not mix concentrated acids directly with concentrated bases
- Examples of protocol to specific work process:

1. Preparation of 100 mL of 1M hydrochloric acid stock solution.

- Place the apparatus and chemicals needed in the fume hood.
- Wear required PPE (gloves, safety goggles, lab coats, closed shoes)
- Prepare a beaker filled with 90 mL of H_2O.
- Transfer 10 mL of concentrated HCl solution (36.5%) into the beaker.
- Mix the solution using magnetic stirrer or simply stirring with glass rod.
- Transfer solution to storage.

2. Adjust pH of acidic buffer solution.

- Place the apparatus and chemicals needed in the fume hood
- Wear required PPE (gloves, safety goggles, lab coats, closed shoes)
- Remove aliquots of base (eg. NaOH) from stock solution
- Add the stock solution to the buffer in dropwise manner until desired pH has been reached.

In the event of any unexpected occurrence such as fire, explosion, sudden change in temperature, sudden gas evolution, and/or colour changes when using acid solutions, the occurrence must be documented and discussed with the laboratory principal investigator or lab supervisor.

UNIVERSITY OF MALAYA

STANDARD OPERATING PROCEDURE

WORKING WITH BASE

TYPE OF SOP:

Process ☐ Hazardous chemicals ☐ Hazard Class ■

1. HAZARD OVERVIEW

Bases are corrosive substances which can be in solids, liquids or gaseous states, and when in contact, it can cause severe damage to living tissues. Corrosive effects can occur not only on the skin and eyes, but also in the respiratory tract and, and in the gastrointestinal tract in the event of accidental ingestion.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

This SOP is applicable to all base solutions and some examples of bases commonly used in laboratory include:

Sodium hydroxide	Ammonium hydroxide
Potassium hydroxide	Lithium hydroxide

Base is generally hazardous regardless of their physical state. Liquid corrosive can cause immediate pain and damage once it comes into contact with skin; hydrated solid base can cause serious damage to the eyes and skin by their corrosive action; fine dust from almost any solid base can cause severe damage to the eyes, upper respiratory tract, lungs, as well as skin irritation. Severity of injury depends on several factors such as the strength of the base, concentration, body parts contacted, as well as the speed and efficiency of emergency treatment given.

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Refer to main section on PPE in the safety handbook

4. ENGINEERING/VENTILATION CONTROLS

Bases, especially concentrated one should be handled in a certified laboratory chemical fume hood with the sash placed at a suitable position to protect the operator. Fume hood has to be periodically inspected to ensure it is in good working condition.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Bases should only be used in laboratories, which are equipped with eye wash.
It is important to ensure that all strong corrosives are stored separately from all incompatible chemicals. Further information and substance-specific storage guidance can be obtained in the safety data sheet (SDS) documentation of the chemical.
In view of the corrosive properties of these materials and the fire hazard risk that it poses, following considerations are applicable in storing the chemicals:

- Cool and dry area

- Bases should be stored separately from acids and in a manner which is consistent with its properties.
- Use of bottle carriers (eg. Winchester bottle carrier or basket) when transporting materials is highly encouraged.
- Store solutions of inorganic hydroxides in polyethylene or other compatible containers.

6. SPILL AND INCIDENT PROCEDURES

Assess the scale of the spill and extent of danger. If it is within your means, help contaminated or injured persons to evacuate the spill area. Keep others from entering contaminated areas. Course of action depends on the size and type of base spilled:

a. Minor spill (10mL up to 1L)

- Inform laboratory principal investigator immediately. If personnel are trained to
- handle the situation and the assessed risk is not greater than normal laboratory operations, put on the appropriate personal protective equipment, and cover the spill with suitable neutralizer such as boric acid, citric acid or other suitable absorbent (available in emergency spill kit). Double bag spill waste in clear plastic bags, label them and arrange for chemical waste pick-up.
- Inform PTj safety committee and file incident report.
- <u>*NOTE:*</u> *In the event a chemical spill causes injury and requires external intervention such as medical assistance and/or others, such incident should be treated as major spill regardless of the volume.*

b. Major spill (> 1L)

- Inform laboratory principal investigator, head of PTj and PTj safety committee
- immediately. PTj assess the situation and determine the next course of action. If spill containment is beyond the ability of PTj personnel, inform OSHE UM at 03-7967 7925, and contact 999 or Fire and Rescue department at 03-8892 7600 for assistance
- Notify others who are in the close vicinity to evacuate the area.
- Close the doors and keep the area away from any non-emergency response personnel.
- You are encouraged to remain there, but stay at a safe distance, to receive and direct safety personnel when they arrive.

c. Chemical spill on body or clothes

- Quickly remove the clothing and rinse body or affected skin with plenty of water in
- emergency shower for ≥ 15 minutes.
- Notify principal investigator of the laboratory / lab supervisor, and inform the incident
- to the department/faculty main office, as well as OSHE UM at 03-7967 7925
- Seek medical attention if there are signs of burn blisters or tissue damage.
- If necessary, contact 999 or UMMC Ambulance Hotline at +603-79492500 for emergency medical assistance.

d. Chemical splash into eyes

- Immediately get help to rinse the eye with water from the emergency eyewash station for at least 15 minutes. Note that it is going to be very painful, but you need to forcibly hold the eye open in order to properly rinse the eye and remove as much chemicals as possible.
- Notify the principal investigator of the laboratory / lab supervisor, and inform the incident to the department/faculty main office, as well as OSHE UM at 03-7967 7925.
- Seek medical attention.
- If necessary, contact 999 or UMMC Ambulance Hotline at +603-79492500 for emergency medical assistance.

7. DECONTAMINATION

Equipment or bench contaminated with base need to be treated with mild acid or other suitable neutralizer, and water. Wear proper PPE during the decontamination procedure.
Any contaminated disposables should be disposed as hazardous waste.

8. WASTE DISPOSAL

- Store hazardous waste in closed containers preferably with secondary containment in a designated location.
- Waste containers have to be labelled using the appropriate Scheduled Waste labels issued by JPPHB, University of Malaya. Waste generator has to provide details of the waste; including the date when the waste is first generated, laboratory, location, name of waste generator, and preferably the major content of the waste as well.
- Basic waste should not be allowed to accumulate in the lab for a long period of time and must be disposed routinely
- Do not discharge base into the drains or environment.

9. SAFETY DATA SHEET (SDS)

SDS of every base used must be made available and accessible all the time.

10. DETAILED PROTOCOL

- It is recommended not to work alone in the laboratory particularly after working hour
- Always put up the required PPE when handling bases
- Concentrated base should be handled only in chemical fume hood
- Unless it is absolutely necessary, do not mix concentrated base directly with concentrated acids

In the event of any unexpected occurrence such as fire, explosion, sudden change in temperature, sudden gas evolution, and/or colour changes when using base solutions, the occurrence must be documented and discussed with the laboratory principal investigator or lab supervisor.

UNIVERSITY OF MALAYA

STANDARD OPERATING PROCEDURE

WORKING WITH FLAMMABLE CHEMICALS

TYPE OF SOP:

Process ☐ Hazardous chemicals ☐ Hazard Class ■

1. HAZARD OVERVIEW

Flammable chemicals are characterized by their relatively low flashpoint. The flashpoint refers to the lowest temperature at which it can form ignitable mixture with air and produce a flame when a source of ignition is present.

2. HAZARDOUS CHEMICAL(S) OR CLASS OF HAZARDOUS CHEMICAL(S)

Flammable liquids can be categorized into several different classes according to their flash point and boiling point (vapour pressure). Generally, the lower its flash point, the lesser effort needed for it to get ignited and produces flame.

Class	Flash point / °C	Boiling point / °C	Examples
Extremely flammable	< 0	< 35	Ethyl ether
Highly flammable	< 21		Acetone, Benzene, Toluene, Methanol
Flammable	≥ 21 and ≤ 55		Xylene, Ethylbenzene

3. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Refer to main section on PPE in the relevant Safety Data Sheet / safety handbook

4. ENGINEERING/VENTILATION CONTROLS

Handling of flammable chemicals should preferably be in a certified laboratory chemical fume hood with the sash placed at suitable position to protect the operator. Fume hood has to be periodically inspected to ensure it is in good working condition.

Always attempt to handle flammable liquids especially if the quantity is greater than 0.5 L in a fume hood. If it is not possible to operate in a fume hood, special ventilation control is necessary in order to minimize exposure to the chemicals.

5. SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

a. Storage of flammables

It is important to ensure that all flammables are stored separately from all incompatible chemicals such as strong oxidizing agents or pyrophoric chemicals. Further information and substance-specific storage guidance can be obtained in the safety data sheet (SDS) documentation of the chemical.

In view of the fire hazard risk associated with these chemicals, following considerations are applicable in the selection of storage site:

- Cool and dry environment
- For a lab that handles more than 5 gallons of flammables, it is recommended to store them in Flammable Liquid Storage Cabinets (FLSC).
- Avoid stockpiling of flammables in the lab. Store only a minimum amount of flammable and combustible liquids needed for research and/or operations in a laboratory.
- Do not store flammables with incompatible chemicals such as acids, bases, compressed gases or pyrophoric chemicals.
- Requirements of FLSC:
    - Capacity should not be larger than 60 gallon capacity
    - Cabinets should be marked with “Flammable-Keep Fire Away” warning
    - Cabinets should be kept in good condition. i.e. doors that close and cabinet intact

b. Transferring flammables

Static electricity can be generated when liquid moves in contact with other material, and this actually takes place when liquid is being transferred between containers, especially metal containers. With sufficient charge build-up, a spark is produced and this could potentially cause a fire or explosion. The probability of this happening depends on the ability of the liquid to conduct electricity as well as the flash point of the liquid.

The following guide is to minimize generation of the static electricity / spark when transferring flammables:

i. Transfer between metallic or conductive containers

- If containers involved are made up of metal or any other conductive materials, it is important to bond and ground the two containers involved during the transfer.
- Bonding can be done by connecting the two containers with conductive cables to eliminate the electrical potential between them and eliminates the likelihood of sparks.
- The purpose of grounding (connecting containers directly to earth/building steel) is to eliminate the difference in static potential charge between the conductive object and ground.

ii. Transfer between non-metallic or non-conductive containers

- Risk of static hazards also exists in non-conductive containers such as plastic or glass containers. Electrostatic charge could be generated by the turbulence of the liquid being poured.
- Since these containers cannot be bonded or grounded, it is recommended to pour the flammables slowly, or if available, consider using a grounded nozzle extension that allows filling the container from the bottom.

c. Labelling

All flammable liquids must be clearly labelled with the correct chemical name.

Other information that must be in the label includes the hazard symbol such as “Flammable”, and/or others, when applicable.

d. Heating

Flammable liquids should not be stored in chemical fume hoods (work station) and must not be in close proximity to heating mantles, hot plates, or open flame.
It is not advisable to place flammable liquids or research samples containing these liquids directly in the oven. Understandably, these substances would evaporate and escape into the laboratory atmosphere, or may even be trapped in the oven to form sufficient concentration of explosive mixtures. If it is absolutely necessary to do this, consider venting the oven to an exhausted system to reduce this hazard.

6. SPILL AND INCIDENT PROCEDURES

Assess the scale of the spill and extent of danger. If it is within your means, help contaminated or injured persons to evacuate the spill area. Keep others from entering contaminated area. Course of action depends on the size and type of chemical spilled:

a. Minor spill (10mL up to 1L)

- Inform laboratory principal investigator immediately. If personnel are trained to handle the situation and the assessed risk is not greater than normal laboratory operations, put on the appropriate personal protective equipment, and cover the spill with vermiculite or other suitable absorbent (if available). Make sure the room is well ventilated. Clean the area, double bag the waste, label them and arrange for chemical waste pick-up.
- Inform PTj safety committee and file incident report.
- *<u>NOTE:</u> In the event a chemical spill causes injury and requires external intervention such as medical assistance and/or others, such incidents should be treated as major spill regardless of the volume.*

b. Major spill (> 1L)

- Inform laboratory principal investigator, head of PTj and PTj safety committee immediately. PTj assess the situation and determine the next course of action. If spill containment is beyond the ability of PTj personnel, inform OSHE UM at 03-7967 7925, and contact 999 or Fire and Rescue department at +603-8892 7600 for assistance
- Turn off ignition sources in the area.
- Notify others who are in the close vicinity to evacuate the area.
- Close the doors and keep the area away from any non-emergency response personnel.
- You are encouraged to remain there, but stay at a safe distance, to receive and direct safety personnel when they arrive.

c. Chemical spill on body or clothes

- Remove the clothing and rinse body thoroughly in emergency shower for ≥ 15 minutes.
- Notify the principal investigator of the laboratory and inform the incident to the department/faculty main office.
- Seek medical attention if necessary.

d. Chemical splash into eyes

- Immediately get help to rinse the eye with water from the emergency eyewash station for at least 15 minutes. You need to forcibly hold the eye open during washing in order to properly rinse the eye and remove as much chemicals as possible.
- Notify principal investigator of the laboratory / lab supervisor, and inform the incident to the department/faculty main office, as well as OSHE UM at 03-7967 7925
- Seek medical attention.
- If necessary, contact 999 or UMMC Ambulance Hotline at +603-79492500 for emergency medical assistance.

7. DECONTAMINATION

Equipment or benches contaminated with flammable chemicals need to be cleaned with soap and water. Wear proper PPE during the decontamination procedure.
Any contaminated disposables should be disposed of as hazardous waste.

8. WASTE DISPOSAL

Store hazardous waste in closed containers, preferably with secondary containment in a designated location.
Waste containers have to be labelled using the appropriate Scheduled Waste labels by JPPHB, University of Malaya. Waste generator has to provide details of the waste; including the date when the waste is first generated, laboratory, location, name of waste generator etc.
Chemical waste must not be left accumulated in the lab for a long period of time and should be disposed routinely
Do not discharge organic solvent into the drains or environment.

9. SAFETY DATA SHEET (SDS)

SDS of every chemical used must be made available and accessible all the time.

10. DETAILED PROTOCOL

Students / employees working with flammable chemicals must demonstrate competence to the lab supervisor/owner. They must be able to identify the hazards associated with relevant laboratory techniques or setups involving the flammables. They are also expected to be able to list the risk and potential emergency situations, and responses according to the situation, as well as measures to minimize the risks.

Before attempting any reaction involving flammables for the very first time, researchers are advised to seek literature precedent (if any) for reaction conditions that have reasonable similarities to the planned work. They are expected to consult the PI or experienced research coworker for approval in case of any doubts or uncertainties.

When working in the lab:

- It is recommended not to work alone in the laboratory particularly after office hour
- Always put up the required PPE when handling chemicals
- Handle flammables in chemical fume hood

In the event of any unexpected occurrence such as fire, explosion, sudden change in temperature, sudden gas evolution, and/or colour changes when using chemicals. Such occurrences must be recorded and made known to the laboratory principal investigator or lab supervisor.

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