YONG LOO LIN SCHOOL OF MEDICINE
SAFETY MANUAL

YONG LOO LIN SCHOOL OF MEDICINE
NATIONAL UNIVERSITY OF SINGAPORE

Contents

General Safety

General Laboratory Safety Rules

Updated: Dec 2019 Rev.3

The rules stated here are applicable to all staff, students, contractors and visitors. The safety rules are the minimum requirements to ensure a healthy and safe environment. Where required, Departments are to formulate their own specific operating rules and procedures in addition to these basic Safety Rules. Each staff, student, contractor or visitor must be aware of and follow at all times, these rules and procedures in the performance of their duties or when attending classes.

General Rules

- **Know and Observe the Safety Rules**
  Each Department has its own specific rules and procedures in addition to these basic Safety Rules. All personnel must be aware of and comply with these rules at all times when working or attending classes.

- **Unauthorised Person(s) Shall Not Be Allowed In a Laboratory**
  No one shall be allowed in a laboratory without the permission of the Principal Investigator. Such authorized person must be made aware of the hazards in the laboratory and provided with the same kind of protection from such hazards as other persons working routinely in the laboratory. Visitors will be required to sign an Indemnity Form that indemnifies the university against any claims for injuries during their visit / stay in NUS labs, workshops or animal facilities. The form can be found here.

  Anyone below the age of eighteen (18) shall not be allowed in a laboratory except with official permission.

  Do not allow unauthorized person to tailgate into the laboratories. Check the unauthorized person for the purpose of the visit and request him/her to contact person visiting.

- **Working Alone**
  Where the work involves a potential hazard, personnel should not work alone or after office hours in the laboratory.

  It is prudent to avoid working in a laboratory alone. If this must be done, persons working alone shall be required to obtain prior approval from their PIs or supervisors. The supervisor of the laboratory has the responsibility for determining whether the work requires special safety precautions, such as having two persons in the same room or in close proximity for periodic cross-checks during a particular operation. Alternatively, security guards may be asked to check on a laboratory worker. Experiments known to be hazardous should not be undertaken by a worker who is alone in a laboratory.

  Contact numbers for emergencies should be clearly posted and personnel working in the laboratory should be made aware of the location of these notices, especially, if they are working alone outside office hours.

  Undergraduate students shall not work unsupervised in the laboratory. They shall be supervised by the PI or his/her nominee, provided the nominee is competent to carry out such supervision

and agrees to do so. The level of supervision shall be decided by the PI who shall take into account the nature of the work and the competency level of the student under his/her charge. Refer to NUS Safety Directive 0701 Access to and Supervision of Undergraduates in Laboratories for Project or Research Work.

- **Inappropriate Behaviour**
  Inappropriate behaviour, such as horseplay, fighting and practical jokes that are dangerous will not be tolerated.

- **No Eating, Drinking, Smoking or Applying of Cosmetics in the Laboratories**
  These activities are strictly prohibited. This is to prevent contamination and injury to persons as a consequence. Storage of food, drinks and their containers is not permitted in the laboratories.

- **No Consumption of Alcohol**
  Anyone under the influence of alcohol is not allowed to work in any workplace as there is danger of injury to themselves or others.

- **All Warning and Safety Signs, Signals and Alarms Shall Be Obeyed and Must Be Kept In Place**
  Warning and safety signs, signals and alarms are meant to ensure protection from recognised hazards. Do not remove any warning and safety sign until hazards have been rectified or removed. Do not ignore any signals / alarms until the cause has been verified / rectified.

- **Always Keep Your Work Area Clean and Orderly**
  Poor housekeeping habits can be a serious safety hazard. Do not leave materials in aisles, walkways, stairways, doorways, etc. Decontaminate all biological spills and clean up any chemical/radioactive spills using the appropriate spill clean-up procedures.

- **Be Aware of the Locations of Safety Facilities of the Laboratory**
  Staff and students should be aware of the location of the nearest safety showers, eyewash stations, fire extinguishers and emergency exits.

- **Report All Injuries and Illnesses**
  Staff and students are responsible for reporting to their Supervisor whenever they become sick or injured at work. All injuries, no matter how minor, must be reported immediately.

- **Report All Incidents, Accidents, Near Misses and Workplace Hazard**
  Any unsafe condition / act, incident, accident or near miss which is encountered shall be reported to the respective Supervisor and the Accident / Incident Management System (AIMS) here.

- **Stay Alert and Correct Unsafe Conditions and Actions**
  Be alert to unsafe conditions and actions, and call attention to them so that correction can be made.

Risk Assessment & SOP

Updated: October 2018 Rev.2

Risk assessment is a cornerstone of a safe working environment to foster an accident-prevention culture. All workplaces shall conduct risk assessments for all routine and non-routine operations to identify the source of risks and subsequently take reasonable steps to eliminate or minimise the risk. Standard Operating Procedures (SOPs) should be developed to incorporate safety interventions to ensure the safest possible conduct of the work.

Be familiar with the potential hazards of the techniques being used, and the appropriate response required.

Please refer to WSHC Code of Practice on Risk Management here.

Risk Assessment for Research

Updated: Dec 2019 Rev.3

Risk assessment is the process of identifying hazards and evaluating the risk(s), taking into account the adequacy of any existing controls, and deciding whether the risk(s) is acceptable or not. This section aims to provide a guide on how risk assessments should be performed as well as indicate the procedure for evaluation and approval of the risk assessment. The University requires all research projects and teaching experiments to be risk-assessed and safety control measures implemented to bring the risk to a minimum.

Responsibilities

Principal Investigators and Laboratory Supervisors are responsible to ensure that risk assessments are conducted for all research projects and teaching experiments.

Head of Department

The Head of Department (HOD) is to evaluate the risk assessment of PIs with the assistance of the Departmental Safety Committee or Faculty Safety & Health Officer.

Principal Investigators/ Supervisors

The Principal Investigators (PIs) / Supervisors shall be responsible to ensure that:

- Assessment of risk for the areas under their control is performed;
- Practicable control measures are implemented;
- Risk assessments are communicated to his/her staff and students in the laboratory;
- Periodic review of the assessment is performed when there is reason to suspect that they may no longer be valid or there have been significant changes since the last assessment was made; and
- Risk assessments are endorsed and retained for a minimum period of 3 years.

Staff and Students

Staff and students are responsible to ensure that they participate as requested in the risk assessment process and use/maintain any control measure identified as being necessary to minimize risks. They are responsible to carry out their work in accordance to the prescribed RAs and SOPs.

Definitions

Harm
Physical injury, ill-health or damage to property.

Hazard
Source, situation, or act with a potential for harm in terms of human injury or ill health, or a combination of these (e.g., physical hazards, chemical hazards and biological hazards).

> *Examples*
> Activity: Handling of sharps such as needles.
> Hazards: Pricking yourself (physical). Pricking and infecting yourself (biological).
>
> Activity: Pouring hazardous chemicals while working on an open bench.
> Hazards: Burning yourself with corrosive chemicals (chemical).
>
> Activity: Eating or drinking in the laboratory.
> Hazards: Swallowing infectious material and getting sick (biological).

Risk
Combination of the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that may be caused by the event or exposure(s).

Risk control
Risk control measure to either reduce the likelihood of occurrence (probability) and/or the severity of potential injury or damage (severity). Choice on controls should consider the hierarchy of hazard control, or application of several different types of control measures concurrently in order to manage the risk effectively.

Residual risk
The risk remaining after physical and management control systems have been put in place.

Procedures

When Should Risk Assessment Be Conducted

Under the Workplace Safety and Health (Risk Management) Regulations, every workplace is required to conduct risk assessments and establish reasonably practicable steps to eliminate, minimize or control the risks. Records of these risk assessments need to be maintained for a period of not less than 3 years.

NUS has migrated towards the Safety & Health Management System (SHMS) Certification Scheme where risk assessment is done as part of an overall safety and health management system. The Scheme certifies PIs who have effectively implemented a laboratory-based safety and health management system. Upon award of the certification to the Scheme. More information on the SHMS Certification Scheme can be obtained here.

PIs (not certified under the SHMS Certification Scheme) who are starting new research grants are required to conduct risk assessment to identify the safety and health risks associated with the project and then update/forward to OSHE for review and final approval by Institutional Biosafety Committee (IBC) or Institutional Laboratory Safety Committee (ILSC). IBC approves life science related research projects and

ILSC approves non-life science related projects. This can be done through the integrated Online Research Compliance (iORC) System here.

In the course of conducting research projects in NUS, if there are significant changes in the protocol, practices, materials, personnel or environment, PIs should submit any amendment for review and approval through the iORC system.

For non-laboratory based research projects (tasks that are purely deskbound e.g., involving purely computational work or conduct of information surveys i.e., involving the use of computers), PIs are not required to participate in the certification scheme.

Lab-based research projects are defined as those involving the use of chemicals, biological agents, radioactive materials/equipment, heavy machinery or high voltage equipment, etc.

Risk assessments may include the use, manipulation, formation or release as an intermediate or by-product, of any of the following hazards:

Biological Agents

Micro-organisms, Cell Cultures and Human Endoparasites
Work with micro-organisms known to produce chemical toxins and/or micro-organisms which may cause severe human disease.

All PIs performing work involving the following biological agents are required to seek IBC approval before application to the respective regulatory agencies:

- First and Second Schedules biological agents and Fifth Schedule toxins regulated under BATA by MOH (link);
- Risk Group 3 veterinary biologics regulated by AVS; and
- Vectors regulated under the Control of Vectors and Pesticides Act administered by NEA.
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For genetic modification work that falls under category A or B of the GMAC guidelines (link), IBC / OSHE needs to be notified.

IBC / OSHE can be notified by submitting:

- A new application or any subsequent amendment of the approved protocol via the iORC system.

Experimental Animals
Work with primates, animals which are venomous or with any species knowingly exposed to any infectious agent, carcinogenic or radioactive substances.

All research projects involving use of animals require NUS IACUC review and clearance. Personnel shall not use any animal for any scientific purposes before written approval is given by the IACUC. Applications to IACUC have to be submitted through the iORC system (link). Further details can be found here.

Human Tissues
Work with any human tissue, excretion, blood or other bodily material of high risk or suspected origin likely to contain a hazardous agent.

Human research studies requires the approval of Institutional Review Board (IRB) and are subjected to the Human Biomedical Research Act. Details are available at the following site:

- NUS Institutional Review Board
- NUS Research Compliance and Integrity

Physical Agents

Electricity
Work with any electrical system, appliance or equipment that may pose an electrical hazard.

Ionising Radiation
Work with any radioactive substance or ionising radiation generator other than equipment in which a cathode ray tube is the only electron beam source.

Non-Ionising Radiation
Work with any Class 3B or 4 lasers or any unshielded UV source at 200 – 320 nm.

Noise
Work where the noise level may exceed 85 dB(A).

Other Hazards

Manual handling operations
Handling any load greater than 40kg.

Risk assessments should incorporate a written protocol describing how the work is to be done. This should include the details and technical specifications of the control measures which are to be used and the means whereby these measures will be maintained. Emergency procedures must be established by assessment and arrangements put in place.

IBC / ILSC Approval

The University requires that risk assessment must be conducted for all new laboratory based research projects / tasks undertaken by staff members of the School prior to commencement of work. These research projects / tasks can be divided into:

Project / Task Requiring Grant Funding
All submissions for grant funding shall be directed through the Research Office (NUHS).

All grant applications are to be accompanied by the Grant Endorsement Form which includes a checklist and declaration of Ethics and Research Compliance. This can be downloaded here.

Upon confirmation of short listed projects, the Research Office (NUHS) shall inform the Principal Investigators to submit their Risk Assessment through iORC for review and approval (link).

Project / Task That Does Not Require Grant Funding
Risk assessments are also required for projects / tasks that do not require any grant funding (e.g., teaching activities, dissertation projects). However, these do not need to be submitted to the IBC or ILSC for approval. The risk assessments should be approved by the PIs / Supervisors / Programme Leaders.

Guide to Risk Assessment

Why Is Risk Assessment Conducted?

A risk assessment is the systematic consideration of any activity, condition or situation in a laboratory to identify:

- The hazards which are present or may be encountered;
- Whether harm is likely to occur; and
- The extent and severity of that harm.

It is conducted to stipulate the action, if any, to:

- Remove or avoid the hazard;
- Prevent, reduce or otherwise protect against the hazard; and
- Comply with any legal requirements which apply to the activity, condition or situation.

It should confirm and record the activity in question as well as identify the hazards and appropriate risk control measures for application.

The steps to be taken for managing safety risks in the workplace are:

- Identify the hazards;
- Assess the risks;
- Control the risks; and
- Evaluate and Review.

Identify the Hazards

All hazards associated with the research process shall be assessed. Identifying the hazards should be done by breaking down the process into component parts and then assessing each step. This is best carried out by, or with the assistance of, someone familiar with the work. The scope of hazard identification includes:

- Identifying the source of harm such as a hazardous event, substance or equipment;
- Identifying who could be harmed or exposed to the hazards e.g. staff, students, cleaners and/or visitors; and
- Identifying how harm could occur such as contacts with corrosive chemical or lab acquired infections.

Hazard Type	Examples
General	Slippery floors, trips, working at heights
Biological	Infectious materials
Physical	Mechanical hazards from equipment, manual handling
Sharps	Glassware, needles, sharp edges on equipment / furniture
Chemical	Disinfectants, laboratory reagents, other substances
Fire / Explosion	Solvents, flammable chemicals, flammable gases
Electrical	Lack of maintenance of equipment, overloading of power points
Mechanical	Moving parts of machinery
Radiation	Radiochemicals, contaminated items and waste materials

Assess the Risks

Hazards identified should be assessed to decide the degree and priority of action required to deal with the risk posed. The assessment should take into account the likelihood that the hazard can cause harm (i.e. Probability of Occurrence) and the severity of a worst-case scenario (i.e. Consequence).

Severity may be classified into the following levels with escalating consequences:

- Low (minor injuries resulted; simple first aid adequate) - 1
- Medium (Medical treatment required) - 2
- High (Serious injuries with possible fatality) – 3

On the other hand, Probability may be classified as being:

- Unlikely – 1
- Possibly – 2
- Likely – 3

A matrix may be constructed to illustrate the product of the two parameters (Risk = Severity x Probability). Risks that are assessed to be high must be immediately eliminated or controlled by appropriate measures.

Probability				
Severity		Likely (3)	Possibly (2)	Unlikely (1)
	Low (1)	**3**	**2**	**1**
	Medium (2)	**6**	**4**	**2**
	High (3)	**9**	**6**	**3**

Risk	Decision Process
<3	Risk Acceptable
3,4	Consider additional risk control measure(s)
>4	Additional risk control measures required

Possible Hazards/Risks	Probabilities / Consequences
Risk of infection	Incidence is low, but consequences could be severe.
Autoclave incidents	Major accidents are rare, but consequences could be severe.
Electric shock	An ever-present hazard that could be fatal.
Manual handling	High frequency of injuries leading to chronic debilitation.
Sharps injury	Not uncommon, unpleasant and stressful, but rarely, although potentially, fatal.
Skin contamination	Irritant or severe, may restrict the individual's work.
Inhalation of toxic vapour	May be acute or chronic effects with long-term consequences.

Standard Operating Procedures
Updated: Oct 2018 Rev.2

Standard Operating Procedures (SOPs) should be written for all procedures that pose an identified potential risk to the health and safety of the staff or students and of others present in the workplace. A SOP contains instructions for performance of designated operations/procedures in designated situations and it should describe concisely specific step-by-step instructions that allow an individual to perform the necessary activities.

Each department should have a library of SOPs for general or common procedures which is supplemented with specific laboratory-based SOPs.

Responsibilities

Principal Investigator / Supervisor

Principal Investigators (PIs) or Supervisors shall be responsible to ensure that written SOPs are formulated for all processes that are identified to be potentially hazardous during the risk assessment exercise.

Staff / Students

Staff and students shall comply with the requirements in the SOPs for the laboratories they are working in.

Procedure

PIs and supervisors should ensure that SOPs are drawn up for routine, repetitive and specific operations as well as for unexpected spills or other emergencies. SOPs should be clearly stated and realistic in scope.

Departmental SOPs should be standardised for specific purposes to allow easy understanding and reading.

The process of writing SOPs requires an individual to think through all the steps of a procedure and perform a risk assessment before work begins. This process allows identification of any potential health and safety issues associated with the procedure.

Typical SOP Format

Every SOP should at least include the following:

- Title or Type of Procedure;
- Date written, dates of revisions, name of person who wrote or collated the SOP;
- Procedure / methods / materials (detailed enough to allow someone to complete the procedure);
- Risk identification (include hazardous materials used);
- Control measures;
- Personal Protective Equipment required;
- Waste disposal;
- Spill procedures;
- Accident procedures (include contact person);
- References (include cross-referencing to other SOPs, if applicable);
- Any required record keeping; and
- Signature of endorsement (usually by the PI).

A sample template for Standard Operating Procedures can be downloaded here.

Supplementary Information

Supplementary information includes:

- Photographs, graphs or illustrations
- Flowcharts
- Appropriate forms
- Published literature as references
- Operating manuals of equipment or protocols, if applicable

Review

SOPs should be reviewed regularly or whenever there is a change in the process or accidents/incidents. Records are to be kept.

Housekeeping

Updated: Dec 2019 Rev.3

There is a definite relationship between safety performance and orderliness in the laboratory. When housekeeping standards fall, safety performance inevitably deteriorates.

- Work areas should be kept clean and free from obstruction;
- Laboratories shall have areas for writing and dry work, separate from wet benches (to prevent contamination of note books, pens, etc.). Facilities external to the laboratory should be provided for any significant writing work. There should be a clear demarcation between 'wet' and 'dry' areas, where paperwork is done;
- Personal belongings should be stored in a safe place, away from the work area;
- Walkways and passages should be kept clear of any equipment or boxes, as this may pose a fire hazard or cause accidents to occur;
  Freezers and equipment which are running continuously should have the names and after-hours contact numbers of personnel who are to be contacted in case of emergencies or power failure / malfunction;
- Never use any chemical or reagent found in an unlabeled container. Unlabeled containers and chemical wastes should be disposed promptly by appropriate procedures;
- Spilled chemicals should be cleared immediately and disposed properly. All spillages must be reported to the PIs or Supervisors. Spill clean-up procedures should be established, and all laboratory personnel made aware of them;
- At the end of any experiment, conduct a check to make sure all equipment is cleaned and put away, while gas supply, vacuum, electrical apparatus, etc. are switched off. Hot plates and water baths which are still hot should be clearly indicated or labelled as such; and
- Clearing and cleaning of the workplace following the completion of any operation or procedure should be done at the end of each day.
- Waste bins shall not be overfilled.

Precautions When Working with Common Laboratory Equipment

Updated: Dec 2019 Rev.3

Electrical Safety

The misuse of electrical equipment can lead to a wide variety of potential hazards. The following precautions shall be observed:

- Do not tamper with electrical equipment and existing electrical installations;
- Unsafe electrical cords and faulty electrical equipment must be replaced or serviced. Do not continue to use them unless proper rectifications have been done. Use electrical plugs certified with "Safety Mark" or "CE";
- Ensure all electrical plugs are labelled with both equipment name and amperage to assist in checks for electrical overloading;
- All electrical equipment should be maintained and repaired by qualified electricians or technicians;
- All electrical equipment should be of safe design and construction and operated in accordance with manufacturer's instructions;
- Equipment must be properly connected to power source by proper power plugs and connections; and
- Power supply for electrical equipment via trailing cables or extension cords should be minimized as much as possible. Permanent wiring should be arranged for equipment which are to be used continuously or for extended periods of time.

Autoclaves

Autoclaves are pressurized sterilizing chambers used to sterilize glassware, instruments, gloves, liquids in bottles, biological waste, and other materials by steam under pressure. As autoclaves are typically set at a little under two atmospheres of pressure, at temperatures of up to 135° C, the stored energy in the steam can cause serious injury.

- Users must be trained in the correct operation of the autoclave;
- The autoclave MUST be depressurised before it is opened;
- Use NON-SEALED Pyrex containers which are designed to withstand the temperatures and pressures of the autoclave, as liquids placed in sealed bottles or in ordinary glass bottles may rupture;
- Be aware that if the unit is set to depressurise rapidly (as might be done for instrument sterilization). The liquids in the container bottles may boil, with a consequent spillage into the autoclave;
- Do NOT sterilise flammable liquids or chemicals which could become unstable at the temperatures attained in the autoclave during the sterilizing cycle; and
- Clean and check autoclave regularly. The inspection label bearing the autoclave and MOM registration number should be prominently displayed on the autoclave.

Centrifuges

- Securely anchor tabletop centrifuges and place them on surfaces where the vibration will not cause items to fall off the bench;
- Extra care should be taken to balance tubes carefully before starting the centrifuge;
- Ensure rotors are securely screwed / fixed before starting the centrifuge;
- Keep the centrifuge lid closed while operating and do NOT leave the centrifuge until you are certain it is running without vibration;

- If the centrifuge starts vibrating, STOP and check the load balances;
- Regularly clean rotors and buckets with a non-corrosive cleaning solution;
- Use sealed safety cups when centrifuging hazardous materials;
- Ensure that the centrifuge lid is secured and supported when it is being loaded. There should be regular maintenance to the piston that holds the lid in place; and
- Display the procedures on emergency centrifuge lid release near the centrifuge and ensure that all are aware of the procedures.

Ultraviolet Lamps

- Wear ultraviolet-absorbing protective safety glasses while working with ultraviolet light. Never view ultraviolet light rays with the naked eye;
- Protect skin from potential burns due to exposure to ultraviolet light; and
- Shield any experiment in which ultraviolet light is used to prevent escape of the direct beam or scattered radiation.

Personal Protective Equipment and Personal Hygiene

Updated: Dec 2019 Rev.3

The selection of appropriate personal protective equipment (PPE) requires the hazards and risks of the work process to be correctly identified. PPE must be provided, used and maintained when it is required. However, it should be noted that PPE is not a substitute for safe work practices as well as good engineering or administrative controls.

All personnel must use the appropriate PPE to protect from hazards in the course of work.
When working in a laboratory, the minimum PPE required are a lab coat, safety glasses, long pants and closed-toed shoes that cover the entire foot.

Various types of PPE are available and are to be selected carefully based on the activity/task performed.

Safety Eyewear

Eye protection is required for all personnel (staff, students, visitors and contractors) in the research or teaching laboratory and workshop even if there is no obvious eye splash or exposure risk from the activity. Eye protection shall be worn at all times, except those exempted activities approved by OSHE.
For activities that are exempted, there must NOT be other hazardous activities in the vicinity when such activities are carried out.

Safety eye protectors used must comply with SS473-2 (2011) Singapore Standard Specification for personal eye-protectors.

- **Safety Glasses**
  Protective eyeglasses are made with safety frames, tempered glass or plastic lenses, temples and side shields which provide eye protection from moderate impact and particles. Safety glasses are also available in prescription form for those personnel who need corrective lenses. Eye-cup type side shields offer the best protection.

- **Safety Goggles**
  Vinyl-framed goggles of soft pliable body design provide adequate eye protection from many hazards. These goggles are available with clear or tinted lenses, perforated, port vented, or non-vented frames. Safety goggles may be worn in combination with spectacles or corrective lenses to insure protection along with proper vision.

Face Shield

Full-face protection shall be worn when there is risk of face injury from biological/chemical splashes, ultra violet radiation, flying particles, exploding cryovials, etc. Face shield normally consist of an adjustable headgear and face shield of tinted/transparent acetate or polycarbonate materials, or wire screen. Face shields are available in various sizes, tensile strength, impact/heat resistance and light ray filtering capacity. However, it does not protect from impact hazards, and must be used with primary eye protection (safety eye glasses or goggles).

Respiratory Protection

Respiratory protection shall be worn when the change in the air (reduced oxygen or contaminated with harmful substances) poses a risk to a person's health.

Hearing Protection

Hearing protection should be worn when there is risk of injury to a person's hearing from noise, ultrasound, etc.

Long Hair

Long hair should be tied back or restrained. The wearing of loose clothing when in the laboratory should be avoided.

Laboratory Coats

Long-sleeved laboratory coats must be worn at all times whilst in the wet work laboratory. The laboratory coat should be removed and left in the laboratory before leaving for non-laboratory areas.
Laboratory coats protect street clothing against biological or chemical spills as well as to provide some additional body protection. Laboratory coats should be fully buttoned.
According to the WHO Laboratory Biosafety Manual, long-sleeved, back-opening gowns or coveralls with elasticised cuffs give better protection than laboratory coats and are preferred in microbiology laboratories and when working with infectious materials.

Aprons may be worn over laboratory coats or gowns where required to give further protection against corrosive chemicals or biological materials such as blood or culture fluids.

All laboratory coats are to be laundered by the institution's contracted agents and should not be brought home. Personnel should know where to put soiled laboratory coats that are to be laundered. Laundry services should be provided by respective Departments.

Hand Protection

Skin contact is a potential source of exposure to toxic and infectious materials. It is important that proper steps are taken to prevent such contacts. Exposed skin should be covered when working with hazardous materials.

There are gloves available that can protect personnel from hazards like chemicals, biological agents, abrasions, cuts and heat. Based on the risk assessment conducted, certain more hazardous procedures may require the need for double gloves. This should be specifically indicated in the laboratory specific SOP.

The selection of gloves based on the hazard types are listed below:

- **Chemical Hazards**
  Look at glove selection guides in catalogues or web sites of various scientific and safety suppliers. Gloves are rated for degradation, breakthrough and permeation rates. Choose a glove that provides the best resistance to the chemical being used. For some hazards, double gloving may be needed. For example, the recommended gloves for dimethyl mercury are a highly resistant laminate glove (Silver-Shield or 4H), which has no abrasion/cut resistance, worn under a pair of long cuffed unsupported neoprene, nitrile, or similar heavy-duty glove.
- **Biological Hazards**
  Protection from biological hazards may be simple or complex depending on whether the biological material is immersed in something other than water.
- **Radioactive Hazards**
  Gloves provide a necessary personal protection barrier and help prevent scatter contamination.

Glove selection is based on the carrier material (i.e. water, toluene, etc.). Radio-iodination procedures require double gloving.

- **Sharps Hazards**
  Chemical compatibility guides may not indicate susceptibility to abrasion or cuts. Need to check manufacturer or supplier for this information.
- **Combination Hazards**
  Selection guides normally list gloves by the protection they provide from one "pure" chemical, not a combination. In this case selection should be based on the component with the shortest breakthrough time.

Consult the relevant SDS and obtain the manufacturers' specific recommendations when selecting chemical-resistant gloves, especially if the gloved hand will be immersed in the chemical. Refer to the table below for the types of protective work gloves and the types of chemical hazards they can guard against.

Type	Advantages	Disadvantages	Use Against
Natural rubber	Low cost, good physical properties, dexterity.	Poor vs oils, greases, organics. May be of poor quality.	Bases, alcohols, dilute water solutions; fair vs aldehydes, ketones.
Natural rubber blends	Low cost, dexterity, better chemical resistance than natural rubber vs some chemicals.	Physical properties frequently inferior to natural rubber.	Bases, alcohols, dilute water solutions; fair vs aldehydes, ketones.
Polyvinyl chloride (PVC)	Low cost, very good physical properties, medium cost, medium chemical resistance.	Plasticisers can be stripped. May be of poor quality.	Strong acids and bases, salts, other water solutions, alcohols.
Neoprene	Medium cost, medium chemical resistance, medium physical properties.	N.A.	Oxidising acids, anilines, phenol, glycol ethers.
Nitrile	Low cost, excellent physical properties, dexterity.	Poor vs benzene, methylene chloride, trichloroethylene, many ketones.	Oils, greases, aliphatic chemicals, xylene, perchloroethylene, trichloroethane; fair vs toluene.
Butyl	Specialty gloves, polar organics.	Expensive, poor vs hydrocarbons,chlorinated solvents.	Glycol ethers, ketones, esters.
Polyvinyl alcohol (PVA)	Specialty glove resists a very broad range of organics, good physical properties.	Very expensive, water sensitive, poor vs light alcohols.	Aliphatics, aromatics, chlorinated solvents, ketones (except acetone), esters, ethers.
Fluoro-elastomer	Specialty glove, organic solvents.	Extremely expensive, poor physical properties, poor vs some ketones, esters, amines.	Aromatics, chlorinated solvents, also aliphatics and alcohols.
Norfoil (Silver Shield)	Excellent chemical resistance.	Poor fit, easily punctures, poor grip, stiff.	Use for HAZMAT work.

Gloves should be replaced periodically, depending on frequency of use and permeability to the substance(s) handled. Gloves should be removed in a way that prevents the skin from coming into contact with the glove's contaminated exterior. Once the gloves are removed, wash hands thoroughly.

Gloves that have been contaminated must be properly disposed of or sent for special cleaning. Do not attempt to reuse disposable gloves. Never wear possibly contaminated gloves outside of the laboratory or to handle office equipment like telephones or computer keyboards.

Gloves should be removed as soon as handling of these hazardous items is done and disposed appropriately. Hands must be washed well with detergent and water prior to leaving the laboratory.

Finger nails should be kept trim and short to avoid trapping of chemicals under the nails.

Footwear

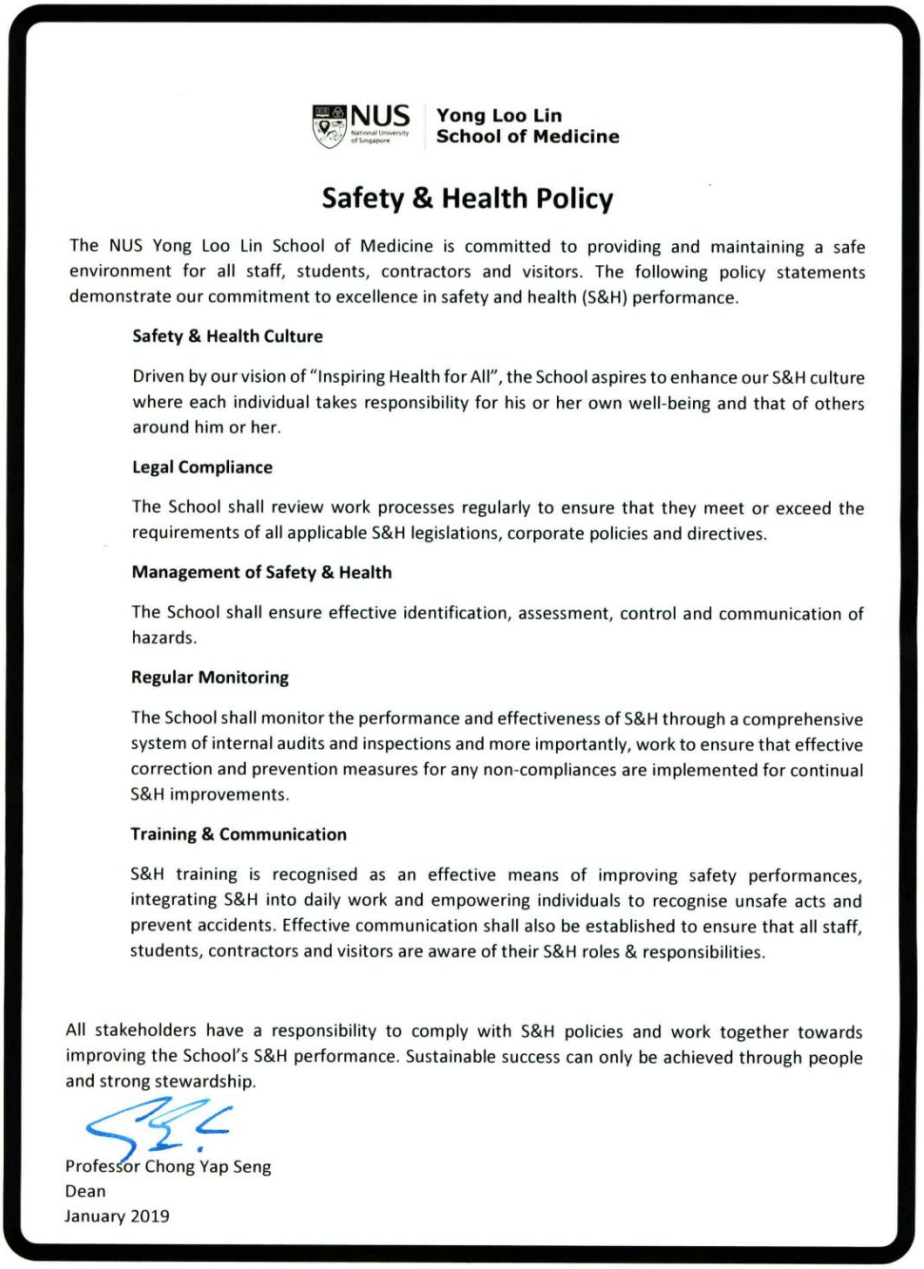
Covered footwear must be worn at all times in a laboratory. Thongs, open-toed shoes, sandals, slippers, etc. are not appropriate footwear as they do not protect the feet from accidental spillage. Depending on the hazards present, shoes must protect against impact, chemical/biological splashes, cuts, etc.

Governance

School Safety & Health Policy

Updated: Dec 2019 Rev.03

The Yong Loo Lin School of Medicine Safety & Health Policy is developed by NUS Medicine Safety Committee (NUSMed SC) in accordance with national regulations and University policies. The policy statement expresses the commitment of the School's management to the safety programmes that is a crucial element in promoting and maintaining a positive safety culture. It is approved by the Dean and will be reviewed periodically.



NUS National University of Singapore | Yong Loo Lin School of Medicine

Safety & Health Policy

The NUS Yong Loo Lin School of Medicine is committed to providing and maintaining a safe environment for all staff, students, contractors and visitors. The following policy statements demonstrate our commitment to excellence in safety and health (S&H) performance.

Safety & Health Culture

Driven by our vision of "Inspiring Health for All", the School aspires to enhance our S&H culture where each individual takes responsibility for his or her own well-being and that of others around him or her.

Legal Compliance

The School shall review work processes regularly to ensure that they meet or exceed the requirements of all applicable S&H legislations, corporate policies and directives.

Management of Safety & Health

The School shall ensure effective identification, assessment, control and communication of hazards.

Regular Monitoring

The School shall monitor the performance and effectiveness of S&H through a comprehensive system of internal audits and inspections and more importantly, work to ensure that effective correction and prevention measures for any non-compliances are implemented for continual S&H improvements.

Training & Communication

S&H training is recognised as an effective means of improving safety performances, integrating S&H into daily work and empowering individuals to recognise unsafe acts and prevent accidents. Effective communication shall also be established to ensure that all staff, students, contractors and visitors are aware of their S&H roles & responsibilities.

All stakeholders have a responsibility to comply with S&H policies and work together towards improving the School's S&H performance. Sustainable success can only be achieved through people and strong stewardship.

Professor Chong Yap Seng
Dean
January 2019

Other Important Policies

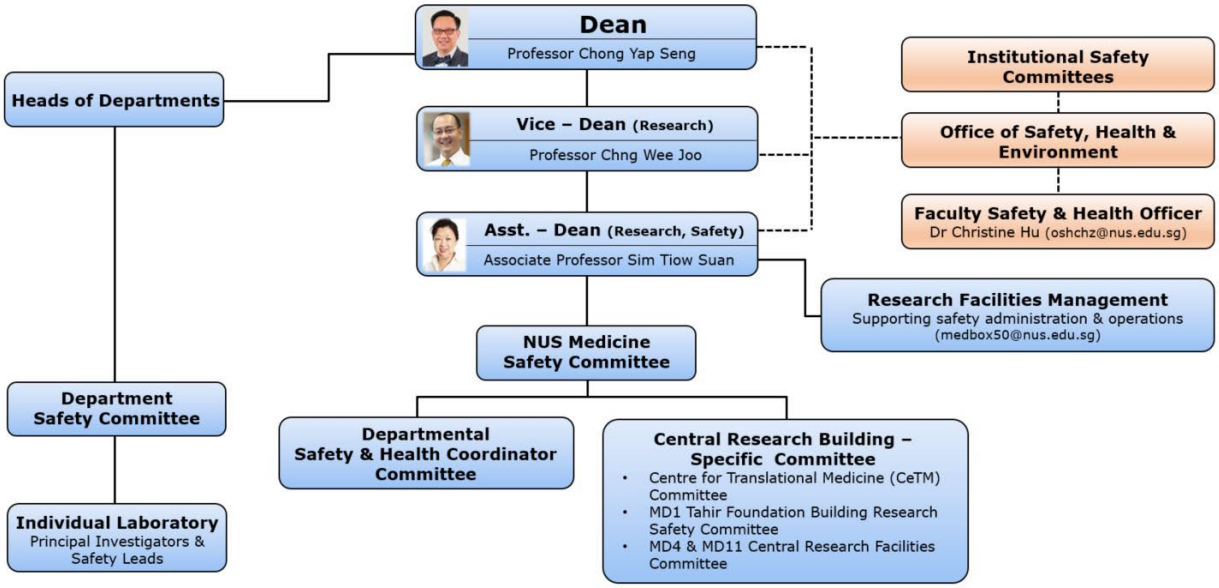
- University Safety & Health Policy
- University Fire Safety Policy
- University Crisis Management Policy
- NUS Construction Safety Policy
- Door Access Control System Policy
- University Policy for Tenants Conducting Teaching and Research Activities on NUS Campus

Safety Organisation Structure

Updated: Dec 2019 Rev.3

The safety organisational structure of the Yong Loo Lin School of Medicine is supported by the NUS Medicine Safety Committee (NUSMed SC) comprising representatives from the various laboratory-based Departments. The School shall work closely with the University Office of Safety, Health and Environment (OSHE) to ensure a healthy and safe work environment.

The NUS Medicine safety governance structure is as follows:



Safety Responsibilities

In view of the direction from NUS Senior Management on "Creating a Sustainable Safety Culture on Campus" and in line with OSHE's safety programmes, the School will communicate the safety policies and responsibilities to all staff and students operating within the premises of the School. Every staff and student has an obligation to ensure the safety of themselves and others.
The different levels of responsibilities are:

Management Responsibilities

Dean, Heads of Departments (HODs) and Directors are responsible for providing leadership in safety and health. They are to ensure that:

- Individuals under their management have defined safety and health roles and responsibilities;
- Individuals under their management have the authority to implement appropriate safety and health policies, standard operating procedures (SOPs) and programmes;
- Areas under their management have adequate resources and funding for safety and health programmes, SOPs and equipment based on risk priority; and
- Areas under their management are in compliance with legislations, NUS safety and health policies and SOPs.

NUS Medicine Safety Committee

The NUS Medicine Safety Committee Chair and members are appointed by the Dean to foster a healthy and safe environment. It comprises representatives from each of the Departments with laboratory facilities, Dean's Office representatives and NUSMed Safety and Health Officer. It shall be responsible for:

- Developing policies, general guidelines, procedures and practices to improve the safety of the work environment;
- Monitoring the follow-up on all reported incidents and accidents concerning breach of safety issues;
- Conducting periodic safety inspections / audits of the workplace; and
- Promoting safety awareness through workshops and training sessions.

Faculty Safety and Health Officer

The NUSMed Safety and Health Officer is an officer from OSHE (Office of Safety, Health & Environment) appointed to support NUSMed. He/She shall assist to provide advice for the University and the School Safety Programmes. He/she shall be responsible for:

- Assisting the NUS Medicine Safety Committee in providing advice and direction in line with the University Safety & Health (S&H) policies to improve the safety of the work environment with consideration given to minimize interference with the conduct of research and teaching;
- Acting as the first point of contact for the School on S&H matters in OSHE and facilitating the periodic inspections / audits by OSHE to ensure compliance with all safety practices and procedures;
- Facilitating programmes that support all laboratories in the development and implementation of Workplace Safety and Health Management System and attaining Lab Certification;
- Investigating laboratory accidents / incidents and dangerous occurrences and reporting to the School and OSHE through the NUS Medicine Safety Committee; and
- Conducting appropriate safety training for all staff and students, with the assistance of the School staff.

Dean's Office Representatives

The Research Facilities Management (RFM) team are representatives from the Dean's Office supporting support the NUS Medicine Safety Committee through the implementation and operational control over safety policies, procedures and practices in research facilities at NUS Medicine. Their responsibilities include:

- Liaising and supporting the NUS Medicine Safety Committee to ensure NUS safety policies are met with high standards;
- Coordinating and supporting sustainable programmes that uphold the safety standards of the School including internal safety inspections and audits, training and communications;
- Managing and coordinating operations in line with national, institutional and the School's safety practices and requirements;
- Updating and communicating with the Dean on School's safety policies, procedures and practices in research facilities at NUS Medicine; and
- Communicating with the regulatory bodies with respect to national and institutional safety policies and regulations.

Central Research Building-specific Safety Committees

The Central Research Buildings that house research laboratories are under the purview of NUS Medicine Dean's Office. The Chairs of these Building-specific Safety Committees are appointed by Dean to promote and enhance laboratory safety at the respective buildings. Each committee comprises representatives from each of the research groups in the respective buildings and Dean's Office representatives (RFM).
The safety committees meet quarterly to deliberate on safety issues that affect all the research laboratories of the respective buildings. Members are also made aware of national and institutional safety regulations and act as the liaison personnel for the communication of safety issues to their research laboratories/groups. The members shall be responsible for:

- Reviewing laboratory safety policies applicable to the building's research activities;
- Monitoring the follow-up on all reported incidents/accidents concerning breach of safety issues involving the research laboratory/group;
- Developing policies, general guidelines, procedures and practices to improve the safety of the work environment;
- Conducting regular safety inspections/audits as well as spot checks for its research laboratory/group; and
- Participating in courses on safety issues for staff and students.

Departmental Safety Committee

The Head of Department (HOD) shall be responsible for the formation of a Departmental Safety Committee and appointing a Departmental Safety and Health Coordinator.
Each Departmental Safety Committee (DSC) is responsible for the implementation of safety policies and procedures within the Department. The committee should be chaired by a senior member of the academic or administrative staff who has knowledge of the workplace S&H and with ready access to the HOD. The committee shall:

- Make recommendations concerning the development, amendment and implementation of procedures and in-house regulations, and to put into practice, the University's and the School's S&H Policies for the Department;
- Coordinate the periodic evaluation of workplace conditions within the Department;
- Review remedial actions taken or as required following an incident or accident investigation. Assist in incident and accident investigation, if required;
- Monitor the corrective actions related to safety deficiencies;
- Coordinate safety training for Departmental staff and students; and
- Ensure that occupational safety concerns of all staff and students are addressed as soon as reasonably practicable.

Departmental Safety and Health Coordinator

The Departmental S&H Coordinator is appointed by their respective Head of Department as representative to the NUS Medicine S&H Coordinators Committee. His/her responsibilities are to:

- Ensure the development, implementation and monitoring of the School's and Department's S&H system and programmes at the Department;
- Serve as the contact point to align S&H matters between the School, OSHE and Department; and
- Provide guidance, advice and technical assistance to HoD and DSC on all S&H matters.

Supervisor / Principal Investigator

A Supervisor is the person or faculty member who is in charge of a workplace or has authority over staff, students, contractors or visitors under his/her charge.

The Principal Investigator (PI) is the faculty member in whose assigned space a research activity is conducted.

The Supervisor/PI shall be responsible for:

- Complying with the NUS Safety Directives, policies, practices and procedures set forth in the University and the School Safety Programmes. Although the Supervisor/PI could choose to delegate certain aspects of the programme, this does not absolve him/her from the ultimate responsibility. He/She remains accountable for all activities occurring in his/her work area (e.g., laboratory);
- Developing and implementing procedures for specific operations within his/her work area in order to minimize hazards;
- Performing risk assessment for all work processes conducted within the area of his/her charge;
- Informing all new employees, students, contractors and visitors of specific hazards and the hazard control procedures for his/her area of charge;
- Coordinating the provisions of medical surveillance, exposure monitoring, record keeping, training and other resources as appropriate;
- Ensuring adequate supply of Personal Protective Equipment (PPE) is available for all personnel requiring the necessary protection;
- Attending relevant safety training based on the hazards involved in his/her work;
- Ensuring the lab personnel attend relevant safety training organised by the Department, School and OSHE;
- Providing Laboratory-Specific Safety Training for his/her staff/students;
- Ensuring that his/her staff/students are adequately trained before they carry out activities which may pose a safety and health risk. Refer to NUS Safety Directive 0705 – link;
- Ensuring that his/her staff/students are adequately supervised when carrying out activities which may pose a safety and health risk. Refer to NUS Safety Directive 0701 – link; and
- Ensuring the S&H of students under their supervision who are performing research activities in non-NUS facilities. Refer to NUS Safety Directive 0704 – link.

Staff and Students

All employees and students working within the NUS Medicine shall be responsible for:

- Complying with the applicable legislative requirements and the established University's and the School's S&H policies and procedures;

- Refraining from any activity which may endanger the safety of themselves or any other persons;
- Participating in the relevant safety orientation and training provided by their supervisors, NUSMed and OSHE;
- Being knowledgeable about safe work procedures in the laboratory and work in a safe manner at all times. In particular, graduate students conducting research must attend and pass the safety test conducted by the NUSMed SC during the School's
- Introductory Laboratory Safety Course for Graduate Students before commencement of laboratory work. The course is conducted twice a year;
- Reporting any unsafe condition/practice as well as accident/incident to his/her Supervisor; and
- Using personal protective equipment where required.

Visitors and Contractors

Every person visiting or using the School's premises or hiring to conduct work (with or without contract) at NUS is responsible for:

- Complying with the applicable legislative requirements of the University's and the School's Safety policies and procedures; and
- Refraining from any activity which may endanger the safety of themselves or any other person within the work premises.

Safety Inspection

Updated: Dec 2019 Rev.3

Regular laboratory inspections must be performed to identify and record unsafe conditions/hazards for corrective actions. Departments may wish to develop their own checklist and inspection procedures to better suit their laboratories.

Responsibilities

Principal Investigators (PIs) / Supervisors

The Principal Investigators (PI) / Supervisors shall ensure that the laboratories are inspected regularly for potential hazards and unsafe acts. These observations and findings and their respective corrective actions shall be documented and made available for inspection by the NUSMed Safety Committee and the Office of Safety Health and Environment (OSHE).

Departmental Safety Committee

The Departmental Safety Committee shall ensure that regular inspections of laboratories are carried out. Records of observations and corrective actions, if any, shall be documented.

NUS Medicine Safety Committee

The NUS Medicine Safety Committee (NUSMed SC) shall conduct inspections of laboratories within the School. Observations and findings shall be recorded. An inspection report indicating the observations and findings with recommendations shall be forwarded to the respective Head of Department and the Principal Investigator or Supervisor concerned for their corrective actions.

Inspection Objectives

Inspections form an essential part of the School's Safety programme. They are conducted to:

- Listen to the safety concerns raised by researchers and supervisors;
- Gain further understanding of jobs and tasks in the laboratories;
- Identify existing and potential hazards;
- Determine underlying causes of hazards;
- Monitor hazard controls that have been put in place like personal protective equipment, equipment usage, policies, procedures, etc.; and
- Recommend corrective actions.

Types of Hazards

During an inspection, the inspection team should pay attention to items most likely to develop unsafe or unhealthy conditions. Typical hazards found in a laboratory include:

- Safety Hazards e.g., inadequate machine/equipment guards, unsafe conditions / work practices;
- Fire Hazards caused by various situations e.g., faulty electrical wiring, overloading of power socket, inappropriate storage of flammable chemicals, excessive storage of combustible materials;
- Biological Hazards caused by microorganisms e.g., viruses, bacteria, fungi or parasites;

- Chemical Hazards caused by chemicals in various forms e.g., solid, liquid, vapour, gas, dust, fume or mist;
- Ergonomic Hazards such as repetitive and forceful movements, vibration, extreme temperatures, awkward postures arising from improper work methods and improperly designed workstations, tools, and equipment.; and
- Physical Hazards caused by noise, vibration, energy, weather, heat, cold, electricity, radiation and pressure.

Inspection Checklists

A sample of Laboratory Safety Inspection Checklist (link) has been developed to guide the departments in the inspection process. It includes questions relating to fire prevention, electrical safety, chemical safety, biological safety, etc.

This checklist may be adapted or modified to suit individual areas or needs.

Types and Frequency of Inspections

The frequency of inspection is dependent on the nature of the work environment and the activities that are being undertaken. The types and frequency of inspections required under this procedure are indicated as:

NUS Medicine Safety Committee Inspections

The NUSMed SC shall conduct periodic inspections of laboratories and workplaces within the School. Departments are to assist the members of the inspection team during their inspection.

Frequency of Inspection: At least once a year or when the need arises.

Inspection Report
After inspection, an inspection report shall be generated containing the following:

- Name of Department and area/laboratory inspected;
- Name of inspector(s);
- List of observations and findings; and
- Recommendations for remedial action.

The completed report must be submitted to the immediate supervisor through the respective Head of Department for corrective action within the stipulated time frame.

Notice of Non-Compliance
Details of Non-Compliance and Corrective Action Plan shall be issued when unsafe practices or conditions are found during an inspection. The Notice shall contain descriptions of the violations/observations, the location and a time frame for remedial action(s) to be completed.

Upon receipt of this Notice, the PI or Supervisor shall rectify the unsafe condition as soon as possible. If the remedial action(s) cannot be completed within the stipulated time frame, the PI / Supervisor shall inform the NUSMed SC and propose a new date for completion.

After the corrective action(s) have been taken, the Principal Investigator or Supervisor shall provide an update to the NUSMed SC indicating the remedial action(s) taken and date completed.

Follow-Up Rectification Inspection
A follow-up rectification inspection shall be conducted by the NUSMed SC representatives to confirm that corrective actions had been taken.

Departmental Safety Committee Inspections

The Departmental Safety Committee shall conduct regular inspections of the Department's laboratories and workplaces. Inspection findings and corrective actions should be communicated to the personnel responsible.

Suggested Frequency of Inspection: Quarterly

Records of such inspections shall be kept and made available for future enquiries.

Laboratory Self-Inspection

In addition to the formal inspection indicated above, the PI / supervisor or their appointed representative should monitor daily activities like housekeeping, observation of safety practices, etc. A formal inspection shall be conducted on a regular basis and documented. Items like machine guarding, equipment operation, monitoring of contamination, proper storage of chemicals, etc. should be checked.

Suggested Frequency of Inspection: Weekly or twice a month

Infringement Penalty

Updated: Dec 2019 Rev.3

The purposes of this Safety Infringement Penalty System are:

- To establish a procedure for identifying the violation of safety and health rules and regulations.
- To formulate a system for recording non-compliance, preparation of non-compliance notice and their corresponding penalties.

Scope

It is the School's policy to provide and maintain a safe and healthy environment for all staff and students as well as visitors working on the School's premises. To achieve this, it requires all who are responsible for and involved with the work and those who do the work to take steps to in ensuring their own safety and that of others as well.

The procedure will apply to all staff, students and visitors working within the premises of the Yong Loo Lin School of Medicine.

Responsibilities

NUS Medicine Safety Committee

The NUS Medicine Safety Committee (NUSMed SC) shall be responsible to ensure proper compliance to this procedure. It shall be the authority for issuance of the non-compliance notices.

Departmental Safety Committee

The Departmental Safety Committee (DSC) should make checks to ensure that the Department and staff in the Department comply with the recommended guidelines. The DSC shall be responsible to ensure that submissions of the Corrective Action Plans by the offenders are made dutifully. The DSC shall ensure that all documentation for the procedure is properly filed.

Head of Department

The Head of Department shall ensure that every personnel working within the Department is aware of and complies with the School's policies, practices and standard operating procedures with regards to laboratory safety. They shall be responsible to ensure that non-compliances are rectified.

Principal Investigators

Principal Investigators (PIs) shall be responsible to ensure that his/her staff and students comply with the School's policies, practices and standard operating procedures with regards to laboratory safety. He/She shall ensure that non-compliances are rectified.

Staff and Students

Staff and students are responsible to ensure that they comply with the safety and health requirements stipulated in the Safety Manual.

Definition

Non-Compliance
An infringement, violation or offence pertaining to safety and health practices, rules and regulations, policies, etc.

Non-Compliance Notice
A notice to inform the PI of non-compliance of safety and health rules within his/her laboratory.

Penalty
An order to stop work in the area of safety and health non- compliance or a closure of laboratory for serious safety and health non-compliance.

Procedures
Non-compliances identified during the NUSMed Safety Committee's inspection of laboratories shall be documented. The categories of non-compliances and their respective penalties are listed below.

1. Critical Non-Compliance

A critical non-compliance is one where there is significant evidence of non- compliance and disregard of the Legislations and/or Safety Guidelines and there is a high damage to human health and/or the environment. A formal notification indicating the details of the non-compliances will be issued to the responsible PI.

A critical non-compliance can also be issued when three or more major non-compliance are identified in any one inspection.

Penalties: Immediate closure of laboratory.

Action: Immediate rectification of non-compliance. Submission of Corrective Action Plan. Re-audit by NUSMed Safety Committee before lifting of closure notice.

2. Major Non-Compliance

A major non-compliance is one where there is significant deviation from the Legislation and/or Safety Guidelines and where there is serious risk to human health and/or the environment. A formal notification indicating the details of the non-compliance will be issued to the responsible PI.

Infringement of any of the following areas will be considered a major non-compliance:

- Neglect of fire safety measures;
- Possession of certain biological agents and toxins regulated by the Biological Agents and Toxins Act requires the prior acquisition of a permit or approval from the Ministry of Health;
- Failure to do so is considered a major non-compliance by the University, and can result in legal action being taken by the Ministry;
- Neglect of radioactive work safety measures;
- Neglect of safety measures for storage and use of regulated hazardous materials e.g., hazardous substances, explosives precursors, poisons, petroleum & flammable materials, chemical weapons convention chemicals; and
- Any other serious breach of safety practices as reviewed by the NUS Medicine Safety Committee.

Penalties: Stop work for area of non-compliance.

Action: Rectification of the non-compliance. Submission of Corrective Action Plan. Re-audit by NUS Medicine Safety Committee before lifting of closure notice.

A major non-compliance is also one where ten or more minor non- compliance items/areas are identified in any one inspection.

3. Minor Non-Compliance

A minor non-compliance is a deviation from the Legislation and/or Safety Guidelines that does not constitute a serious risk to the environment or to human health. A formal notification of non-compliance will only be issued to the PI, following similar observation by one of the Inspection Teams on a second occasion.

Infringement of the individual items within the Laboratory Safety Inspection Checklist is considered a minor non-compliance.

Penalties: None

Action: Rectification of the non-compliance. Submission of Corrective Action Plan.

Upon receipt of the notice, the Principal Investigator shall consider the corrective action that he/she would take and prepare the corrective action plan. He/She shall complete the column on Corrective Action Plan in the Non-Compliance Notice and return it to the NUS Medicine Safety Committee within the stipulated time frame.

A follow-up inspection/review of the laboratory shall be conducted by the NUS Medicine Safety Committee to ascertain that the corrective action had been satisfactorily undertaken.

Sample of Non-Compliance Notice & Details of Non-Compliance & Corrective Action Plan (link).

Records

The following records must be documented and made available for inspection:

- Safety Inspection Report
- Safety Rectification Report

Laboratory Commissioning & Decommissioning

Updated: Dec 2019 Rev.3

Laboratory commissioning and decommissioning are to be conducted by the Faculty Safety & Health Officer and a Dean's Office representative from the Research Facilities Management team.

Laboratory Commissioning

Principal Investigators are to have their laboratories commissioned before starting bench work.
The checklist for lab commissioning, declaration form for possession of regulated materials and the NUS Laboratory Design Standard can be obtained via the following links.

- Lab Commissioning Form
- Declaration Form for Regulated Materials
- NUS Laboratory Design Standard

For phlebotomy room/area, a separate commissioning form can be found here.

Laboratory Decommissioning

All PIs who are decommissioning a lab or lab area prior to leaving the university, relocating to another University laboratory, or renovating their laboratory, are required to follow the procedure according to OSHE SOP on Laboratory Decommissioning Procedures.

A checklist for laboratory decommissioning is available here.

Biological Safety

Updated: Dec 2019 Rev.3

This section focuses only on work at the Biosafety Levels (BSLs) 1 and 2. For work in BSL-3 and above facilities, please refer to Laboratory Biosafety Manual by the World Health Organization and the NUS Medicine BSL-3 Core Facility Safety Manual.

Certain biosafety issues and local government regulatory requirements will be highlighted. It is not and does not attempt to be comprehensive. Researchers are recommended to refer to the WHO Laboratory Biosafety Manual for further information.

In establishing safe practices in the biological laboratory, it is paramount that appropriate and sufficient concern be given to the more esoteric and poorly understood risks, such as those arising from genetic manipulation, handling and culturing of tissues and microorganisms, etc. It should always be assumed that any microorganism and biological agent handled in the laboratory is capable of causing disease. This applies to material containing biological agents whose epidemiology and etiology are unknown or incompletely understood. Great care should therefore be taken in handling cultures, slides and all materials that contain or have been in contact with living microorganisms and questionable biological agents.

Any hazardous biological agent must be properly handled or disposed, so as not to constitute a health risk. It should be borne in mind that any accident/incident involving these biological agents may result in an infection. The main entry routes of infection to the body are: by inhalation, by ingestion, through cuts and abrasions and by infecting the mucous membranes (e.g., eyes). The majority of exposures often results from more subtle sources such as the production of aerosols during routine laboratory procedures. Safety procedures should be directed towards the prevention of infection.

Standard Microbiological Practices & Techniques

Updated Dec 2019 Rev.3

Standard microbiological practices and techniques MUST be strictly adhered to when working with infectious agents or potentially infected materials or any material of biological origin capable of causing harm to human and its environment. Personnel must be made aware of the potential hazards and must be trained to handle such material(s) safely.

In general, the following practices must be followed:

Good Housekeeping

- Work bench shall be kept clean and orderly at all times;
- Clean work bench with appropriate disinfectant before and after use;
- First aid kits, emergency showers and eyewashes, and spill kits shall be regularly maintained;
- The location of first aid kits, emergency showers and eyewashes, spill kits and fire extinguishers should be made known to all laboratory personnel;
- Avoid placing laboratory equipment or materials on the floor; and
- Avoid storing cardboard boxes in the cold room for long term.

Prohibited Activities and Items

- Do not eat, drink, smoke, apply make-up or handle contact lenses in the laboratory;

- Laboratory refrigerators, cold rooms and other laboratory equipment must not be used to store any food for human consumption. Food can only be stored, handled and consumed using designated refrigerators in specified rooms like pantries and tea-rooms;
- The laboratory work bench should be free of any personal items (e.g., pets/ plants/ soft toys) and items unrelated to experiments;
- No mouth pipetting is allowed. Use a mechanical pipetting device; and
- The content of laboratory waste bins should not be searched.

Personal Protective Equipment (PPE)

In handling of biological specimens, appropriate barrier protection (e.g., gloves, eye and face protection, lab coats) should be used at all times. Appropriate PPE (eye protection, lab coats, covered shoes) are to be worn at all times. Cover any abrasion, cut or open wound with adhesive plaster before beginning work.

Ear, Eye and Face Protection

- Safety eye protection shall be worn for all work that generates aerosols or splashes that are biohazardous in nature. Safety eye protection shall also be worn over normal prescription eye glasses and contact lenses for protection from splashes;
- Face shield should be worn when working with ultra-violet radiation, such as a UV trans-illuminator and lasers that are not shielded in a physical containment cabinet. Face shield should also be worn while handling cryogenics; and
- Hearing protection must be worn by all laboratory personnel in a designated room when using the sonicator.

Respiratory Protection

- Lab personnel shall undergo a fit test and medical fitness assessment prior to the use of N-95 and respirator. Refer to NUS Respiratory Protection Programme here.

Laboratory Coat and Other Protective Clothing

- Laboratory coat should be worn at all times in the laboratory;
- Do not wear the protective clothing outside the laboratory or in lifts;
- Laboratory coats should not be kept in the lockers where personal clothing is stored but placed on convenient hooks, preferably in the laboratory where they are worn; and
- All laboratory coats should be washed regularly and when contaminated, should be autoclaved before washing.

Gloves

- The use of the correct disposable (single use) gloves provides a barrier between infectious agents and the skin. Different types of gloves are used for various laboratory purposes, such as handling liquid nitrogen, dry ice and heat, etc. Hence, gloves must be selected on the basis of the materials being handled and the type of work undertaken;
- Contaminated disposable gloves should be disposed in the appropriate waste bags immediately after use;
- When double gloves are worn, the outermost pair of gloves should be removed first; and
- Wash hands frequently and always after removing protective clothing and before leaving the laboratory.

Shoes

- Proper footwear (closed-toe shoes) must be worn at all times in the laboratory.

Minimization of Aerosols

- Rapid and forceful ejection of the contents of a blow-out pipette can produce an aerosol. In general, slow and unhurried movements are to be preferred in microbiological work, but with minimum delays between operations.
- Aerosols can be generated while using pipettes, centrifuging tubes, heat-sterilising wire loops and during the removal of a screw cap or a rubber bung from a culture tube. Caution should be exercised in all procedures and manipulations to minimize aerosol formation.
- Homogenizers and blenders must not be used in conjunction with bacterial cultures without adequate precautions against the spread of air-borne contamination. Such processes should be done within a biological safety cabinet. Before opening a blender bowl, wait for at least 1 minute to allow the aerosol to settle.

Handling of Live/Viable Micro-organisms or Tissue Cultures

- Live cultures must not be removed from the laboratory without permission.
- All vessels containing viable biological material should be properly labelled to provide information to others in case of breakage and spillage. Label information should include: organism present, special features, if any, and name of the investigator responsible for it.
- Live micro-organisms and tissue cultures shall not be directly poured down the sink. It shall be decontaminated first either through autoclaving or using an appropriate freshly prepared disinfectant at a correct working strength for a period of exposure depending on the biological agent used.

Use of Syringes, Needles and Wire Loops

- Used needles, disposable syringes, scalpel blades, pipettes, and other sharp items are to be placed in puncture-resistant containers marked with a biohazard symbol for disposal by a licenced contractor via incineration.
- Used needles shall not be re-capped, bent, broken or manipulated by hand. Discard these items into the sharps container immediately after use to prevent accidental skin puncture. Where possible, use blunt-end needles instead of sharp hypodermic needles.
- Inoculating wire loops must be sterilized before and after use, by heating in a Bunsen flame until red hot along the entire length of the wire. Splattering of material from the wire should be avoided by very gradual introduction into the Bunsen flame. Loop should enter the coolest (central, blue flame) part of a hot Bunsen flame and then be lifted gradually into the hotter region above. The flame should be turned off when not in use. Never put flammable solution (e.g., beaker of alcohol) too close to an open flame. Do not leave open flame unattended.

Use of Test Tubes with Cultures

- Test tube cultures should always be kept in test tube racks and should not be placed horizontally on the bench top.

Sterilization and Disinfection of Items/ Equipment/ Wastes

- Used petri dishes and other culture vessels (tubes, bottles, etc.) should be put into the appropriate discard container for sterilization.
- Equipment which have been contaminated with live micro-organisms should be decontaminated or sterilized as soon as possible.
- Autoclave or otherwise disinfect contaminated items such as glassware and laboratory equipment before washing, re-using or discarding.
- Used glass pipettes must be placed in pipette jars containing freshly prepared disinfectant solution or appropriate biohazard sharps waste containers.
- Microscope slides and cover slips must be discarded into jars of disinfectant solution or appropriate biohazard sharps waste containers.
- Used disposable pipettes and inoculating loops should be discarded as biohazard waste if they have been in contact with live cultures or any biological agents.
- Biohazardous waste (e.g., contaminated lab ware, biological waste, etc.) must only be discarded into specifically assigned waste bin.
- The waste bins should be lined with two layers of appropriate autoclavable bags and opening of the lid is operated in a hands-free manner.

Autoclaving

- Autoclaves should be regularly maintained and checked to ensure that they operate at the required temperatures and pressures. In-use checks should be performed and usage records should be kept.
- Laboratory materials to be autoclaved should be placed in leak-proof containers/biohazard bags and properly labelled with autoclave tape.
- Used or clean glassware should be autoclaved separately from disposable waste. Used glassware should be rinsed following autoclaving, and then sent through the normal wash cycle.
- Containers should be available in each lab for the disposal of liquids and solids which are contaminated with microorganisms or mammalian cells.
- For large volumes of liquid waste, closed flasks or autoclavable bottles can be used.

Transportation of Biological Materials

Biological materials when transported between buildings must be in a secured double-container system. There should be no glass to glass contact; separate each tube on a rack or keep tubes separately bagged. If any material is dropped or spilt whilst being carried between buildings, the incident must be reported immediately to the Departmental Safety Committee Chairperson and the spillage must be treated immediately. The incident must also be reported to Accident & Incident Management System (AIMS) within 24 hours.

Biosafety Containment Levels

Updated: Oct 2018 Rev.2

The recommended biosafety containment is dependent on the transmission risk of the specific biological agents. A summary of the laboratory practices, safety equipment and facility requirements for biological agents assigned to BSLs 1, 2, 3 and 4 are described in the table below.

BSL	Agents	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
1	Not known to consistently cause disease in healthy adults.	Standard Microbiological Practices.	None required.	Laboratory bench and sink required.
2	Associated with human disease. Route of transmission include percutaneous injury, ingestion, mucous membrane exposure.	BSL-1 practice plus: • Limited access. • Biohazard warning signs. • "Sharps" precautions. • Biosafety manual defining any needed waste. Decontamination or medical surveillance policies.	**Primary barriers:** Class I or II BSCs or other physical containment devices used for all manipulations of agents that cause splashes or aerosols of infectious materials. **PPE:** laboratory coats; gloves; eye protection; face protection as needed.	BSL-1 plus: • Autoclave available.
3	Indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences.	BSL-2 practice plus: • Controlled access. • Decontamination of all waste. • Decontamination of laboratory clothing before laundering. • Baseline serum.	**Primary barriers:** Class II BSCs or other physical containment devices used for all open manipulations of agents. **PPEs:** protective lab clothing; gloves; eye protection; respiratory protection as needed.	BSL-2 plus: • Physical separation from access corridors. • Self-closing, double-door access. • Exhausted air not re-circulated. • Negative airflow into laboratory.
4	Dangerous/exotic agents which pose high risk of life-threatening disease; aerosol-transmitted laboratory infections have occurred; or related agents with unknown risk of transmission.	BSL-3 practice plus: • Clothing change before entering. • Shower on exit. • All material decontaminated on exit from facility.	**Primary barriers:** All procedures conducted in Class III BSCs or Class I or II BSCs in combination with full-body, air-supplied, positive pressure personnel suit.	BSL-3 plus: • Separate building or isolated zone. • Dedicated supply and exhaust, vacuum, and decontamination systems. • Other requirements outlined in BMBL text.

Adapted from Biosafety in Biological and Biomedical Laboratories, CDC, NIH & USHHS

The recommended biosafety containment is dependent on the transmission risk of the specific biological agents. A summary of the laboratory practices, safety equipment and facility requirements for biological agents assigned to BSLs 1, 2, 3 and 4 are described in the table below.

In the NUS Medicine, most microbiological work is carried out in BSLs 1 and 2 facilities. Principal Investigators (PIs) should consider using standard BSL-2 laboratory practices when handling and disposing genomic DNA and PCR products of human origin.

For laboratory work involving the use of macaque-derived materials, approval from IBC is required in addition to working in a BSL-2 plus facility.

For laboratory work involving the use of non-advanced lentiviral vectors, approvals from IBC and MOH are required in addition to working in a certified BSL-2 plus facility.

More details on the specific requirements and controls for working with macaque-derived materials and lentiviral vectors can be found in the NUS Biorisk Management Manual here.

Working at Biosafety Level 3 Facilities

Any laboratory work at BSL-3 must be approved by the NUS Institutional Biosafety Committee (IBC). More information can be obtained from the NUS Medicine BSL-3 facility.

The PI shall submit his or her training protocols to the IBC for approval. Refer to NUS Safety Directive 0703 here.

- Personnel shall undergo appropriate general safety training (e.g., chemical, biosafety, radiation, fire), BSL-3 work training and on-the-job training.
- Standard operating procedures including risk assessments shall be formulated for ALL procedures.
- Medical surveillance and immunization programme (where applicable) of all personnel involved shall be implemented.

Biological Safety Cabinet

Updated: Dec 2019 Rev.3

The use of a Biological Safety Cabinet (BSC) is to ensure the health and safety of lab personnel, to protect the research samples and to prevent the release of infectious materials into the environment. An appropriate type of BSC should be used in accordance with the class of BSL required for the biological agents used. Refer to the table below on the different types of BSCs.

BSC	Face Velocity (m/s)	Airflow (%)		Exhaust System	Application	
		Recirculated	Exhausted		Non-volatile Toxic Chemicals and Radionuclides	Volatile Toxic Chemicals and Radionuclides
Class I[a]	0.36	0	100	Hard Duct	Yes	When exhausted outdoor[1,2]
Class II Type A1	0.38 – 0.51	70	30	Exhaust to room or thimble connection	Yes (minute amounts)	No
Class II Type A2 vented to the outside[a]	0.51	70	30	Exhaust to room or thimble connection	Yes	When exhausted outdoor (Formerly "B3") (minute amounts)[1,2]
Class II[a] Type B1	0.51	30	70	Hard duct	Yes	Yes (small amounts)[1,2]
Class II[a] Type B2	0.51	0	100	Hard duct	Yes	Yes (small amounts)[1,2]
Class III[a]	Not Applicable	0	100	Hard duct	Yes	Yes (small amounts)[1,2]

Modified from WHO Laboratory Biosafety Manual, 3rd edition, and BMBL Manual, 5th edition.

[a] All biologically contaminated ducts are under negative pressure or are surrounded by negative pressure ducts and plenums.

[1] Installation requires a special duct to the outside, an in-line charcoal filter, and a spark proof (explosion proof) motor and other electrical components in the cabinet. Discharge of a Class I or Class II, Type A2 cabinet into a room should not occur if volatile chemicals are used.

[2] In no instance should the chemical concentration approach the lower explosion limits of the compounds.

Experiments involving all agents (especially mutant species) that are of BSL-2 and above should never be performed on an open bench. Approval from the IBC is required for such experiments. BSCs should be tested and certified annually by trained personnel for proper and optimum working conditions.

Safe Use of the BSCs

The BSC must be used correctly in order to obtain the protective benefits that it offers. In general, the following guidelines should be adopted:

- Ensure the cabinet is in working condition before use;
- Movement of arms in and out of the cabinet should be done slowly, perpendicular to the front opening, so that the airflow is minimally affected;
- All materials to be used in the BSC should be surface-decontaminated with 70% alcohol. Keep the amount of materials to a minimum;
- Materials should be arranged in the cabinet such that the work should flow from clean to contaminated areas across the work surface;

- Larger items, such as sharps bin, biohazard bags, pipette collection trays should be placed to one side of the interior of the cabinet. All used pipettes, glassware, etc. should be discarded into appropriate containers placed within the cabinet;
- All air grills and back plenum must not be blocked with any materials, as this will disrupt the airflow causing potential contamination and exposure to the user;
- Bunsen burners must not be used in the BSC. The heat produced will distort the airflow and may damage the filters;
- Ultraviolet lights are not required in BSCs. If they are used, they must be cleaned weekly to remove any dust and dirt that may block the germicidal effectiveness of the light. Ultraviolet light intensity should be checked when the cabinet is recertified to ensure that light emission is appropriate. Ultraviolet lights must be turned off while the room is occupied, to protect eyes and skin from inadvertent exposure; and
- The surface of the biological safety cabinet should be wiped using an appropriate disinfectant after work is completed and at the end of the day.

The cabinet fan should be run for at least 5 min before beginning work and after completion of work in the cabinet.

Safety Data Sheet for Infectious Substances

Updated: Dec 2019 Rev.3

The Public Health Agency of Canada website has a database of Safety Data Sheet (SDS) for infectious agents here. It provides a quick reference for laboratory personnel working with infectious agents. However, this list is not exhaustive and does not contain all biological agents known.

The SDSs are organized to contain health hazard information such as infectious dose, viability (including decontamination), medical information, laboratory hazards, recommended precautions, handling information and spill procedures.

Possession of Biological Agents and Toxins and Risk Group 2 Veterinary Biologics

Updated Dec 2019 Rev.3

All PIs shall declare the possession of biological agents and toxins regulated in the Biological Agents and Toxins Act (BATA) and Risk Group 2 Veterinary Biologics controlled under MOH and AVS respectively on an annual basis. The completed form should be endorsed and submitted to the Dean's Office through their respective Heads of Departments. For new agents, please inform FSHO and Dean's office at medbox50@nus.edu.sg before bringing them in.

Transportation of Biological Materials On/Off Campus

Updated Dec 2019 Rev.3

All biological materials should be transported in a way that maintains the integrity of the material during normal transport conditions, as well as prevents any accidental release and endangerment to the public and the environment. The transportation of all biological materials is prohibited by public transport.

Transfer within Campus (In-between Laboratories or Buildings)

Diagnostic and clinical specimens, infectious and biological materials need to be packaged in a sealed, leak-proof primary container (e.g., screw-capped tube), which is securely positioned in a secondary leak-proof and closable container and preferably lockable (e.g., cooler, ice chest) containing a clearly visible biohazard symbol on the outside.

A list of content and emergency information (e.g., PI's name and phone number) needs to be attached on the outside the secondary container. Other information needed include a statement that the container contains infectious substance, name of the agent, name, laboratory addresses and phone numbers of both the transferor and transferee.

Transportation and Shipment off Campus

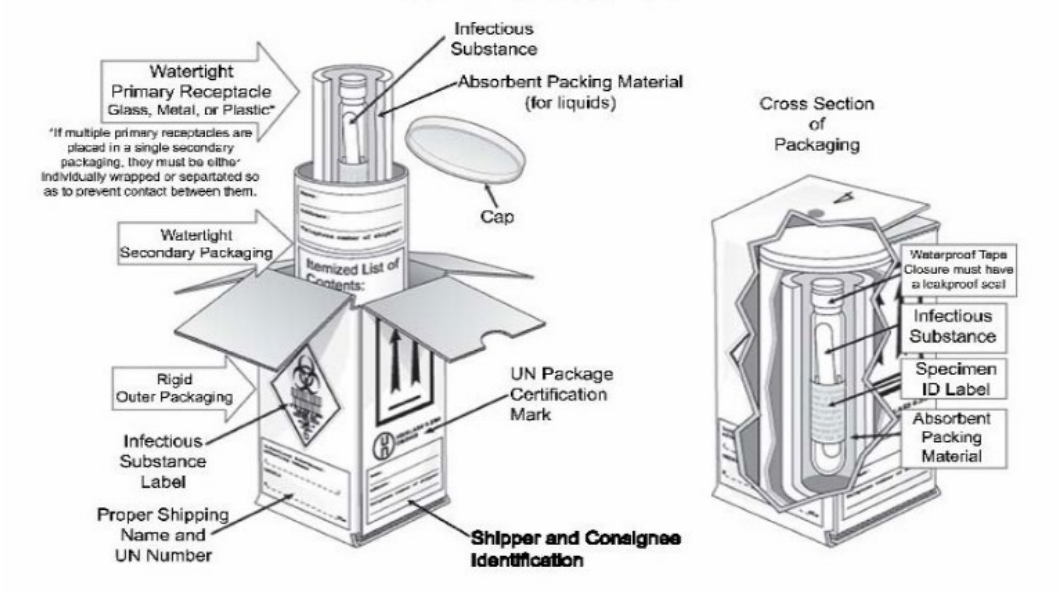
The shipment of diagnostic and clinical specimens, biological products and infectious agents is regulated by national and international transportation rules. These include specific procedures for the correct packing and packaging of these materials, necessary documentation and labeling and permits.

Refer to the following documents for details regarding shipping of such materials:

- The International Air Transportation Association (IATA), Dangerous Goods Regulations, (link);
- Biological Agents and Toxins Act (Transportation) Regulation (link); and
- The appropriate types of packaging recommended by the Biosafety in Microbiological and Biomedical Laboratories manual are as follows:

Category A Packing and Labelling

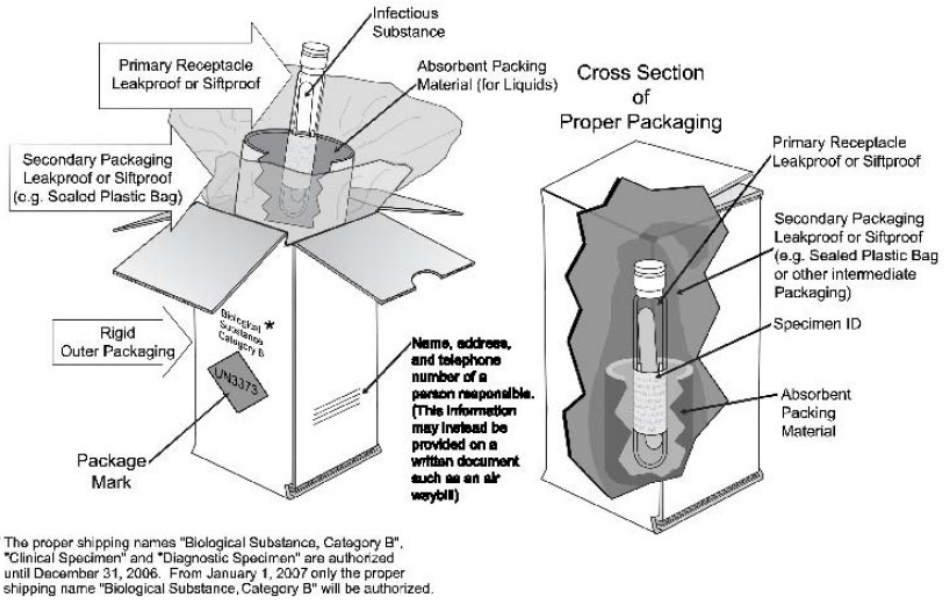
Category A material is an infectious substance that is transported in a form that is capable of causing permanent disability or life-threatening or fatal disease to otherwise healthy humans or animals when exposure to it occurs. The figure below illustrates the packing and labelling required for Category A.



Source: BMBL, 5 edition.

Category B Packing and Labelling

Category B infectious substance is one that does not meet the criteria for inclusion in Category A. A Category B infectious substance does not cause permanent disability or life-threatening or fatal disease to humans or animals when exposure to it occurs.



Source: BMBL, 5 edition

Percutaneous and Other Exposures to Infectious and Toxic Materials

Updated: Dec 2010 Rev.3

Percutaneous injuries and exposure to fluid splashes to the eyes and mucous membranes of the mouth and nose may result in laboratory-acquired infections, some may be serious or even fatal. The role of individual PIs, research staff, technical staff and students in both research and teaching laboratories in ensuring safe work practices is recognised, and the following checklist offered as a supplementary aid.

Transportation and Supervision Regarding Safety Issues

All staff and students should receive appropriate active support and guidance in these areas, both generally and with regard to the particular demands of their project activities.

Responsibilities and lines of communication

The responsibilities and lines of communication should be clear to all members of a research or teaching team who are responsible for safety within a laboratory. Team members must also be aware of how to contact appropriate senior staff in the event of an accident/incident. This may entail a PI of a laboratory having to nominate a colleague to cover leave periods. Contact numbers should be displayed prominently.

Design of experiments and protocols

- Staff should receive all appropriate immunizations, depending on their possible exposures. Hepatitis B and tetanus toxoid vaccines will be among the common recommendations.
- Whenever possible, the use of equipment which has the potential to breach skin should be avoided; for example by using soft plastic Pasteur pipettes to replace glass ones, if possible. Cuts on the hands should be covered with adhesive waterproof dressings.
- Gloves may be used when indicated and although they do not protect against sharps injuries, they can help to reduce the amount of inoculum in some cases. Injuries commonly occur due to poor housekeeping during the experiment. There must be proper sharps disposal containers located at the workbench. Improvised disposal containers should not be used, even for pipette tips.
- Do not pass sharps from one person to another.
- Do not recap needles. Where possible, use blunt-end needles instead of sharp hypodermic needles.
- Eye protection shall be used when handling infectious materials.
- Mouth/nose/face protection should be considered and employed if splashing of infectious fluids or toxic chemical agents is a possibility.
- Proper techniques should be used to minimize the risk of accidental skin puncture, splashing and aerosol production.
- Appropriate training, team work, use of recommended restraining devices, adequate anaesthesia and protective gloves can help to minimize animal bites and scratches.

Awareness of Spectrum of Risk

- In clinical practice, emphasis is often placed on blood-borne agents including HIV, hepatitis B and hepatitis C viruses. Many other microbial infections can be acquired by “sharps” and splash exposures. In the research laboratory, use of human-derived materials including blood and blood derivatives (including serum and cells), other fluids and tissues give rise to the same concerns. Other agents must also be considered, depending on the source (for example, use of animals) and known microbial hazards consequent to the nature of a particular research activity.

- It is important to be aware that human-derived material may be present in particular kits and reagents, for example, anti-sera; standards provided with serological and other kits; proteins added as stabilizers.
- Screening of human-derived material is useful but it should be remembered that it has limitations. For example, a serum sample may test negative for HIV antibodies, but still contains infectious HIV virions.
- The physician involved will need full and clear knowledge of what the individual concerned may have been exposed to, if correct action is to be taken.

All human-derived materials and reagents should be treated as potentially biohazardous and handled as such.

Biosafety Emergency & Disinfection Procedures

Updated: Dec 2019 Rev.3

Significant Exposure to Microbiological Agents

Accidental exposure to microbiological agents, including by the percutaneous route and by inhalation of aerosols, may result in infection. Exposure to cultures of a known microbe presents a defined hazard. Accidents involving clinical samples from patients or from healthy subjects may result in infection by a wide range of agents. Needlestick and other "sharps" injuries and splashes to eyes or mucous membranes involving exposure to material from clinical samples (including blood, other body fluids and tissues) always require assessment for the possibility of transmission of hepatitis B and C viruses and HIV.

All significant exposures during Office Hours should be reported immediately to the University Health Centre (Tel: 6776 1631). For on campus emergencies after Office Hours, please proceed to NUH Emergency Department (Tel: 6772 5000).

The chance of such exposure firstly should be minimised by the adoption of appropriate personal protective measures and safe working practices. Workers planning to work with a particular agent may draw up a contingency plan for such accidental exposures. Depending on the agent, measures to prevent infection or manage the consequences may include the adoption of one or more of the following:

- Vaccination;
- Post-exposure prophylaxis with antimicrobial agent(s); and
- Long term, follow-up.

Vaccination is important in the prevention of certain infections including hepatitis B and tetanus. Tetanus may result from animal bites and scratches among other injuries. Animal bites require immediate reporting to the University Health Centre (UHC) for optimal management. Monkey bites, scratches and saliva splashes to eyes may transmit herpes simian virus which can cause fatal encephalitis unless post-exposure measures are instigated.

Workers planning to work with clinical samples are recommended to seek advice on protection and post-exposure measures. There is a 4.1% prevalence of chronic hepatitis B virus infection in Singapore adults (MOH Clinical Practice Guidelines – Chronic Hepatitis B Infection 2011). Workers intending to handle any human samples, blood, etc., must be tested for immunity against hepatitis B beforehand. If their antibody levels are absent, Hepatitis B vaccination must be obtained and records kept. It is highly recommended that they complete a course of vaccinations based on the individual's serological results.

Disinfection of Blood and Body Fluid Spills

Spills containing clinical material are generally disinfected using a chlorine- releasing agent. Material containing prions requires special consideration and appropriate information and advice should be sought. Common household bleach comes in various concentrations of sodium hypochlorite as the bleaching agent. Bleach at certain dilutions has sometimes been recommended for disinfection of blood and body fluid spill. However it should be noted that the potency of such products cannot be guaranteed, particularly if old, inadequately sealed and/or partially emptied bottles are used, as hypochlorite concentrations drop over time in such circumstances.

Various commercial preparations (for example, "Presept" or "Haz-Tab" tablets) are available which may be dissolved for use when required. These provide fresh solutions and when dissolved according to the

manufacturer's instructions will provide available chlorine to described parts per million (ppm) levels. Attention should be paid to instructions provided: for example "Presept" and "Haz-Tab" tablets are manufactured in several different sizes and concentration and once prepared the active solution should be discarded within the time limit specified by the manufacturer. The total tablet weight should not be confused as supplied available chlorine per tablet.

The efficacy of a chlorine-releasing solution to act as a disinfectant is considerably reduced:

- by presence of organic material (e.g. serum and protein in blood);
- with storage; and
- by exposure to high temperature, oxygen and sunlight.

Hypochlorite and other chlorine-releasing disinfectants may cause corrosion of metals and this must be taken into account when decontaminating equipment. Whatever the choice of agent, the first priority must be safe and effective decontamination. Further information may be found in the WHO Laboratory Biosafety Manual, 3rd edition (Chapter 14 – Disinfection and Sterilization) or in NUS Laboratory Biorisk Management Manual.

Actions To Be Taken After Injury

Animal bites, scratches, cuts and needle stick injuries should be immediately washed with soap and clean water. Bleeding should be encouraged prior to reporting for treatment. Splashes to eyes or mucous membranes should be washed with copious amount of water.

All injured personnel must visit the UHC for treatment. The attending physician should be informed of the details regarding the injury as well as any suspected exposure and the biological agent involved. Out of working hours, they should visit the NUH Emergency Department for immediate attention then UHC later.

It is vital that individuals realize that they should seek medical advice **IMMEDIATELY**. For example, if exposure to HIV has occurred, post-exposure administration of anti-retroviral drugs should be instituted as soon as possible after the incident.

Follow-up

Generally follow-up will be instituted by the attending physician, but the individuals concerned need to maintain his/her own vigilance. Percutaneous and splash exposures may result in bacterial infections, including from the individual's own flora, and eye and hand infections can both be very serious. Obvious signs of infection like pain, reddening, local heat or swelling should prompt the subject to seek immediate medical assistance, and not to wait for any appointment already made.

Accident/Incident Reporting

All injuries must be reported to the PI or supervisor even if it is not felt to be serious at the time. Individuals must notify their PI or supervisor if they have any suspicion that they may have a laboratory-acquired infection, including one acquired from an experimental animal. Fever is a common, though not an invariable sign of most infections, and workers should also be made aware of specific clinical symptoms associated with infection by the agent(s) with which they work.

As well as making an immediate report to local senior staff (usually the PI or the senior teaching laboratory technologist) an accident/incident report must be made to OSHE. It is most helpful if the incident is described briefly but with sufficient detail, abbreviations defined when used, and immediate remedial

actions and follow-up procedures relevant to the person involved be outlined. To prevent future recurrences, the PI should also consider if laboratory methods and protocols need to be adjusted in the light of the incident in question.

All accidents/incidents must be reported at the Accident & Incident Management System (AIMS; link) within 24 hours.

Chemical Safety

Updated: Dec 2019 Rev.3

The objective of this section is to highlight laboratory practices that are important for protecting laboratory staff/students and the environment from exposure to hazardous chemicals. Implementation of appropriate controls and hazard communication are important to ensure safe use and storage of chemicals in the lab. Here different level of controls are discussed in relation with chemical safety.

Hierarchy of Control

Updated: Oct 2018 Rev.2

Implementation of appropriate controls and hazard communication are important to ensure safe use and storage of chemicals in the lab. Here the hierarchy of controls is discussed in relation with chemical safety.

Elimination/substitution

An effective form of hazard control in the laboratory. Staff/students are advised to adopt alternate procedures that utilize a less hazardous chemical or to substitute for a less hazardous form of the same chemical whenever possible. For example, the use of perchloric acid in some phosphate assays can be eliminated by using commercially available phosphate assay kits.

Engineering control

Protect the user by removing the air contaminants and/or provide a physical barrier when handling hazardous chemicals. The chemical fume hood is an example of engineering control.

Chemical fume hoods are useful when handling chemicals that are volatile and/or possess strong odors. Chemical should be handled at least 16cm behind the hood opening with the sash lowered to an appropriate level so as to ensure adequate protection of the user. In addition, the fume hood should be free of clutter to prevent reduced air flow and/or altered air flow patterns which can compromise extraction efficiency and user safety. Finally, the fume hood should be certified annually.

Administrative controls

Work procedures that include safety policies, supervision, laboratory specific trainings, standard operating procedures, GHS compliant chemical labels and Safety Data Sheets (SDS).

It is essential that users are well informed of the hazards before handling any chemicals. PIs/Supervisors have the responsibility to prepare the standard operating procedures for handling, storage and disposal of hazardous chemicals.

In addition, responses during an emergency, such as chemical spillage, should also be established. These instructions must be readily available and strictly adhered to avoid accidents and personnel injuries.

Manufacturers/suppliers are expected to provide SDS for their products. These data sheets contain detailed safety information about the chemicals purchased and, hence, should be filed as a reference guide in a central location of the laboratory. Personnel intending to use the chemicals should refer to the relevant SDS before commencing the experiments. When referring to the SDS, it is important to ensure that the data sheet is within 5 years from its published date and is GHS compliant.

Labels on Chemical Containers – chemical containers should be clearly labeled with their product identifiers and relevant hazard information. It is a good practice to also indicate the date of purchase, preparation and/or opening. When an emptied container is reused to contain a different substance, the old label should be completely removed or covered and replaced with a new label to prevent any misinformation.

Singapore has implemented the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) for chemical classification and hazard communication. Users of chemicals are required to comply with this guideline by end of 2012 for single chemicals/substances and mid of 2016 for mixtures.

Under this guideline, labels on chemical containers should ideally carry seven elements, illustrated below. However, it is recognised that in many situations, it is impractical to produce a complete GHS label in the laboratory. Thus provisions have been made whereby the principal investigators can use alternative means of labelling but must ensure that each container of hazardous chemicals is labeled with product identifier and words, pictures, symbols, or combination thereof, which will provide at least general information regarding the hazards of the chemicals. In addition, other information, e.g., safety data sheets, should be made available to employees to provide the specific information regarding the physical and health hazards of the hazardous chemical.

Procurement control can help to minimize risk exposure and accumulation of obsolete chemicals. Laboratories are encouraged to procure the minimal quantities of chemicals required for the prescribed research work. Storing large quantities of unwanted chemicals increases unnecessary risks and some chemicals may acquire hazardous properties over prolonged storage. For instance, concentrated picric acid may dehydrate over time during storage and form crystals that possess explosive properties. In addition, overstocking chemicals may lead to poorer management of storage spaces and incur unnecessary disposal costs in the future.

Before any procurement, it may be prudent to consider purchasing less hazardous forms of chemicals. The purchaser should also check the inventories for the existing quantities of chemicals to prevent overstocking. In addition, it is necessary to declare the procurement of chemicals through the Laboratory Material Management System (LMMS) set up by OSHE prior to any purchase. Staff / students may also use the Online Regulated Material Inventory to check if a particular chemical is regulated by any government authorities.

Personal Protection Equipment

This is the last line of defence and should be carefully selected and maintained to ensure effective protection.

- ***Eyes and Face Protection***
  Safety eyewear must be worn at all times while in a laboratory to protect the eyes. If the risk of splash is high or when handling volatile chemicals that can cause skin burns e.g., fuming acids, a face shield should also be worn.

- ***Respirators***
  In situations where a respirator, e.g., chemical cartridge respirator is required, staff/students are required to undergo a fit test and medical examination by the Occupational Health Physician.

- ***Laboratory coats***
  Inside the laboratory, staff / students should wear (buttoned) laboratory coats to protect them from potential contaminations and/or accidental splashes that may occur. These should never be worn outside the laboratory to prevent contaminating areas outside the laboratories.

- ***Gloves***
  Considerations on glove material and thickness should be made based on the chemicals being handled, the hazards involved, and dexterity required during operation. Disposable gloves should never be reused after handling hazardous chemicals and/or materials. Although nitrile gloves are deemed more suitable for handling chemicals, it is important to note that they may not be appropriate for heavy contact, e.g. submersion, with chemicals.

- ***Closed-toed shoes***
  Staff/students should always wear closed-toed shoes in the laboratory to protect the feet from any spills or splashes.

GHS Chemical Hazard Communication

Updated: Feb 2019 Rev.1

The Globally Harmonised System of Classification and Labelling of Chemicals (GHS) was developed by United Nations to align the classification and communication of chemical hazards. Singapore has adopted the GHS in 2002 and details of this adaptation can be found in the Singapore Standard, SS586:2014 Specification for Hazard Communication for Hazardous Chemicals and Dangerous Goods. Of note, chemical users must ensure that:

- Chemicals are labelled in accordance to GHS requirements;
- Safety Data Sheets are GHS compliant; and
- Hazard communication is in place to inform personnel about the hazards present and precautions needed.

The Office of Safety, Health and Environment, NUS, requires that all containers, packaging and cylinders containing chemicals (solid, liquid or gas) to be labelled in compliance with SS586. The label must be clear, legible and written in English. It must be affixed firmly on the container at all times, and be able to withstand the expected environment it is exposed to.

At a minimum, the label must contain the following information:

- Name of hazardous substances
- Chemical formula/ composition (if relevant)
- Chemical hazard pictograms/ symbol
- Date of purchase
- Date of first opening (especially important for peroxide-forming chemicals)
- Date of preparation (e.g. for solutions)

To assist laboratories with these requirements, Dean's Office has prepared the following notes.

GHS Hazard Classification

Updated: Feb 2019 Rev.1

Chemicals are classified based on their inherent properties or hazards in accordance with classification criteria specified in the GHS manual. There are 29 hazard classes described in GHS and they fall under three main type of hazards, i.e. Physical, Health and Environment.

Each hazard class is further divided into different categories depending on the varying degrees or severity of the hazard. To help convey these hazards, two sets of pictograms are assigned in GHS. One set is for labelling chemical containers and workplace hazard warnings while the other set is for use during the transport of dangerous goods. Here we will only look at the former. These pictograms shall not be used as a means to identify chemicals scheduled in legislative Acts. For instance, the Skull & Crossbones pictogram should not be used for substances scheduled in the Poison Act; the Exploding Bomb pictogram should not be used for substances scheduled in the Explosive Precursor Act.

S/N	Physical Hazard Classes	Health Hazard Classes	Environment Hazard Classes
1	Explosives	Acute toxicity	Acute toxicity
2	Flammable gases (including chemically unstable gases)	Skin corrosion/irritation	Chronic toxicity
3	Aerosols	Serious eye damage/eye irritation	Hazardous to the ozone layer
4	Oxidizing gases	Respiratory or skin sensitization	
5	Gases under pressure	Germ cell mutagenicity	
6	Flammable liquids	Carcinogenicity	
7	Flammable solids	Reproductive toxicity	
8	Self-reactive substances & mixtures	Specific target organ toxicity - single exposure	
9	Pyrophoric liquids	Specific target organ toxicity - repeated exposure	
10	Pyrophoric solids	Aspiration hazard	
11	Self-heating substances & mixtures		
12	Substances & mixture which, in contact with water emit flammable gases		
13	Oxidising liquids		
14	Oxidising solids		
15	Organic peroxides		
16	Corrosive to metals		

Safety Data Sheet
Updated: Feb 2019 Rev.1

Chemical suppliers (i.e. manufacturer, importer and distributor) are required to classify their chemical products in accordance to the GHS and present the information on **product labels (GHS label)** and **Safety Data Sheets** (SDS). If the chemical products are not produced locally, suppliers are required to obtain and provide this information to the purchasers.

As quality of the SDS may vary from supplier to supplier, it is important that **chemical users** check the SDS for completeness, (i.e. no missing pages, incomplete sections), accuracies (i.e. product name, supplier information), up-to-date (i.e. latest and no older than 5 years), and compliance with GHS requirements. In addition, according to the Workplace Safety & Health (General Provision) Regulation, it is the responsibility of the laboratory to ensure that the appropriate SDSs are obtained and made available to all personnel in the laboratory who are liable to be exposed to these hazardous chemicals (i.e. hazardous substances specified in the Fifth Schedule of the Act). Furthermore, the SDSs should be assessed (i.e. risk assessment) and appropriate precautionary measures shall be taken to ensure safe use of the hazardous chemicals.

Suppliers are required to review the SDS at least once every five years. However, if new or significant information is received, suppliers must reflect these changes in the revised SDS within six months. To ensure that the laboratory has the most relevant hazard information, it is suggested that the SDSs of commonly used chemicals be **reviewed annually** and ensure the remaining SDSs are no older than **5 years**.

Comprehensive Labelling of Chemical Containers in the Laboratory
Updated: Feb 2019 Rev.1

Ideally, the full GHS label should be used for all chemical containers in the workplace. There are seven elements required in a full GHS Label:

1. Product identifier

Name of the product in accordance with IUPAC, CAS or technical names listed on the SDS for the product. It provides a unique means by which a user can identify the product in a particular use setting e.g. transport or workplace.

2. Pictogram

It conveys the hazardous properties and hazard severity of a chemical. There are nine GHS pictograms assigned to represent different classes and categories of chemical hazards. Every product should be properly classified and assigned appropriate pictogram(s).

Explosive, Self-reactive & Organic peroxide

Flammables, Aerosols, Self-reactive, Pyrophoric, Self-heating & Emits flammable gas

Oxidiser

Corrosive

Carcinogen, Respiratory sensitizer, Reproductive toxicity, Target organ toxicity, Mutagenicity & Aspiration toxicity

Acute toxicity (severe)

Gases under pressure

Environmental toxicity

Irritant, Skin sensitizer, Acute toxicity, Narcotic effects, Respiratory tract irritation & Hazardous to the ozone layer

3. Signal words

They indicate the relative hazard severity and alert the reader to a potential hazard. There are two signal words used on a GHS label - “Danger” is for a more severe hazard while “Warning” is for a less severe hazard.

4. Hazard statements

These are phrases assigned to a hazard class and category to describe the nature and degree of the hazards of the product. All hazard statements should be included on the label for substance/mixture possessing more than one hazard.

5. Precautionary statements

These are phrases / precautionary pictograms which describe recommended measures that should be taken to minimise or prevent adverse effects resulting from exposure to a hazardous product, or improper storage or handling of a hazardous product. The number of precautionary statements should be kept to a maximum of six.

6. Supplementary information

The supplementary Information on the label of a product is provided by the manufacturer or supplier at its discretion. Such information should not lead to variation or undermine the GHS hazard information.

7. Supplier information

This is the name, address and telephone number of the manufacturer or supplier of the product.

In addition to the full GHS label, it is a good practice to include the laboratory/user identifier (i.e. PI/user initial), date of purchase/preparation/opening. This is especially important when two or more laboratories share a common storage facility e.g. flammable safety cabinet.

Download a comprehensive label template here.

Principles of Precedence

Laboratory should note that there is precedence in the allocation of pictograms, signal words, hazard statements and precautionary statements for hazardous chemicals classified in more than one hazard class. More information can be found in the Singapore Standard 586.

Of note are those in the following health hazard classes:

- If the skull and cross bone pictogram applies, the exclamation mark pictogram should not appear.
- If the corrosion pictogram applies, the exclamation mark pictogram should not appear.
- If the health hazard pictogram appears for respiratory sensitisation, the exclamation mark pictogram should not appear where it is used for skin sensitisation or for skin / eye irritation.

Concise Labelling of Chemical Containers
Updated: Feb 2019 Rev.1

It is recognised that a full GHS label may be impractical in certain situations. Hence, a reduced workplace label may be utilised when the chemical is:

- Used in a laboratory

- Decanted, transferred or dispensed from its purchased/supplied original container to a working-sized container
- In small containers (125ml or less)
- Sent out for research and analysis
- Not supplied to another workplace

This workplace label shall at least consist of information on the 1) product identifier and 2) GHS pictograms (red or black borders). If it is impractical to label the actual container, labelling its supporting apparatus/secondary container or tie-on tag is also acceptable. Similarly, it is a good practice to include the laboratory/user identifier (i.e. PI/user initial), date of purchase/preparation/opening.

Download a reduced workplace label template here.

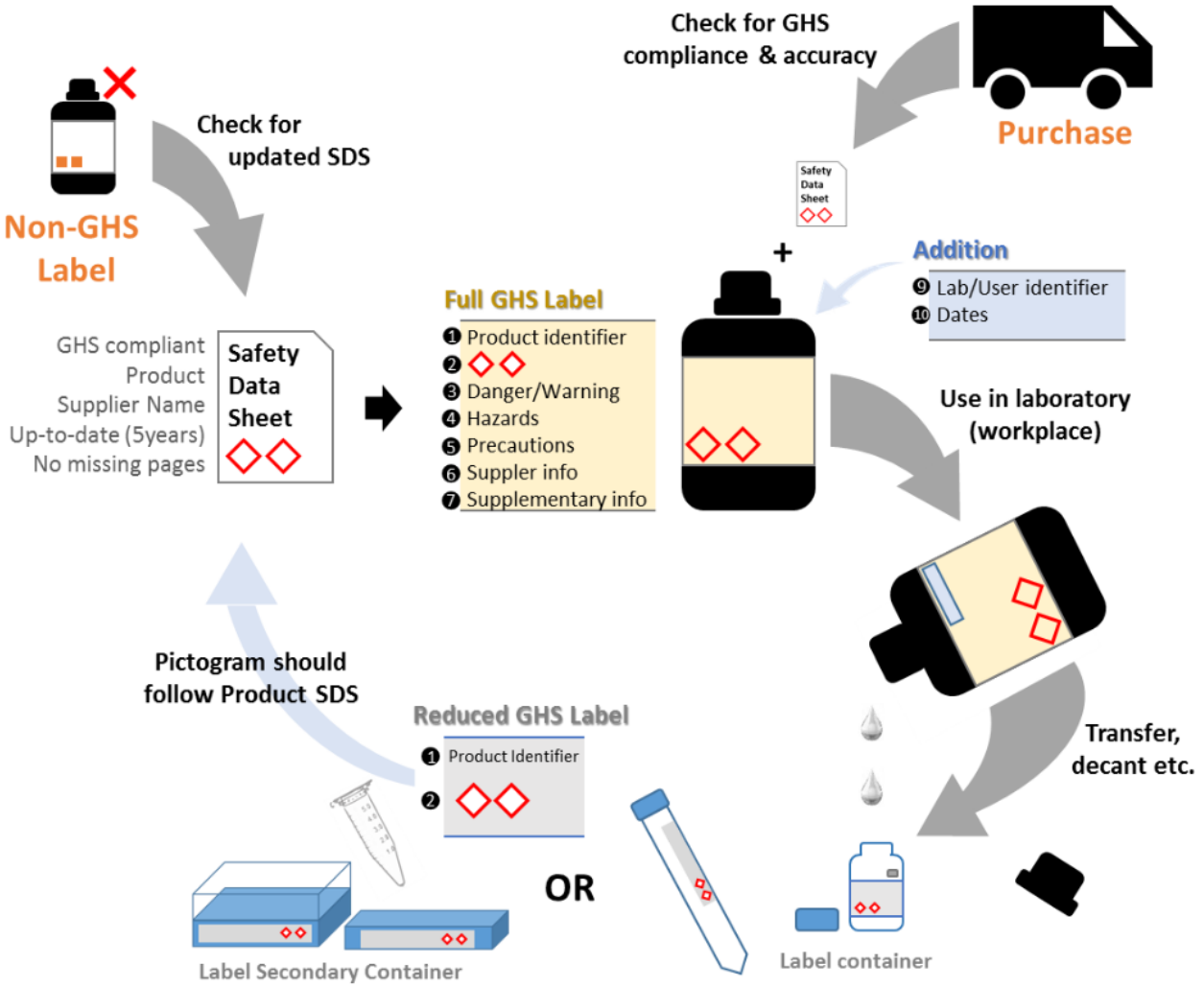
Principles of Precedence
Laboratory should note that there is precedence in the allocation of pictograms, signal words, hazard statements and precautionary statements for hazardous chemicals classified in more than one hazard class. More information can be found in the Singapore Standard 586.

Of note are those in the following health hazard classes:

- If the skull and cross bone pictogram applies, the exclamation mark pictogram should not appear.
- If the corrosion pictogram applies, the exclamation mark pictogram should not appear.
- If the health hazard pictogram appears for respiratory sensitisation, the exclamation mark pictogram should not appear where it is used for skin sensitisation or for skin/ eye irritation.

GHS Labelling Workflow in NUSMed Laboratory
Updated: Feb 2019 Rev.1

Upon receiving a chemical product, the GHS Label and SDS should be checked for accuracies. Hazard information should be copied onto the new container where the chemical product is transferred, decanted or dispensed. If it is not practical to affix a full GHS label, a reduced workplace label can be used instead. Labelling secondary containers is acceptable in some cases.



Dimension of Full GHS Label

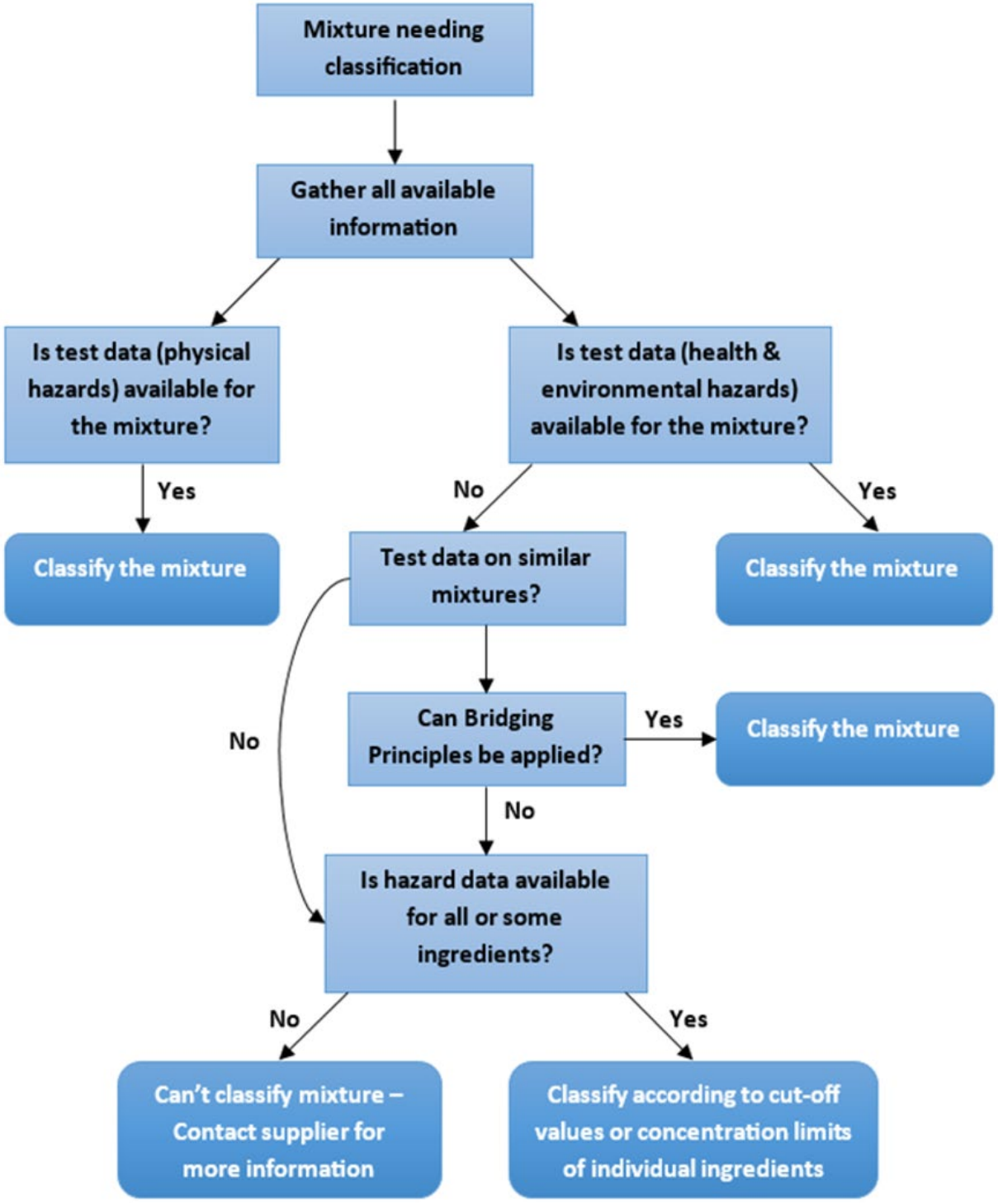
Container Volume	Dimension of Label (mm)
0.125 - 3 litres	if possible, ≥ 52 X 74
3 - 50 litres	≥ 74 X 105
50 - 500 litres	≥ 105 X 148

Hazard Classification of Lab Prepared Mixtures

Updated: Feb 2019 Rev.1

Due to the complex nature of research activities, laboratory preparations of two or more substances (mixture) are commonly made. To maintain effective hazard communication, mixtures shall be labelled in accordance to GHS requirements. Generally, mixtures can be classified based on available test data.

However, if these are not available, depending on the hazards involved, the following alternative methods can be used.



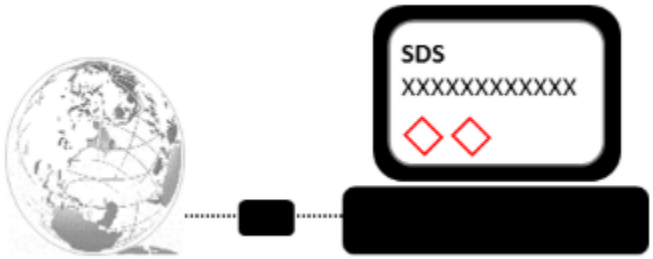
References

1. Singapore Standard SS 586:2008 on Specification on Hazard Communication for Hazardous Chemicals and Dangerous Goods.

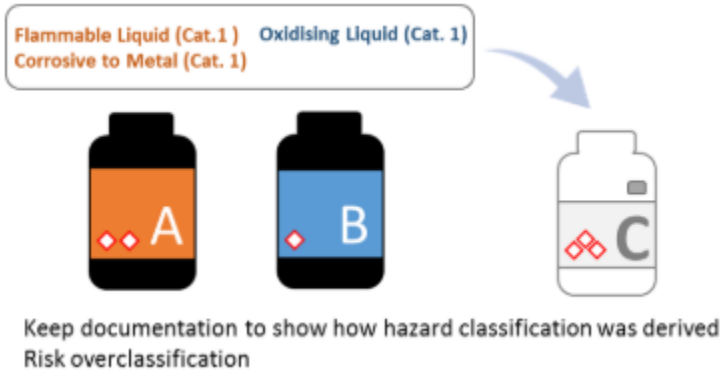
2. Guidebook on GHS of Classification and Labeling of Chemicals (link)
3. Workplace Safety and Health (WSH) Act and its related legislation (link)
4. United Nations Economic Commission for Europe (UNECE) GHS document (Rev. 4) (2011) (link)
5. For latest information on GHS in Singapore, please refer to the GHS Website (link)
6. ChemSafetyPRO - GHS Classification of Mixture (link)

Provisional Physical Hazard Classification
Updated: Feb 2019 Rev.1

Temporary measures for classifying mixtures with ingredients that possess one or more physical hazard classifications.



Provisional Approach 1 - If a SDS of substance that has the same constituent as Mixture C is available, the same hazard classification can be used for Mixture C. Laboratory must keep the SDS of the substance that has the same constituent.



Provisional Approach 2 - Mixture C assumes the hazard classifications of substances A & B regardless of concentration. Laboratory must keep the SDSs of substances A & B as documentation proof on how hazard classification was derived.

Bridging Principles
Updated: Feb 2019 Rev.1

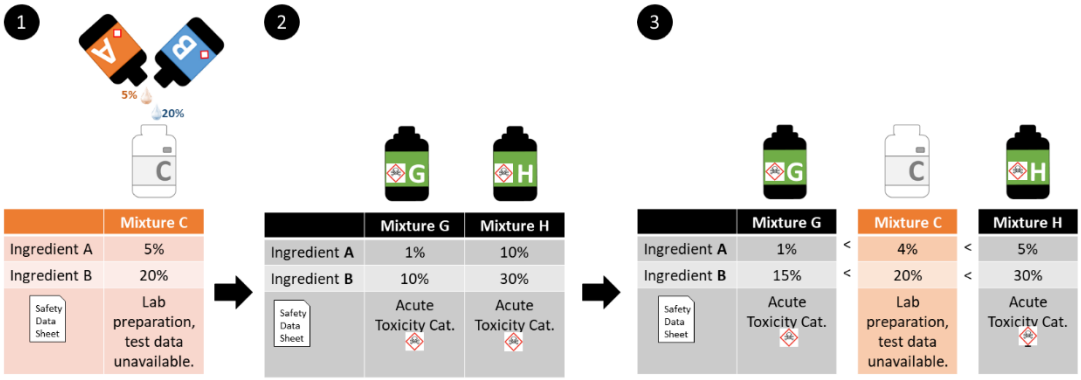
Health & Environmental Hazards Classification

Bridging Principles - Four relevant bridging principles are presented here and laboratory can choose the most appropriate one for classification. If none of the bridging principles is appropriate, laboratory should use the ***Generic Cut-off Values*** or ***Concentration Limits*** approach.

For ease of illustration, Mixture C refers to laboratory prepared mixture where test data is unavailable for health/environment hazard classification.

a) Interpolation from available hazard information

This bridging principle may be applied if SDSs of two mixtures containing identical ingredients, albeit different concentrations, to Mixture C are available. The two reference mixtures must be classified under the same hazard category. In addition, the concentration of ingredients in Mixture C must be intermediate to the concentrations in the reference mixtures.



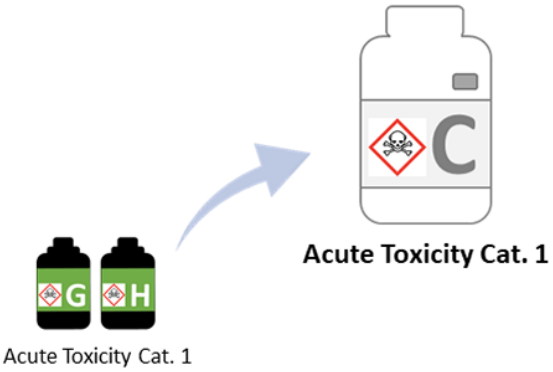
***Rationale**:*

Classification via interpolation can be applied because:

1. Mixture C was made up of ingredients A & B.
2. **Mixture A & B** had the same ingredients as **Mixture C** but in different concentrations. Safety Data Sheets of **Mixture A & B** showed that they have the same hazard classification.
3. Concentration of ingredients in **Mixture C** was ***intermediate*** to **Mixtures G & H**.

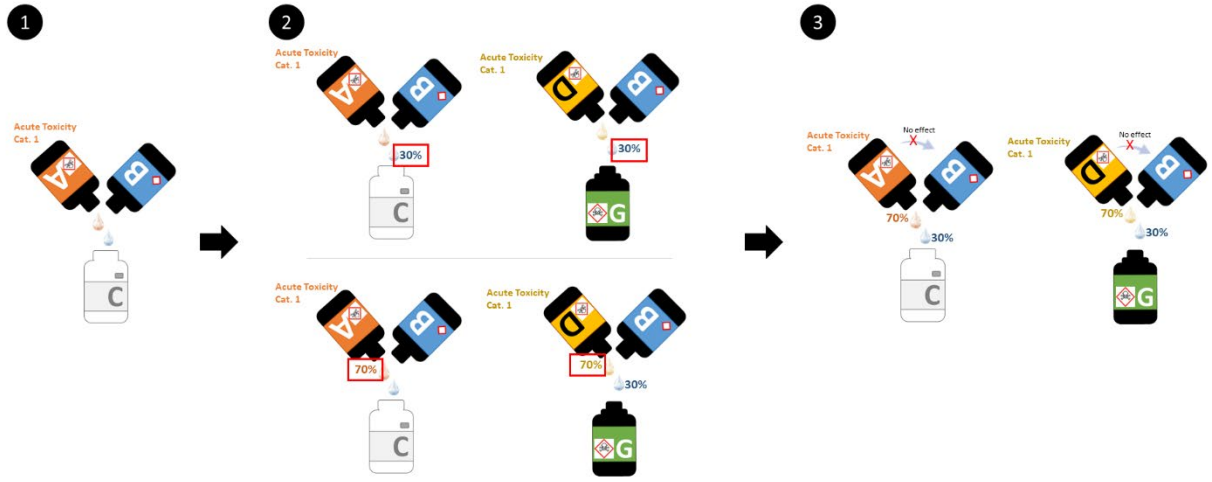
***Conclusion**:*

Following Mixture G & H hazard classification, Mixture C can be classified under **Acute Toxicity Category 1** without additional testing.



b) Substantially similar mixtures

Bridging may be applicable if the most relevant SDS found depicts a mixture that shares a common ingredient with Mixture C. In this case, the proportion of ingredients in the Mixture C should be the same as the reference mixture and the differing ingredient should not affect the hazard potential of the common ingredient.



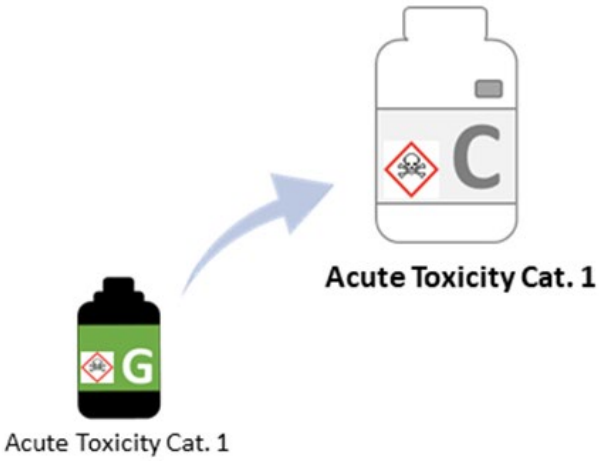
***Rationale**:*

Classification via the substantially similar mixtures bridging principle can be applied because:

1. Mixture C is made of Ingredients A & B.
2. Concentrations of Ingredient B in Mixtures C & G are the same. Concentrations of Ingredients A & D are also the same in Mixtures C & G, respectively.
3. Ingredients A & D not expected to affect toxicity of Ingredient B. Data on toxicity for Ingredients A & D are also available and equivalent.

***Conclusion**:*

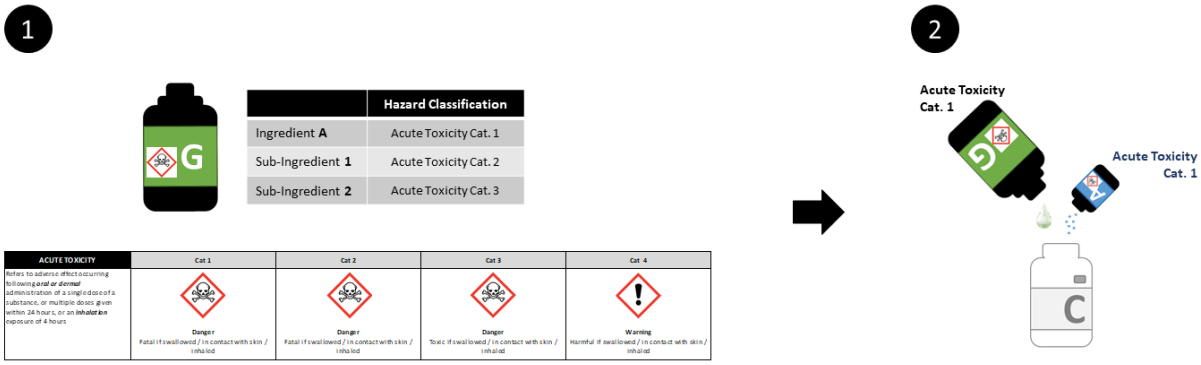
Following Mixture G hazard classification, Mixture C can be classified under **Acute Toxicity Category 1** without additional testing.



c) Concentration of highly hazardous mixtures

This bridging principle may be applied if the concentration of ingredient(s) in a tested mixture is increased to form Mixture C. The tested mixture must be classified in the highest sub-category of the hazard class as well.

For Germ Cell Mutagenicity; Carcinogenicity & Reproductive Toxicity, principle does not apply.



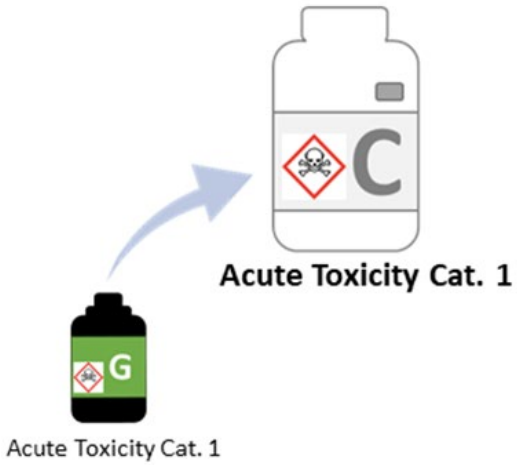
***Rationale**:*

Classification via the highly hazardous mixtures bridging principle can be applied because:

1. Mixture G classified under Acute Toxicity Cat. 1 and is made of Ingredient A with other non-"Acute Toxicity Cat. 1" ingredients
2. Mixture G is further concentrated with Ingredient A to make Mixture C.

***Conclusion**:*

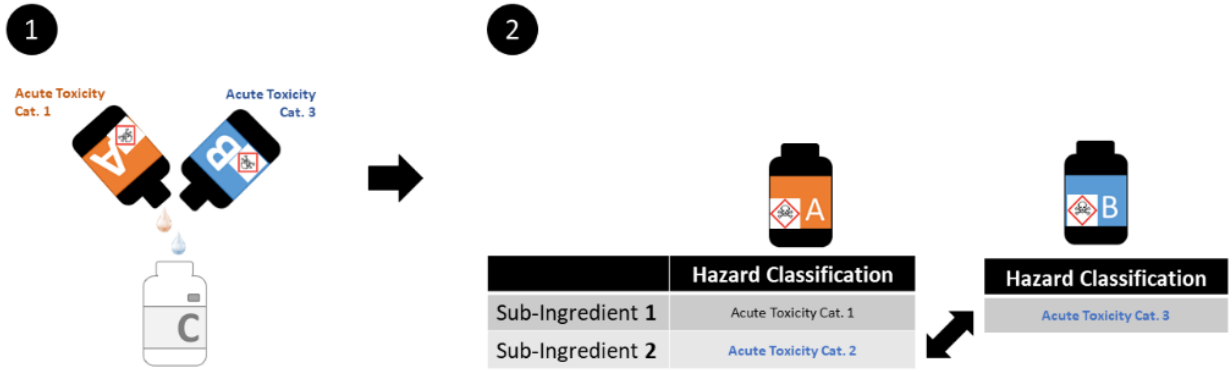
Following Mixture G hazard classification, Mixture C can be classified as **Acute Toxicity Category 1** without additional testing.



d) Dilution with substance of equivalent or lower hazard classification

This bridging principle may be applied if a tested mixture is diluted with a diluent which has an equivalent or lower hazard classification than its least hazardous ingredient to form Mixture C. The diluent is also expected not to affect the hazard potential of other ingredients in the tested mixture.

For Aspiration Hazard, principle does not apply if concentration of aspiration toxicant(s) falls below 10%.



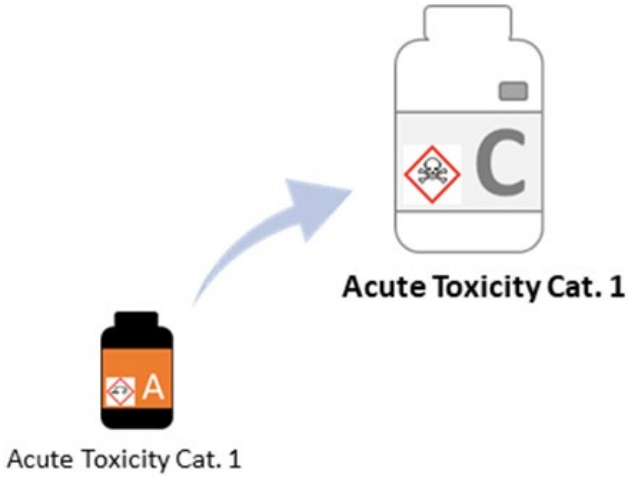
Rationale:

Classification via the dilution bridging principle can be applied because:

1. Ingredient B equivalent or lower than the least hazardous ingredient in A
2. Ingredient B not expected to affect hazardous properties of other ingredients.

Conclusion:

Following Mixture G hazard classification, Mixture C can be classified as **Acute Toxicity Category 1** without additional testing.



Generic Cut-off Values or Concentration Limits
Updated: Feb 2019 Rev.1

GHS cut-off value or concentration limit is the minimum concentration for a hazardous substance to trigger the classification of a mixture containing it. They are mainly expressed as % thresholds and are primarily used for mixture classification under GHS. The use of formulae or generic cut-off values/concentration limits may be necessary for untested mixtures and sufficient data is not available to apply the bridging principles.

Three types of calculations:

1. **Simple cut-off values/concentration limits** – The concentration of any ingredient exceeds a classification cut-off value.
2. **GHS summation methods (additivity approach)** – The sum of the concentration of ingredients in a mixture exceeds a classification cut-off value.
3. **Proportional calculations (additivity formulae)** – Toxicity for the mixture is calculated using the acute toxicity of each ingredient and its percentage in the mixture.

Hazard Class	Calculation Type		
	Cut-off values/ concentration limits	Summation method	Additivity formula
Acute toxicity			✓
Skin corrosion/irritation	✓ (NOTE)	✓	
Serious eye damage/eye irritation	✓ (NOTE)	✓	
Respiratory/skin sensitisation	✓		
Germ cell mutagenicity	✓		
Carcinogenicity	✓		
Reproductive toxicity	✓		
Specific target organ toxicity (single, repeated)	✓		
Aspiration hazard		✓	
Hazardous to the aquatic environment		✓	✓

Generic GHS Cut-off Values for SDSs

When concentration of chemicals meets the cut-off value of hazard classes, they will require classification. An SDS should be prepared and provided for a mixture meeting classification criteria or for a mixture containing a hazardous ingredient with a concentration exceeding the cut-off limits given in the table below.

Hazard class	Generic cut-off value to be taken into account
Acute toxicity (Category 1-3)	≥ 0.1 %
Acute toxicity (Category 4)	≥ 1.0 %
Skin corrosion/irritation	≥ 1.0 %
Serious eye damage/eye irritation	≥ 1.0 %
Respiratory/skin sensitisation	≥ 0.1 %
Germ cell mutagenicity (Category 1)	≥ 0.1 %
Germ cell mutagenicity (Category 2)	≥ 1.0 %
Carcinogenicity	≥ 0.1 %
Reproductive toxicity	≥ 0.1 %
Specific target organ toxicity (single exposure)	≥ 1.0 %
Specific target organ toxicity (repeated exposure)	≥ 1.0 %
Aspiration hazard (Category 1)	≥ 10% of Category 1 ingredient(s) and kinematic viscosity of ≤ 20.5 mm^2/s @ 40°C
Hazardous to the aquatic environment	≥ 1.0 %

Ignored ingredients

- Presumed not acutely toxic (e.g. water, sugar)
- Proven not to be classified based on valid data/information
- Substances with unknown acute toxicity if < 1%

Untested Mixtures – "Relevant Ingredients"

Acute Toxicity, Skin Corrosion/Irritation and Serious Eye Damage/Irritation

- Relevant ingredients - ingredients present in a concentration ≥ 1%
- Unless there is presumption that an ingredient is relevant at < 1% (e.g. Acute Toxicity Category 1 or 2, or Skin & Eye corrosive ingredients)

Environmental Toxicity

- Relevant ingredients - ingredients present in a concentration ≥ 0.1% (Acute and/or Chronic 1) and ≥ 1% for other ingredients
- Unless there is presumption that an ingredient is relevant at < 0.1% (e.g. highly toxic ingredients)

Acute Toxicity Example 1

- Classification where data are available for all ingredients of the mixture
- Using LD50 data values in the Acute Toxicity Estimate (ATE) calculation
- Ignoring ingredients that are presumed not acutely toxic

A mixture contains:

Ingredient	Weight percent	Available toxicity data	GHS category
Substance X	40%	Oral LD_{50}: 400 mg/kg	Category 4
Substance Y	20%	Oral LD_{50}: 200 mg/kg	Category 3
Substance Z	10%	Oral LD_{50}: 1,000 mg/kg	Category 4
Water	30%	Not applicable	Not classified

Apply formula from 3.1.3.6.1:

Acute oral toxicity:

$$\frac{100}{ATEmix} = \sum_n \frac{C_i}{ATE_i}$$

C_i = concentration of ingredient *i*;

N = number of ingredients, and *i* is running from 1 to n

ATE_i = Acute Toxicity Estimate of ingredient *i*

ATE_{mix} = Acute Toxicity Estimate of mixture

Acute oral toxicity:

$$ATE_{mix} = \frac{100}{(40/400 \text{ mg/kg} + 20/200 \text{ mg/kg} + 10/1000 \text{ mg/kg})}$$

ATE_{mix} = 476 mg/kg

Answer: The mixture is classified as **Acute Oral Toxicity; Category 4**.

Acute Toxicity Example 2

- Classification where data are not available for one or more ingredients of the mixture
- Converting range estimates into conversion values which are used in the ATE calculation
- Using the modified ATE formula for mixtures when the concentration of ingredients with unknown acute toxicity exceeds 10%

A mixture contains:

Ingredient	Weight percent	Available toxicity data	Conversion value from table 2	GHS category
Substance P	60%	Oral LD_{50}: 900 mg/kg	Not applicable	Category 4
Substance R	25%	Oral LD_{50}: Range value 50-300 mg/kg	ATE = 100 mg/kg	Category 3
Substance S	15%	No data available	Not applicable	Unknown

Apply formula from 3.1.3.6.2.3:

Acute oral toxicity:

$$\frac{100-(\sum C\ unknown\ if\ >10\%)}{ATEmix} = \sum_n \frac{C_i}{ATE_i}$$

Acute oral toxicity:

$$ATE_{mix} = \frac{100-15}{(60/900\ mg/kg + 25/100\ mg/kg)}$$

ATE_{mix} = 268 mg/kg*

Answer: The mixture is classified as **Acute Oral Toxicity; Category 3**.

** If corrected formula was not used, ATE_{mix} = 315 (Category 4)*

Skin Corrosion/Irritation Example

- Classification where data are available for all ingredients of the mixture
- Additivity approach applies for skin corrosion/irritation classification
- Ignoring ingredients that are not classified for skin corrosion/irritation

A mixture contains:

Ingredient	Concentration	GHS Skin Category
Hydrocarbon Solvent	95%	Not Classified
Primary Alkyl Amine	0.5%	Category 1
Biocide	0.4%	Category 1
Antioxidant	4.1%	Category 2

Skin Corrosion/Irritation Calculations:

Step 1: Add the Category 1 ingredients together to see if the mixture is classified under Category 1.

Category 1:	
Σ% Skin Category 1 ≥ 5%	0.5% + 0.4% = 0.9%

The sum of Category 1 ingredients is below the cut-off value for Category 1, therefore the mixture is not classified under Category 1.

Step 2: Add the Category 1 ingredients and the Category 2 ingredients together to see if the mixture is classified under Category 2.

Category 2:	
Add Category 1 ingredients together:	
Σ% Skin Category 1 ≥ 1% but < 5%	0.5% + 0.4% = 0.9%
Category 2 ingredient:	
Σ% Skin Category 2 ≥ 10%	4.1%
Add Category 1 & 2 ingredients together:	
Σ[10 x (Σ% Skin Cat 1)] + Σ% Skin Cat 2 ≥ 10%	(10 x 0.9%) + 4.1% = 13.1%

The sum of the Category 1 and the Category 2 ingredients is above the cut-off value for Category 2, therefore the mixture is classified under **Skin Irritant; Category 2**.

Download supporting Appendix.

Safe Storage

Updated: Oct 2018 Rev.2

Proper storage of chemicals is an important component of hazardous material management in the laboratory. Chemicals should be segregated and stored according to their hazard classification and applicable legislations. In addition, all chemicals must be stored separated from incompatible chemicals.

Staff/students should also note that "Acute Toxic" (represented by the skull and bone pictogram) is a hazard class used to describe certain substances in the GHS and "Poison" refers to substances scheduled in the HSA Poison Act. Hence, "Acute toxic" and "Poison" should not be used interchangeably as it may lead to confusion during storage and segregation. For instance, boric acid is not classified under "Acute Toxicity" in GHS but it is regulated by the HSA Poison Act. Consequently, the skull and bone pictogram should not be used to label poisons, instead the wording "Poison" would suffice for this purpose.

All regulated chemicals must be tracked with a chemical inventory record.

Safe Use of Liquid Nitrogen

Updated: Oct 2018 Rev.2

Liquid nitrogen is commonly used as a cryogen for the preservation and/or preparation of biological samples. Although it is an inert gas, careless handling can pose significant health risks to the users. Contact with liquid nitrogen (-196◦C) or objects cooled by it can cause severe cold burns. Consequently, staff/students handling them, should wear:

- Face shield to protect against splashes;
- Gloves that can insulate from the extreme temperature; and
- Covered shoes to protect the feet from any spillage.

Liquid nitrogen expands ~700-fold when it vaporizes at room temperature. In confined spaces, e.g. cold room, and/or areas with poor ventilation, the air can be rapidly displaced by the nitrogen gas, causing an oxygen-deficient atmosphere and risk of asphyxiation. Hence, storage of liquid nitrogen receptacles, e.g., dewars and tanks, and their refills should never be performed in such places. Furthermore, liquid nitrogen receptacles should only be transported in unmanned lifts. If necessary, staff/students should consider deploying a portable oxygen sensor to help warn them during the occurrence of an oxygen-deficient atmosphere. Expansion of liquid nitrogen in closed receptacles can cause them to burst due to the pressure that is being build-up within. As a result, staff/students should ensure that:

- Cryogenic vials stored immersed in liquid nitrogen should possess a thick thread with a sealing ring to prevent liquid nitrogen from seeping into the vials; and
- Receptacles containing liquid nitrogen should not be fully sealed and their vents, if present, are not blocked.

Hazardous Waste Management

Updated: Oct 2018 Rev.2

Collection of chemical waste should be done using a primary container that is in good condition and made of compatible material. The container must be labelled at the point of initial collection and staff/students must ensure that there are no misleading labels (e.g., manufacturer's labels on reuse bottles) are present. It is recommended that the collected chemical wastes are stored no longer than three months.

For highly hazardous chemical wastes, staff/students should consider arranging for their disposal as soon as possible.

Information on the labels should include:

- Constituent of chemical waste (name and percentage; chemical formula is not acceptable)
- Date of waste generation
- Contact information of Laboratory (i.e., name of PI, laboratory location and contact number)
  Information on hazard(s) present, e.g., GHS pictogram
  Secondary containers shall be provided for liquid waste to hold any possible leakages from the primary container. If feasible, it should have a volume that is large enough to hold the entire content of the primary container.
  Chemical waste should be stored in appropriate designated areas and segregated according to their hazard classification and applicable legislations. Chemical fume hoods should not be used to store the chemical waste unless there are compelling reasons to do so.

Chemical waste that do not meet the requirements described in the PUB sewage Act or contain substances scheduled in the NEA EPM Act must be disposed via a licensed waste collector. After disposal, a consignment note must be completed using the NEA e-tracking service and records should be kept for at least a year.

Information on the list of licensed waste collectors and the NEA e-tracking service can be found at here and here, respectively.

Other Work Practices

Updated: Oct 2018 Rev.2

Manipulation of Hazardous Chemicals

This should be done in primary containment equipment (e.g. chemical fume hood) with the necessary personal protection equipment. When using gloves, it is important to ensure that the glove material and thickness are suitable for the intended task. Disposable gloves should not be reused after handling hazardous chemicals even though there are no visible signs of contamination. In addition, staff/students should not wash the disposable gloves under the tap to remove any contaminants and prolong their usage.

Working Alone and/or After Working Hours

Working with hazardous chemicals in the laboratory alone or after office hours is discouraged. If necessary, staff/students should inform their supervisors and/or at least one laboratory colleague of their plans. The informed supervisor and/or colleagues should check in to make sure that the staff/student has completed the work and has left the laboratory safely.

Unattended and/or Scaled-up Experiments

Unattended and/or scaled-up experiments involving hazardous chemicals should not be performed without prior approval from the supervisors. The necessary risk assessment should also be carried out to ensure that the experiment can be performed without compromising the safety of the staff/students and the environment.

Chemical Transportation

Hazardous chemicals shall be transported in a secondary container to help contain any possible leakages. As far as possible, the secondary container should be shatter-proof, sealable and able to hold the content within itself during an accidental breakage of the primary container. Consequently, it is important that the secondary containers are made of materials compatible to the chemicals being transported.

Staff/students transporting hazardous chemicals outside the laboratory areas should not wear their PPE so as to avoid contaminating the public areas.

During chemical transportation, staff/students should choose routes with the least traffic and use the stairs and/or service lifts whenever possible. Areas, such as canteen and passenger lifts, should be avoided as far as possible. In cases where highly hazardous chemicals (e.g., explosives, chemical waste), cryogens or compressed gas tanks are transported in the service lifts, staff/students should be sent these items to the designated floor unmanned.

Ethidium Bromide and Alternatives

Ethidium bromide (EtBr) is commonly used for visualizing DNA under UV illumination. Due to its health hazardous properties, “safer” alternatives had been available by some manufacturers. However, there is currently a lack of comprehensive studies to validate / quantify such claims. Hence, staff/students are also advised to handle these agents with the same level of precautions as EtBr. In addition, all unwanted items and medium, e.g. gels and buffers, containing/contaminated with EtBr and its “safer” alternatives must be handled as cytotoxic waste and should not be discharged into the public sewage or disposed as general waste as directed by PUB and NEA.

Radiation Safety

Updated: Oct 2018 Rev.2

Work with radiation sources are governed by the Radiation Protection Act (link). Information regarding regulations and recommended procedures for working with radiation sources in order to protect staff and students and to prevent spread of contamination are provided here.

Radiation Licensing

Updated: Oct 2019 Rev.3

All personnel intending to work with radioactive materials or irradiating apparatus must receive formal training on radiation safety and protection and subsequently obtain a Radiation Licence from the Radiation Protection and Nuclear Science Department (RPNSD) at the National Environment Agency (NEA).

Responsibilities of the Principal Investigator

Principal Investigators (PIs) are directly responsible for compliance with all regulations governing radiation safety in the laboratory, and for safe practices of individuals working under their supervision.

Responsibilities of the Licencees

All licencees working with radioisotopes must ensure that they prevent harmful exposure not only to themselves but also to others, and prevent contamination of the work areas or environment.

Application of Radiation Licences

For Radiation Licence Application, allow at least two months for administrative processing after submission. Application of NEA Radiation Licences are submitted through GoBusiness Licensing (link).

Responsibilities

Supervisor (L6 Licence Holder)
Supervisors are responsible to ensure that his staff / students have valid licences prior to commencement of work involving radioactive materials.

Supervisor (L5 Licence Holder)
Supervisors are responsible to ensure that his staff / students have valid licences prior to commencement of work involving irradiating apparatus.

Radiation Safety Officer
Departments shall appoint a Radiation Safety Officer who will be the liaison person regarding radiation safety matters.

Faculty/ School (L4 Licence)
The Faculty/ School holds this licence to possess radionuclides for use. Users of radionuclides are responsible to inform the Faculty/ School to include the types and sources of radionuclides materials that they will be using for their work in the L4 licence before they can purchase them. Please contact the RFM team at medbox50@nus.edu.sg for such changes.

Legislative Requirements

Licences are required for the import, export, sale, manufacture, dealing in, possession and use of radioactive materials and irradiating apparatus under the Radiation Protection Act and its subsidiary legislations. A licence is also required for the transport of radioactive materials.

Licences are issued by the Radiation Protection and Nuclear Science Department, National Environment Agency (RPNSD, NEA). The types of licences are as follows:

Ionising Radiation (IR)
L1 - To manufacture, possess for sale or deal in irradiation apparatus.
L2 - To manufacture, possess for sale or deal in radioactive materials.
L3 - To keep or possess an irradiating apparatus for use other than sale*. (for individual equipment owner)
L4 - To keep or possess radioactive materials for use other than sale* (licence under School).
L5 - To use irradiating apparatus (other than sale)* (for individual PI/Supervisor)
L6 - To use, handle and transport radioactive materials (other than sale)* (for individual PI/Supervisor)
L6A - To handle and transport radioactive materials.
L7A - To import a consignment of irradiating apparatus.
L7B - To export a consignment of irradiating apparatus.
L8A - To import a consignment of radioactive materials. To transit a consignment of nuclear materials
L8B - To export a consignment of radioactive materials
R1 - Registration as a radiation worker* (students and workers based on L5 or L6 of PI)

Non-Ionising Radiation (NIR)
N1 - To manufacture or deal in the apparatus specified in Parts I, II and III below.
N2 - To keep or possess for use the irradiating apparatus specified in Parts II and III below*.
N3 - To use the irradiating apparatus specified in Part III below* (Each individual person operating laser needs to apply for this licence. No need N3 to operate sonicator).
N4A - To import the irradiation apparatus specified in Parts I, II and II below.
N4B - To export irradiation apparatus specified in Parts II and III below.
** Licences applicable to the School.*

Classification of NIR Irradiating Apparatus
Part I - Ultraviolet sunlamps, microwave ovens, fetal heart monitoring doppler non-imaging ultrasound apparatus and any other industrial ultrasound apparatus with power output of not more than 1200W^, and any apparatus with any or combination of the above as part of the apparatus. (^ *wef 01/08/2019*)
Part II - Medical diagnostic imaging ultrasound and therapeutic ultrasound, industrial ultrasound apparatus with power output of 1200W^ or more, and magnetic resonance imaging apparatus. (^ *wef 01/08/2019*)
Part III - Apparatus or entertainment laser containing Class 3b or 4 laser.

Laser Licence Application

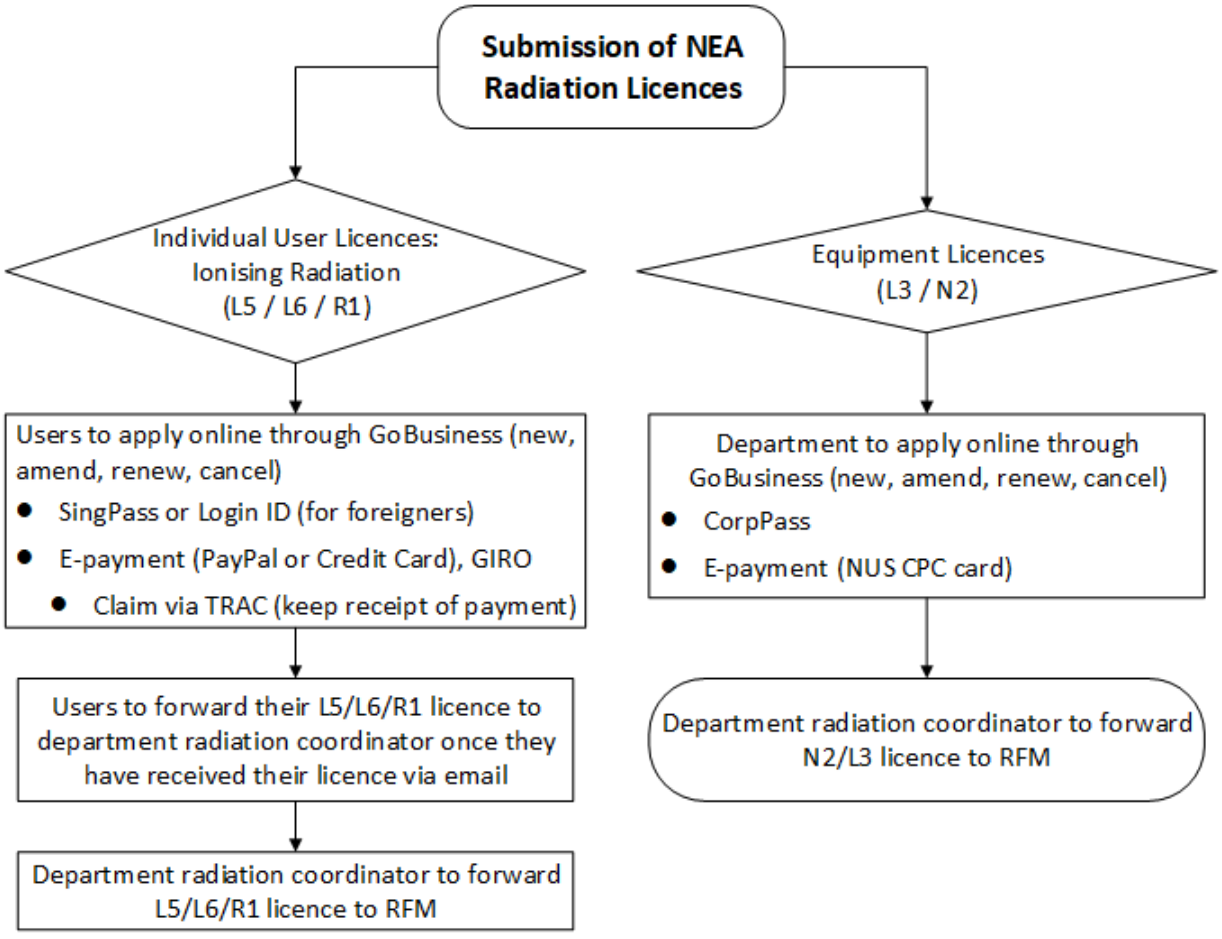
All staff, research fellows, graduate and undergraduate students participating in Undergraduate Research Opportunities Programme (UROP) & Final Year Honours Programme would need to obtain a N3 Licence for the possession and use of Class 3b and 4 lasers.

Students exposed to Class 3b and 4 lasers in the course of teaching experiments in undergraduate modules need not be subjected to licensing procedures by NEA provided they are adequately supervised during the course of the experiment by an academic staff or laboratory supervisor.
A Class 3b or Class 4 laser which is fully enclosed is considered as a Class 1 exempt laser. No N3 licence is necessary unless laboratory staff is to carry out maintenance and servicing job to the laser system.

Licence Application Process

All personnel intending to work with irradiating apparatus or radioactive materials are to refer to the RPNSD's website for the licence that is applicable to them. They are to do the following:

- Complete and pass the Radiation Safety (Ionising) Course conducted by OSHE (through IVLE);
- Go for their medical examination if necessary. The form for Request for Medical Examination can be obtained here if medical examination is done at the University Health Centre. Appointment for medical examination is to be made with Occupational Health Services; and
- Apply for radiation licence at GoBusiness Licensing (link). Allow at least two months for administrative processing.
- To obtain a Thermoluminescent Dosimeter (TLD) or radiation badge, please inform the RFM team at medbox50@nus.edu.sg of your approved licence.



Unless exempted, RPNSD may require applicants to sit for a qualifying test. A licence together with the monitoring dosimeter will be issued by the RPNSD once the application has been approved.

The licence holder is responsible to ensure that his/her dosimeter is returned to RPNSD for analysis at the end of the monitoring period through the Research Facilities Management (RFM) team. RPNSD will impose an administrative fee on the licence holder for loss of the dosimeter.

Ionising Radiation Safety & Protection

Updated: Oct 2018 Rev.3

Personal Protection

- Personal dosimeters (issued with a licence) must be worn at all times while working with radioactive materials. Dosimeters are not to be shared as the radiation dose received by each user is logged by the RPNSD.
- Double gloves should be worn during the procedure. This will permit changing of a contaminated outer glove while still receiving protection from the inner glove.
- Do not handle with gloved hands any items that are accessible to other personnel who do not wear gloves (e.g., the radiation monitor, door knobs, keyboards, etc). Personnel may have to wear and remove gloves several times during a procedure.
- A laboratory coat, eye protection and impervious closed-toe shoes must be worn to protect against splashes.
- Radioactive materials that present an inhalation hazard, e.g. unbound Iodine-125 or Iodine-131, should only be handled in a ducted fume cupboard or a ducted biological safety cabinet.
- When working regularly with high activities (except low energy beta emitters mentioned below), a ring dosimeter may be worn under the gloves to monitor dose towards the palm of the hand where the highest radiation exposure occurs.

Monitoring Equipment

A suitable radiation monitor must be in place before the start of the experiment. The choice of monitor may depend on the type and energy of the radioisotope to be used. Advice can be sought from the Faculty Safety and Health Officer or the vendor of the product. The radiation survey equipment should be sent to RPNSD for calibration annually. All personnel working with radioactive materials should receive proper training for the correct usage of the monitoring equipment.

Workstation

Radioactive work should be carried out in a designated work area. The area designated for the radioactive work should be kept clear of materials not required for the experiment and should have the following:

- Prominent warning stickers bearing the universal ionising radiation hazard symbol below;

- A shield that is suitable for the radionuclide to be used;
- A tray with raised edges that can accommodate all materials required for the work;
- Work surfaces covered with plastic-backed absorbent paper;
- A waste bin of the same material as the shield. The waste bin should be lined with the red disposal bag that bears the universal ionising radiation hazard symbol;
- Spill clean-up materials (e.g., detergents, gloves, shoe covers, absorbent materials such as paper towels, vermiculite, tongs);
- The experimental protocol, in point form and large print, should be taped at a working eye-level for quick reference by the personnel; and

- Workstation and equipment should be monitored for radioactive contamination before and after the procedure.

Apparatus

Where possible, use disposable materials to minimise the need for decontamination. Equipment to be used should be labelled with the universal ionising radiation hazard symbol and should not be indiscriminately used for non-radioactive work. Where possible, all equipment to be used, including disposable plastics such as pipette tips and tubes, should be placed behind the shield and within easy reach of the personnel.

Dry Run

The entire protocol should be carefully planned in advance to minimise unforeseen problems and mistakes while working with the radioactive materials. A preliminary run-through should be conducted without the radionuclide. This will build confidence in handling the radioactive substances in the actual experimental situation.

Handling of Radioactive Materials

While handling radioactive material, the worker should constantly remain behind the shield. The source container should be opened for as short a time as possible. Tongs may have to be used to handle high activities of any radionuclide whilst temporarily in a container which does not provide sufficient shielding.

At all times the personnel should maximise the distance from the source, minimise time of exposure and use shielding where appropriate.

Supervision

Supervision from a trained person should be sought if the worker is uncomfortable with or is not confident of handling any radioactive material.

Storage and Record of Radioactive Materials

Radioactive materials should be stored appropriately in a designated area. The storage cabinet, fridge or freezer should be lockable and the key shall be kept by a responsible person. A record of the quantities taken and the quantity left shall be maintained and checked regularly. A list of stored radionuclides should be pasted onto the door of the storage cabinet, fridge or freezer.

Regular Monitoring

All staff working with radionuclides should record the location in the laboratory where the work is to be carried out and the radiation levels in this area (benches, etc) before and after the experiment.

Throughout the procedure, the radiation monitor should be turned on for constant audible surveillance of the work area. The window of the probe should face towards the work area. Do not place the radiation monitor in a position that will lead to its contamination. It may be expedient to monitor gloved hands occasionally during the procedure (but do not contaminate the monitor).

For work with low level activity radionuclide (e.g. 3H), regular monitoring of the area should include a wipe test.

Post-Experiment Clean-Up

Updated: Oct 2018 Rev.2

On completion of the work, the following clean-up procedure should be performed:

- Check the work area with the radiation monitor at its most sensitive setting;
- Check all equipment and apparatus that have been used for possible contamination;
- Remove all uncontaminated material, equipment and glassware;
- Dispose, or decontaminate, items that have been contaminated;
- Check the entire work area that has been used and if necessary, use wet absorbent paper (with foaming detergent, if necessary) to wipe till the monitor readings are reduced to near background or pre-experiment levels;
- Dispose all clean-up materials into the radioactive waste container. Waste from different isotopes should be separated and stored in separate containers;
- Remove gloves and wash hands thoroughly. Monitor hands, clothing and shoes for possible contamination before leaving the laboratory;
- If any radioactivity is detected on personnel, an investigation as to its source should be conducted once decontamination has been performed;
- Record the post-procedure radioactive work area readings. If the readings have increased, investigate if any items have been contaminated unexpectedly; and
- Unexpected contamination should be reported to the Departmental Radiation Safety Officer (DRSO) or Faculty Safety and Health Officer (FSHO).

Disposal of Radiation Waste

Updated: Oct 2018 Rev.2

OSHE coordinates the radioactive waste disposal 3 to 4 times per year. Contact OSHE for the disposal schedule.

All radioactive waste should be in the dry form for the regulators (NEA) to accept the waste for disposal. Hence, any liquid waste generated should be at a minimum and absorbed in a chemically compatible absorbent (e.g., vermiculite) before disposal. Compaction of radioactive waste is not allowed.

Contaminated sharps and glassware, e.g., vials and needles, should be placed in sharps disposal bins which are subsequently placed in radioactive waste bags for disposal.

Each disposal bag should contain waste only contaminated with a single radionuclide. The exposure rate on the surface of each bag must NOT be greater than 0.1 mrem/hr or 1 μSv/hr. OSHE shall measure the levels of each radioactive waste bag as a second level of inspection and audit upon collection.

Sealed radioactive materials cannot be disposed in Singapore. All sealed radioactive materials should be returned back to the vendor or be stored in a secluded storage area permanently.

No disposal of any irradiating apparatus is allowed without the prior approval in writing to OSHE and RPNSD.

General Information on Commonly Used Radionuclides

Updated: Oct 2018 Rev.2

Emission and half-life of radioisotopes

Forms of ionising radioactive emission include alpha particles (α), beta particles (β), and gamma rays (γ). The Maximum Energy Emission is the maximum amount of radiative energy that can be emitted by the radionuclide and the half-life of a radioisotope is the time taken for half of all the nuclei in the sample to decay or disintegrate.

Radionuclide	Symbol	Maximum Energy Emission (MeV)	Particle types	Half-life
Tritium	$_{3}H$	0.019	β	12.3 years
Carbon-14	$_{14}C$	0.156	β	5730 years
Phosphorous-32	$_{32}P$	1.71	β	14.3 days
Phosphorous-33	$_{33}P$	0.249	β	25.4 days
Sulphur-35	$_{35}S$	0.167	β	87.4 days
Chromium-51	$_{51}Cr$	0.320	γ	27.7 days
Iodine-125	$_{125}I$	0.035	γ	59.4 days
Iodine-133	$_{131}I$	0.364 / 0.610	γ / β	8.04 days

Shielding

Typical shielding requirements to reduce emission intensities by factors of 100-1000 are:

Perspex

- Tritium (3H) - <0.5mm
- Carbon-14 (14C) - 1mm
- Sulphur-35 (35S) - 1mm
- Phosphorus-33 (33P) - 2mm
- Phosphorus-32 (32P) - 10mm

Lead

- Iodine-125 (125I) - 0.5mm
- Chromium-51 (51Cr) - 15mm
- Iodine-131 (131I) - 25mm

Emission of low-energy X-rays called "Bremsstrahlung" can occur when high energy beta radiation hit dense materials such as lead shielding. To minimise X-ray production from "Bremsstrahlung", high energy beta emission (e.g., 32P) is best controlled through the use of thick low density materials (e.g., Perspex). However, in the case of 131I, which has beta emissions of moderate energy, the lead shielding required for control of its gamma emissions (364Kev, 637KeV) also controls any X-rays produced.

All radionuclides are internal radiation hazards if they enter the body by inhalation, puncture, ingestion or absorption through the skin. High energy beta emitters (32P) and gamma emitters also pose external hazards, i.e. their radiation will penetrate normal laboratory apparatus and expose body parts (i.e. eyes, skin and other internal organs).

Special precautions should be taken with the use of 125I and 131I due to their volatility and affinity for the thyroid. Solutions of 125I and 131I as iodide should only be handled in a ducted fume cupboard.

Contamination Limits

In the Radiation Protection Act, radioactivity is expressed in Becquerels (1 Bq = 1 disintegration/s; MBq denotes 106 Bq; KBq denotes 103 Bq). Nano-, micro-, and milli-Curie equivalents will still be quoted (1Ci = 37000MBq). Contamination limits for low level laboratories [Schedule 5 Parts I and II of the Radiation Protection (Ionising Radiation) Regulations] are 0.01Bq/cm2 (0.00027nanoCi/cm2) for P-32, 0.1KBq/cm2 (2.7mampCi/cm2) for I-125 and I-131 and 1KBq/cm2 (27nanoCi/cm2) for all other radionuclides in the table above.

Radio Frequency Radiation & Microwave

Updated: Oct 2018 Rev.3

Radiofrequency (RF) radiation and microwave (MW) radiation have similar characteristics and are usually treated together. RF waves and microwaves are forms of "electromagnetic" radiation; which are oscillating electrical and magnetic energy waves. They are not to be confused with X-rays which are more powerful.

Health Hazards

The nature and degree of the health effects of overexposure to RF/MW fields depend on the frequency and intensity of the electromagnetic fields, the duration of exposure, the distance from the source, the presence of shielding, and other factors.

The main effect of exposure to RF/MW fields is the heating of body tissues as energy from the fields is absorbed by the body. Prolonged exposure to strong RF/MW may increase the body temperature, producing symptoms similar to those of physical activity. In extreme cases, or when exposed to other sources of heat at the same time, the body's cooling system may be unable to cope with the heat load, leading to heat exhaustion and heat stroke.

Operating Microwave Ovens in the Laboratory

- Follow the manufacturer's instruction manual for recommended operating procedures and safety precautions;
- Do not operate the oven if it is damaged. It is very important that the oven door closes properly and that there is no damage to the door seals and sealing surfaces, hinges and latches;
- Since there may be residual contamination, never use the laboratory microwave oven to heat food or drinks;
- Do not use the microwave oven to heat hazardous chemicals or radioactive materials;
- Do not use ALUMINUM FOIL at any time during the heating cycle;
- Metal utensils and utensils with metallic trim should not be used in the microwave oven;
- Avoid heating materials in cylindrical-shaped containers. Liquids heated in certain shaped containers (especially cylindrical-shaped containers) may become overheated. When overheated, liquids may splatter during or after heating resulting in possible personal injuries and/or damages to the microwave oven;
- If steam accumulates inside or outside of the oven door, wipe with a soft cloth. This may occur when the microwave oven is operated under high humidity condition but in no way indicates malfunction of the unit;
- Be careful when removing containers from the microwave. Some containers absorb heat and may be very hot. Always use protective gloves and appropriate eye/face protection to minimize any possible injuries;
- When heating liquids, the liquid should be stirred before placing in the container in the oven and again halfway through the heating cycle;
- If materials inside the oven should ignite, KEEP OVEN DOOR CLOSED, turn the microwave oven off, and disconnect the power cord; and
- Repairs should be done by qualified service personnel only. Do not attempt to tamper with or make any adjustments or repairs to door control panel, safety interlock switches or any other part of the oven.

First Aid

- Remove personnel from exposure area to a cool environment and provide cool drinking water;
- Minor burns: Cool the areas under cool running water or apply a cool, wet compress. Remove any rings or other tight items from the burned area. Cover the burned area.
- Seek immediate medical attention; and
- Severe MW or RF overexposure may damage internal tissues without apparent skin injury. A follow-up physical examination is advisable.

Laser Safety

Updated: Oct 2018 Rev.2

Most lasers are capable of causing eye injury to anyone who looks directly into the beam or specular reflections. In addition, diffuse reflections of a high-power laser beam can cause permanent eye damage. High-power laser beams can burn exposed skin, ignite flammable materials and activate toxic chemicals that release hazardous fumes, gases, debris and radiation. The equipment and optical apparatus required to produce and control the laser energy may also introduce additional hazards associated with high voltage, high pressure, cryogenics, noise, radiation and toxic fluids. Hence each proposed experiment or operation involving a laser must be evaluated to determine the hazards involved and the appropriate safety measures and controls that will be required. The two most hazardous situations exist during the alignment and servicing of equipment.

Responsibilities & Medical Surveillance

Updated: Oct 2018 Rev.3

Responsibilities

The safe operation of a laser is the responsibility of both the Principal Investigator (PI)/Supervisor of the area and the staff or student who perform the work.

PIs/Supervisors must ensure that controls and procedures described here and other relevant safety procedures are followed. Everyone including service technicians must understand the danger of working with lasers and must comply with all safety requirements. Personnel and students must keep their PIs/supervisor informed of any breach of safety procedures or any request to perform potentially hazardous tasks.

Management of contractor

The PI or his/her designate must ensure that all contractors working with Class 3b and Class 4 lasers possess the appropriate licence from RPNSD, NEA.

Medical Surveillance

Anyone who works in areas where he may be exposed to laser radiation from a Class 3 or Class 4 laser is required to have an eye examination prior to the work assignment and following any accidental exposure where an eye injury is suspected.

In instances where eye disease is found at the time of the examination, the personnel will be referred to an ophthalmologist. An eye examination is also recommended when the personnel leaves the School.

Short-term visitors for whom arrangements for an eye examination are not feasible may have this requirement waived by the Head of Department upon evaluation of experience, level of involvement and work supervision at NUS.

Classification of Lasers

Updated: Oct 2019 Rev.3

Laser Classification

To provide a basis for laser safety requirements, all lasers and laser systems and/or devices in Singapore are classified into one of several classes. Corresponding labels are affixed to the laser or laser system. Understanding the laser classification is a fundamental prerequisite for any discussion of laser safety. Check the manufacturer's operating instructions or the laser hazard label for the correct classification.

- **Class 1 Laser**
  A Class 1 laser is considered to be incapable of producing damaging radiation levels and is therefore exempted from most control measures or other forms of surveillance (e.g., laser printer). As a matter of good practice, unnecessary exposure to Class 1 laser light should be avoided. Class 1 lasers have power levels of less than 0.39uW. However, it is important to note that Class I laser systems often imbed more hazardous lasers of a higher class in the device.

- **Class 2 Laser (Low Power)**
  Class 2 lasers emit radiation in the visible region of the spectrum (0.4-0.7μm) and are capable of causing eye damage through chronic exposure. In general, the The blink reflex of the human eye provides adequate protection. It is possible, however, to overcome the blink reflex and to stare into a Class 2 laser long enough to cause damage to the eye. Class 2 lasers have power levels less than 1 mW. Class 2 lasers are commonly found in alignment applications or in laser pointers.

- **Class 3 (Medium Power)**
  A Class 3 laser may be hazardous under direct and specular-reflection viewing conditions but the diffuse reflection is usually not a hazard. Class 3 is divided into two subclasses, i.e. 3a and 3b with slightly different control requirements. A Class 3 laser is normally not a fire hazard.

- **Class 3a Lasers**
  Class 3a lasers and laser systems are normally not hazardous when viewed momentarily with the naked eye, but they pose severe eye hazards when viewed through optical instruments (e.g., microscopes and binoculars). Class 3a lasers have power levels of 1–5 mW.

- **Class 3b Lasers**
  Class 3b laser radiation will cause injury upon direct viewing of the beam and specular reflections. The power output of Class 3b lasers is 5-500 mW continuous wavelength or less than 10 J/cm2 for a 1/4- second pulsed system. The specific control measures for Class 3b lasers described in this chapter must be implemented.

- **Class 4 Laser (High Power)**
  Class 4 lasers include all lasers with power levels greater than 500 mW continuous wavelength or greater than 10 J/cm2 for a 1/4-second pulsed system. They pose eye hazards, skin hazards, and fire hazards. Viewing of the beam and of specular reflections or exposure to diffuse reflections can cause eye and skin injuries. All of the control measures in this document must be implemented.

Personnel Qualification

All personnel who operate Class 2, Class 3 or Class 4 lasers or Class 1 laser systems containing embedded Class 3 or Class 4 lasers must have:

- Successfully completed training course on operating the laser equipment;
- Read the NUS Laser Manual here;
- Read the Departmental Standard Operating Procedures (SOPs);

- The PI determines the employee's operational qualification from departmental or technical training or other acceptable learning experience; and
- All staff and students operating lasers are required to take the Laser Safety training course conducted by OSHE (through LumiNUS).

Standard Operating Procedure

A standard operating procedure (SOP) is required for any laser operation when:

- The laser is Class 4;
- Two or more Class 3 lasers will be used in the same area by different operators without intervening barriers;
- The safety interlock system has multiple, separately interlocked zones, an interlock system or warning devices that do not conform to the stipulated conditions;
- The laser uses dyes requiring moderate or strict control or toxic gases;
- A Class 3 or Class 4 laser is used or operated by non-School or non- NUS personnel or student;
- A laser installation does not include all the required controls specified in this manual (e.g., temporary operation);
- Modifications to commercial lasers or laser systems that decrease the designed safety;
- A Class 2, Class 3 or Class 4 laser or laser system is operated off site or for outdoor applications;
- The beam of a Class 2, Class 3 or Class 4 laser must be viewed directly or where it is necessary to work with the eye or with optical viewing aids close to the laser beam; and/or
- Unattended operations of Class 3 or Class 4 lasers do not conform to the specified conditions. Other non-optical hazards may be involved that require an SOP (e.g., electrical or pressure).
-

An approved copy of the SOP must be available in the area where the laser operation is conducted.

Laser Hazard Analysis

Before appropriate controls can be selected and implemented, laser hazards must be identified and evaluated. Below are three aspects of the application of a laser or laser system which influence the total hazard evaluation and thereby influence the application of control measures:

- The laser or laser system's capability for injuring personnel;
- The environment in which the laser is used; and
- The personnel who may use or be exposed to laser radiation.

Controls for Class 1 and Class 2 Lasers

Incidental viewing of Class 2 laser beams, although painful, will probably not cause permanent eye damage. In some cases, however, they are capable of causing injury if stared into for extended periods. The best rule to follow is never to look directly into a laser beam, or at a specular reflection, regardless of its power.

Beam Control

To minimize direct eye exposure, observe these procedures:

- Terminate the beam at the end of its useful path;
- Locate the beam path at a point other than eye level;
- Minimize specular reflections and use non-reflective tools;
- Enclose beams as much as possible; and

- Locate lasers so that no beam hazard exists at the point of entry for the room.

Warning Signs and Labels

Display 'CAUTION" signs at each entrance to the operating area and attach a laser classification label to the laser in a conspicuous location (if no manufacturer label exists). Every Class 1 laser shall have affixed an explanatory label with these words "CLASS 1 LASER PRODUCT". For Class 2 laser, a warning label as shown below shall be affixed.

Alignment

Class 2 laser optical systems should not be aligned by direct viewing if the radiant exposure or irradiance exceeds the Class 1 maximum permissible exposure.

Controls for Class 3 and Class 4 Lasers

Class 3 and Class 4 lasers include lasers with a broad range of radiant power and energy, which can pose hazards from those of minimal eye injuries (1 mW alignment or demonstration lasers) to those capable of causing severe skin burns and significant eye injuries. Class 4 lasers are capable of creating a fire hazard.

Selecting Controls

Class 4 lasers require more rigid control measures, including a SOP. Not only is there is a greater likelihood that direct beam and specular reflections will have sufficient energy to cause injury, there is also a greater risk of injury from hazardous diffuse reflections.

Laser Controlled Area

Class 3 and Class 4 lasers should be operated only in areas specifically designed for the laser operations. The facility should be an enclosed room or laboratory area with walls that confine laser radiation to this area. Access to the area during laser operation requires the permission of the responsible operator.

Spectators or Visitors

Spectators or visitors should not enter controlled laser areas during laser operations unless prior permission has been obtained from the laser operator and protective measures taken. The supervisor of the operation must give special attention to the orientation of persons who are unfamiliar with the hazards in the laser area.

Entrances and Exits

Laser laboratories and controlled laser areas should be designed in such a way that personnel can enter and leave under emergency conditions. Doors to controlled laser areas should not be locked when personnel are within the controlled area. Deviation from this requirement will require a Hazard Analysis.

Warning Signs and Labels

Each entrance to a controlled laser area should be posted with a 'DANGER' sign (or 'CAUTION' for Class 3a lasers with reduced irradiance). A laser classification label should be conspicuously affixed to the laser housing. Laser users should keep signs and labels current and legible. Refer to the figures below for the warning labels that shall be affixed on Class 3 and 4 lasers.

Warning Devices: Entrances to laboratories with a Class 3b or Class 4 laser shall have a lighted warning sign that is fail- safe interlocked with the laser to activate when the laser is energized. The warning device must be tested monthly.

Beam Control

The entire beam path of Class 3 and Class 4 lasers including the target area should be surrounded by an

enclosure equipped with interlocks that prevent the operation of the laser system unless the enclosure is properly secured.

The laser system should be securely mounted on a stable platform to maintain the beam in fixed position during operation and limit beam traverse during adjustments. The laser should be oriented so that the beam is not directed toward the entry doors. Primary beams and dangerous reflections should be confined to the optical table or enclosed and open beam paths should be clearly identified and should not pass crowded areas or traffic paths. When the beam path is not totally enclosed, the laser system should be located so that the beam is outside the normal eye level range (1.2-2 m) from the floor in areas accessible to personnel. A beam path that exits from a controlled area should be enclosed wherever the beam irradiance exceeds the Class 1 maximum permissible exposure.

The addition of beam-stopping panels to the sides of optical tables is recommended.

Deviation from these procedures may be acceptable if other precautions and controls are employed to provide a similar level of protection.

Reflection Control

Materials with low reflective coefficients that diffusely reflect laser radiation should be used in place of specularly reflective surfaces wherever possible. To minimize personnel exposure, specularly reflecting surfaces that are needed for beam-path control should be enclosed or shielded. Non-reflective tools should always be used.

Invisible Beams

Several additional controls are required for ultraviolet (UV) and infrared (IR) lasers which both emit invisible beams.

- Visual or audible beam-warning devices should be installed in areas containing radiation in excess of the maximum permissible exposure. These warning devices should be clearly identified and visible from all such areas;
- Shielding should be installed that will attenuate UV radiation to levels below the Class 1 maximum permissible exposure at all points where personnel may be located;
- Hazardous concentrations of by-products formed by the reaction of intense UV radiation with materials in the area must be controlled; and
- Infrared beam enclosures and backdrops should be fabricated of IR-absorbent material. For Class 4 lasers, the absorbent material should also be fire-resistant.

Direct Viewing

Personnel should NEVER look directly into any laser beam. The primary beam and specular reflections of Class 3 or Class 4 lasers are particularly hazardous. In cases where it is necessary to directly view a beam from a Class 3 or Class 4 laser, special provisions such as filters, are mandatory. A SOP should be prepared for operators where the beam of Class 3 or Class 4 laser must be viewed directly or where it is necessary to work with the eye or optical viewers close to the laser beam.

Optical Viewing Aids that Concentrate Light

Using optical systems such as cameras, telescopes, microscopes and endoscopes to view laser beams may increase the eye hazard. Hence, it is extremely important that interlocks or filters be placed on these

instruments to prevent eye exposures above the Class 1 maximum permissible exposure. Normal or prescription eyewear are not considered to fall into this category.

Eye Protection

Safety equipment designed to protect the eye from laser radiation of a given wavelength and intensity should be used if all other controls are unable to eliminate exposures above the maximum permissible exposure. Even when the radiant levels are considered to be safe, it is good practice to wear eye protection when lasers are in use. The supervisor or PI of the laser equipment will determine the appropriate laser eyewear.

Unattended Laser Operation

A laser is considered unattended if none of its authorized operators are in the laser area. If it is not in use, de-energize its power supply and remove the keys from power switches or master interlocks. Lock the laser area to prevent access.

An unattended laser may be operated if its beam is contained in an interlocked enclosure (e.g. a laser room or a beam tube) and if:

- An authorized personnel is available;
- A Hazard Analysis has been performed to identify the hazards and necessary controls; and these controls are in place;
- Security Control Centre is notified; and
- Proper signs are posted; lights and the door interlock (if required) are functional. Signs must indicate who should be notified if an emergency occurs.

Temporary Installations

Occasionally it may be necessary to remove protective enclosures or override equipment interlocks or other safety devices for service adjustments, maintenance, special training exercises, etc. In these instances, a temporary controlled laser area should be set up. Specific methods of handling situations of this type must be described in an SOP. When the entire beam is not fully enclosed, restrict access into the area to persons wearing proper protective equipment. Make sure all optical paths from the restricted-access area are adequately covered to prevent escape of laser radiation greater than the Class 1 maximum permissible exposure.

Single Occupancy

A controlled laser area should have only one laser or laser system.

<u>Hazards Associated with Laser Research Work</u>
Updated Oct 2018 Rev.2

Controlling Associated Hazards

Many hazards other than laser radiation can be found in the laser area and must also be adequately controlled.

Electrical Equipment and Systems

Always be aware of the high risk of injury and fire in laser operations because of the presence of electrical power sources. The installation, operation and maintenance of electrical equipment and systems should conform to the standards stated in OSHE Electrical Standards in Laboratories and Workshops.

Metal laser tables should always be bonded to the building ground.

Lighting

Adequate lighting is necessary in controlled areas. If lights are extinguished during laser operation, provide control switches in convenient locations or install a radio-controlled switch. Luminescent strips should be used to identify table and equipment corners, switch locations, aisles, etc. When natural light is not sufficient for safe egress from a laser area during an electrical power failure, emergency lighting should be installed.

Pressure

Pressure vessels and systems used in conjunction with lasers should meet the requirements set by the Ministry of Manpower. Details regarding the testing requirements and registration for pressure vessels can be downloaded here.

Ionising Radiation

A laser operation may involve ionising radiation that originates from the presence of radioactive materials or the use of electrical power in excess of 10 kV.

Non-Ionising Radiation

Microwave and radio-frequency fields may be generated by laser systems or support equipment.

Industrial ultrasonic equipment with power output of more than 50 W and above 16 KHz require licensing. This will include ultrasonic cleaners, ultrasonic welders, ultrasonic cutters etc.

Hazardous Materials Control

Bring into the laser area only those hazardous materials that are needed for the operation. Make certain that these materials are properly used, stored and controlled. Do not, without providing adequate controls, allow laser beams and strong reflections to impinge on combustible materials, explosives, highly flammable liquids or gases or substances that decompose into highly toxic products under elevated temperatures. Conduct or sponsor tests that establish the effects of beam interactions with hazardous materials. Test results can then be used to determine safe parameters for laser operation.

Laser Accidents & Prevention

Updated Oct 2018 Rev.2

Laser Accidents

It is up to the laser user to prevent laser accidents. Once the user accepts this fact, he or she can put controls and actions in place to ensure safety. The likelihood of a laser accident is greatest during the alignment

process: 60% of laser accidents in research settings can be traced to alignment. The overwhelming majority of laser-alignment accidents occur when the user is not wearing protective eyewear, or is not taking steps to protect himself/herself from the possibility of stray reflections. Stress and fatigue are the next two greatest contributors of laser accidents.

Some common laser accidents are:

- Not wearing protective eyewear during alignment procedures;
- Not wearing protective eyewear in the laser control area;
- Misaligned optics and upwardly directed beams;
- Equipment malfunction;
- Improper methods of handling high voltage;
- Intentional exposure of unprotected personnel;
- Lack of protection from non-beam hazards;
- Bypassing of interlocks, door, and laser housing;
- Insertion of reflective materials into beam paths;
- Lack of pre-planning;
- Turning on power supply accidentally;
- Operating unfamiliar equipment; and
- Wearing the wrong eyewear.

All accidents/incidents must be reported centrally to OSHE via AIMS within 24 hours.

Laser Radiation Effect on Skin

Laser radiation injury to the skin is normally considered less serious than injury to the eye, since functional loss of the eye is more debilitating than damage to the skin, although the injury thresholds for both skin and eyes are comparable (except in the retinal hazard region, 400–1,400 nm). In the far- infrared and far-ultraviolet regions of the spectrum, where optical radiation is not focused on the retina, skin injury thresholds are about the same as corneal injury thresholds. Obviously, the possibility of skin exposure is greater than that of eye exposure because of the skin's greater surface area.

Injury thresholds resulting from exposure of less than 10 seconds to the skin from far-infrared and far-ultraviolet radiation are superficial and may involve changes to the outer dead layer of the skin. A temporary skin injury may be painful if sufficiently severe, but it will eventually heal, often without any sign of injury. Burns to larger areas of the skin are more serious, as they may lead to serious loss of body fluids. Hazardous exposure of large areas of the skin is unlikely to be encountered in normal laser work.

A sensation of warmth resulting from the absorption of laser energy normally provides adequate warning to prevent thermal injury to the skin from almost all lasers except for some high-power far- infrared lasers. Any irradiance of 0.1 W/cm2 produces a sensation of warmth at diameters larger than 1 cm. On the other hand, one tenth of this level can be readily sensed if a large portion of the body is exposed. Long-term exposure to UV lasers has been shown to cause long-term delayed effects such as accelerated skin aging and skin cancer.

Examples of laser injuries

Exposure to an invisible carbon dioxide laser beam (10,600 nm) can be detected by a burning pain at the site of exposure on the cornea or sclera.

Exposure to a visible laser beam can be detected by a bright colour flash of the emitted wavelength and an afterimage of its complementary colour (e.g., a green 532 nm laser light would produce a green flash followed by a red afterimage). When the retina is affected, there may be difficulty in detecting blue or green colours as a result of eye injury.

Exposure to a Q-switched Nd:YAG laser beam (1,064 nm) is especially hazardous and may initially go undetected because the beam is invisible and the retina lacks pain sensory nerves. Photoacoustic retinal damage may be associated with an audible "pop" at the time of exposure. Visual disorientation due to retinal damage may not be apparent to the operator until considerable thermal damage has occurred.

Exposure to ultraviolet radiation over the maximum permissible exposure (MPE) may produce no immediate effect, but several hours later the accident victim may experience extreme pain in the eye and a sensation of sand in the eye.

Laser Alignment Guidelines to Help Prevent Accidents

- No unauthorized personnel will be in the room or area.
- Laser protective eyewear must be worn.
- All laser users must take the Laser Safety Training provided by OSHE (through IVLE).
- The individual who moves or places an optical component on an optical table is responsible for identifying and terminating every stray beam coming for that component.
- To reduce accidental reflections, watches and reflective jewellery should be taken off before any alignment.
- Beam blocks must be secured.
- When the beam is directed out of the horizontal plane, it must be clearly marked.
- A solid stray beam shield must be securely mounted above the area to prevent accidental exposure to the laser beam.
- All laser users must receive an orientation to the laser use area by an authorized laser user of that area.
- Laser users must have had their baseline eye examination prior to performing any alignment procedures.
- The lowest possible/practical power will be used during alignments.
- When possible, a course alignment should be performed with a HeNe alignment laser.
- Have beam paths at a safe height, below eye level when standing or sitting, not at a level that temps one to bend down and look at the beam. If necessary, place a platform around the optical table to raise one's height.

What to Do in Case of a Suspected Injury

If an individual suspects a laser hit, he/she should obtain medical attention immediately. Report the incident to PI/Supervisor and FSHO/OSHE. The critical time for treatment of the injury is within 24 to 48 hours.

Eye Protection

Eye protection is required wherever the viewer might view the laser beam. The eye protection must have the appropriate optical density and/or reflective properties based on the wavelengths of the beams encountered, the beam intensity, and the expected exposure conditions. At the same time, the need for laser eye protection must be balanced by the need for adequate visible light transmission. Laser eye protection should be inspected periodically to ensure that it is in good condition.

Emergency Response

Updated Oct 2018 Rev.2

This section serves as a guide to develop comprehensive emergency response plans to minimize injuries and maximize the protection of lives and properties on the School's premises.

The purpose is to identify the potential for incidents and emergency situations, to establish and maintain procedures to respond to such situations, and to prevent and reduce the environmental impacts that may be associated with them.

This procedure assigns roles and responsibilities to Departments and individuals that are directly responsible for emergency response and critical support services, and provides a management structure for coordinating and deploying essential resources for effective control of situations.

All incidents shall be reported to the PI / supervisor immediately and report to AIMS within 24 hours here. Please refer to Accident/Incident Reporting and Investigation here for details.

All emergency response procedures and business continuity plans shall be reviewed annually or when there is a change in process.

Emergency Response Plan

Updated Oct 2018 Rev.2

Scope

This procedure is applicable to all staff, students and visitors within the premises of the Yong Loo Lin School of Medicine. Potential incidents that may happen in our School include:

- Fire
- Hazardous Material Incidents (e.g., spills, gas leaks)
- Assault / Violence
- Personnel Injury
- Terrorism
- Pandemic Outbreak ~~Flu~~ (e.g., H1N1, SARS, Ebola virus, MERS-CoV)
- Haze

Responsibilities

Heads of Departments

The Head of Department (HOD) shall be responsible for ensuring that the Department develops and maintains the Departmental Emergency Response Plan. This includes appointment of the Emergency Response Team that shall be headed by a senior staff and acquiring the appropriate resources for response and distribution to staff and students.

It is the responsibility of each Department to ensure that an up-to-date copy of the Department Emergency Response Plan is updated annually.

Faculty Safety and Health Officer

The Faculty Safety and Health Officer (FSHO) shall provide advice to the Departments in developing their Departmental Emergency Response Plan.

Staff

All staff shall familiarize themselves with the emergency procedures and evacuation routes. They shall follow the emergency plan to report fire or other emergencies and evacuate the building in an orderly manner to a pre- designated Assembly Area (AA) except when otherwise instructed by the Emergency Response Team. Members of the teaching staff must be prepared to direct their students to the designated Assembly Areas in the event of an emergency.

Students

Students shall familiarize himself/herself with the emergency procedures and evacuation routes in buildings that they frequently use. They shall evacuate buildings to a pre-designated Assembly Area (AA) in an orderly manner when the alarm sounds or when directed to do so by the Emergency Response Team.

Emergency Response Plan

The effectiveness of response during emergencies depends on the amount of planning and training performed. It is the Department's responsibility to see that a programme is instituted and that it is frequently reviewed and updated. The emergency response plan should be developed locally and should be comprehensive enough to deal with all types of emergencies specific to that Department.

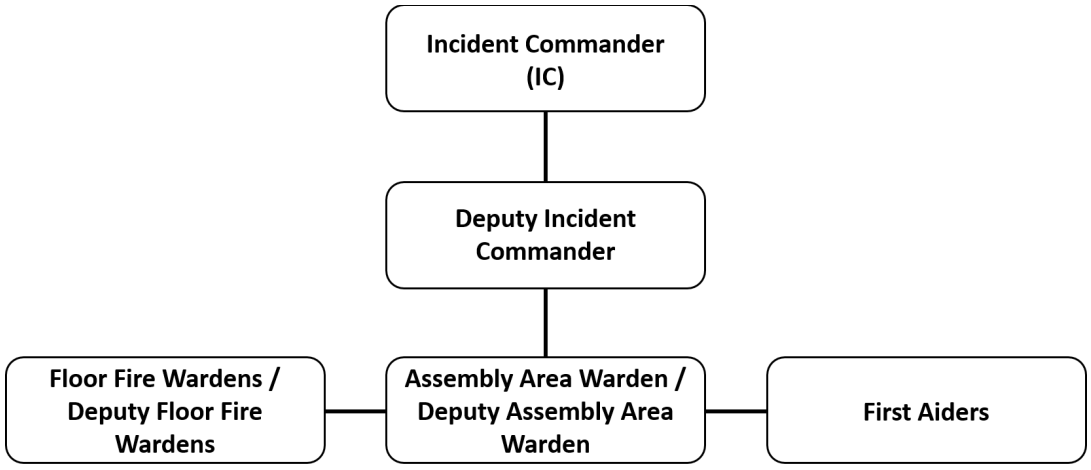
The plan must include, as a minimum, the following:

Emergency escape procedures and emergency escape route assignments

The use of floor plans or maps that clearly show the emergency escape routes and safe or refuge areas should be included in the plan. All staff and students must be told what action they are to take in emergency situations that may occur in the workplace, such as the location/route to the designated assembly areas after evacuation.

Chain of Command

A chain of command should be clearly established to minimize confusion so that staff and students will have no doubt about who has authority for making decisions. The following is a typical organizational chart of an Emergency Response Team:



An Incident Commander (IC) should be appointed to coordinate the work of the emergency response groups which includes Floor Fire Wardens, Assembly Area Warden as well as First Aiders. Due to the importance of these functions, adequate backup must be arranged so that trained personnel are always available.

The duties of the Incident Commander (IC) should include the following:

- Assessing the situation and determining whether an emergency exists that requires activating the emergency procedures;
- Directing all efforts in the area including evacuating personnel;
- Ensuring that outside emergency services such as the fire service and medical aid are called in when necessary; and
- Directing the shutdown of premises when necessary.

The Assembly Area Warden shall be responsible to account for staff and students and to inform the Incident Commander or the rescue personnel of those persons believed to be missing. The Floor Fire Wardens shall be responsible to guide and advise personnel on the route to take for evacuation.

The members should be trained in the following areas:

- Use of various types of fire extinguishers and fire hose reel;
- Fire alarm activation and reporting procedures;
- First aid, including cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED);
- Evacuation procedures;
- Chemical, biological, radiation (if required) spill control procedures; and
- Shut-down procedures (if required).

All Staff are required to complete an online Fire Safety Training IVLE course unless they have previously attended the Fire Safety Education or the Fire Safety Refresher course.

Emergency Equipment

All personnel should familiarize themselves with the location and use of the emergency equipment provided in their building. Departments are responsible to ensure that these equipment are maintained and regularly serviced. The types of emergency equipment installed are:

- Fire extinguisher;
- Fire protection system;
- Spill kits (biological, chemical and radiation, if required);
- Eye wash (weekly flushing); and
- Safety shower (monthly flushing).

Safety Signs

All areas and equipment or machinery where hazardous materials are used, or where hazards or potential hazards may exist shall be identified with appropriate hazard warnings (safety signs).

Meaning of Safety Signs

Safety signs are categorized according to their functions and differentiated by colours and shapes. The purpose is to draw attention to objects or situations affecting health and safety and to gain understanding of a specific message. According to the Specification for Graphical Symbols – Safety Colours and Safety Signs (Singapore Standard 508: 2013 Part 1), the general meanings assigned to the shapes and colours are given under point 5 "General meaning of geometric shapes and safety colours".

Briefing to New Staff

First time laboratory users must be briefed on the meaning of the signs in the laboratory as part of the orientation/induction programme.

NUS Laboratory Sign Posting and Labelling

The Office of Safety, Health and Environment (OSHE) has formulated a procedure on Laboratory Sign Posting and Labelling.

- **Sign Posting of Laboratory Doors**
  The standard format for signs to be posted outside laboratories is shown in "Appendix 22 – Sample Door Sign-Posting Template". Laboratories can make use of the Standard Laboratory Signposting Generator software here. The standard sign shall be printed in colour on a standard A4 sized paper. The sign has to be posted at least 1.5 metres from the floor either on the door to the laboratory or at the side wall next to the door provided that the sign is not more than 500mm from the door. If the laboratory has more than one external door, all doors must be sign posted. The sign must be enclosed in a transparent plastic folder or laminated and firmly affixed. The sign posting must be reviewed at least once a year or when the scope of work within the laboratory changes which necessitates a new risk assessment exercise to be done or reviewed.

- **Internal Laboratory Sign Posting**
  The person responsible for the laboratory should put up internal sign postings if there are specific hazards identified within the laboratory or at a certain area of the laboratory. In addition, signs requiring the use of personal protective equipment must be posted at the area or equipment where it is needed.

- **Standardised Safety Signs**
  The list of standardised safety signs used can be found in Appendix 23.

Internal Emergency Contact

Description	Contact
Campus Security	**6874 1616**
S16 Security Post	6516 2365
MD6 Security Post	6601 2336
Office of Safety Health and Environment Emergency Hotline	6778 6304
University Health Centre **Dr Patrick Tan** **Lifeline NUS (24 hour phone line for life-threatening psychological emergency)**	6601 5035 6516 4341 6516 7777
Occupational Health Clinic Dr Gregory Chan	6516 7333 8112 9214
Incident Commander Mr Sim Tiong Kian	6772 3788
NUSMed Faculty Safety and Health Officer (FSHO) Dr Christine Hu Zhi-Wen	6601 2263
Dean's Office (Medicine) Reception	6772 3737
Research Facilities Management (RFM) Dr Doreen Tan	medbox50@nus.edu.sg / 6601 5594
For enquiries regarding Chemical Toxicity Professor Ong Choon Nam (Saw Swee Hock School of Public Health)	Choon_nam_ong @nuhs.edu.sg

External Emergency Contact

Description	Contact
Police	**999**
Singapore Civil Defence Force (Fire or Medical)	**995**
Radiation Protection & Nuclear Science Department (RPNSD) **Radioactive material incident**	**1800 225 5632**

Departments are required to include specific Departmental and laboratory-specific emergency contacts to this list.

In calling for help, remain calm and provide the following information:

- Your name and contact telephone;
- Brief description of incident;
- Location of incident – include block number, room number;
- How to get to the incident location; and
- Agree on possible meeting place.

Do not hang up the telephone until the telephone operator indicates so. Avoid using IP phone. Leave your contact number with the telephone operator so that they can call back for additional information, if necessary. Inform Campus Security to alert them after a call is made to request for external emergency services such as ambulance, and fire engine. Send a person to the entrance of the building and/or office to receive and bring the emergency responders to the scene of the incident.

All accidents and incidents must be reported to the PI or Supervisor immediately.

Report all incidents and accidents to AIMS within 24 hours here.

Biological Spill Response

Updated Oct 2018 Rev.2

Content of Biological Spill Kit

The content of a biological spill kit is dependent on the biological agent that the kit will be used for. A risk assessment should be conducted to identify and decide the appropriate disinfectant (consult authoritative sources such as those quoted here and including Chapter 14 of the WHO Laboratory Biosafety Manual, 3rd edition, for advice on appropriate disinfectants), personal protective equipment (PPE) as well as the appropriate clean-up procedure. Generally, the kit should contain:

- Storage container for items;
- Disinfecting solution appropriate to the biological agent. Solutions should be freshly prepared;
- An empty bottle for the disinfectant;
- Forceps or tongs, autoclavable or disposable broom and dustpan, or other mechanical device for handling sharps;
- Paper towels or other suitable absorbent;
- Biohazard bags for the collection of contaminated spill clean-up items;
- Disposable waterproof gloves;
- Appropriate PPE (e.g., face shield, splash goggles, disposable lab coat, shoe covers);
- Disposable lab coat;
- Biological spill response procedure and emergency contact numbers; and
- Spill signage to post on door to room.

Biological Spill Clean-Up Procedure

Spill Outside a Biosafety Cabinet

1. EVACUATE ROOM. Avoid inhaling airborne material, while quickly leaving the room. Notify others to leave the room. Close the door and post a warning sign for no entry. Allow a minimum of 30 minutes for any airborne biological materials to settle. Small droplets, and particles including fungal spores, may remain airborne for considerable periods; for certain agents consider the use of N95 masks.
2. Remove contaminated clothing and/or lab coat, turning exposed areas inward, and place in a biohazard bag.
3. Wash all exposed skin with antiseptic soap and water. If there has been an exposure to the eyes, flush eyes for a minimum of 15 minutes. Inform PI/supervisor and report to the University Health Centre immediately for further medical evaluation after exposure by any route.
4. Inform PI/supervisor to determine who will decontaminate the spill. A serious spill may need to be decontaminated by the Hazmat Team from SCDF.
5. DECONTAMINATE THE AREA. Assemble clean-up materials to include appropriate personal protective equipment, disinfectant, paper towels, biohazard bags, forceps and sharps container, if necessary.
6. Allow any aerosols to settle for at least 30 minutes prior to re- entering laboratory with clean-up materials and personal protective equipment (PPE) to manage the spill. (If the spill occurs in a common area such as a corridor or elevator lobby, alert others to stay away from the area and notify Campus Security (Tel: 6874 1616) and SHO/OSHE for assistance.)
7. Wear protective clothing (disposable lab coat, gown or jump suit, splash goggles, disposable respirator, utility gloves or double gloves, and booties if necessary). Depending on the nature of the spill and mode of transmission, it may be necessary to wear a N95 mask.

8. Trace the spill for splatters to prevent stepping on them and spreading the spill and ensure that all contaminated areas are covered in the clean-up.
9. Cover spill (including splatters) with paper towels, and carefully pour a sodium hypochlorite solution containing 5000 parts per million (ppm or 5 g/litre) or other disinfectant effective against the agent in use on the towels and around the spill allowing it to mix with the material. If using proprietary disinfectant product, follow the manufacturer's instructions for proper use, concentration and contact time. When using sodium hypochlorite for this initial decontamination step, allow a contact time of 20 minutes.
10. Pick up any sharp objects with forceps or other mechanical device (tongs, broom and dustpan, plastic scoops, two pieces of cardboard, etc.) and discard in a sharps container.
11. Soak up the disinfectant and spill, and place material into a biohazard bag or sharps container. Since smaller pieces of broken glass may not be visible, avoid wiping the floor or work surface directly with the hands. Use a thick wad of paper towels to wipe the work surface, or push paper towels into a dustpan with a piece of cardboard.
12. Clean the surface with an effective detergent/disinfectant and allow to air dry. Alternatively, clean the surface with detergent and water, followed with an application of 500-600 ppm sodium hypochlorite solution. Allow to air dry.
13. Keep personnel out of the spill area or post a "Spill Clean-up In Progress" sign.
14. Place all contaminated paper towels and any contaminated protective clothing into a biohazard bag and autoclave as per decontamination procedures.
15. Wash hands and exposed skin areas with antiseptic soap and water.
16. Notify PI/supervisor of the spill immediately and report to AIMS within 24 hours here.

Spill in a Biosafety Cabinet

1. Leave the biosafety cabinet turned on and begin clean-up immediately.
2. While wearing PPE (gown and gloves) cover the spill area with plastic-backed towels or disinfectant-soaked towels. Do not place your head inside the cabinet to clean the spill. Keep your face behind the front view screen. If necessary, flood the work surface, as well as the drain pans and catch basins below the work surface, with disinfectant.
3. Spray cabinet walls, work surfaces, and inside the front view sash with disinfectant and allow to dry.
4. After 20 minutes of contact time, soak up the disinfectant and discard the absorbent materials into a biohazard bag.
5. If the spill entered the drain basin, pour disinfectant and clean up after allowing sufficient contact time.
6. Autoclave all clean-up materials and protective clothing. Wash hands and exposed skin areas with antiseptic soap and water.
7. Notify PI/supervisor of the spill immediately and report to AIMS within 24 hours here.

Centrifuge Decontamination Procedure

1. When centrifuging biological agents, utilize sealed tubes and either a sealed rotor or safety buckets for containment. Ensure that all O-rings or gaskets are in place and in good condition prior to use.
2. Wait 5 minutes before opening the centrifuge following the end of a run with potentially hazardous biological material.
3. As a routine, open the rotor or safety bucket as well as tubes within the biological safety cabinet to contain aerosols.
4. If however centrifuge contamination is identified after the lid is opened, carefully close the lid, and evacuate the laboratory for at least 30 minutes. Post a warning sign on the laboratory door.

5. In the event of an incident during centrifugation, turn off the centrifuge, leave the lid closed, and evacuate the laboratory. Allow aerosols to settle for at least 30 minutes. Post a warning sign on the laboratory door.
6. Remove any contaminated protective clothing, turning exposed areas inward, and place it in a biohazard bag. Wash hands and any exposed skin surfaces with soap and water.
7. DECONTAMINATE THE AREA after 30 minutes. Enter the laboratory with personal protective equipment and spill clean-up materials. Full face protection, a lab coat and utility gloves should be worn. Determine if a respirator N95 mask must be worn.
8. Transfer rotors and buckets to a biological safety cabinet. Immerse in an appropriate freshly prepared disinfectant for an adequate time period. Sodium hypochlorite solutions may cause metal corrosion. The immediate priority however is, reliable and complete inactivation of the microbial agents(s) which are known or may be present. In some circumstances it may be possible alternatively to autoclave a centrifuge bucket with the sealing cover still in place if tube breakage has been noted within. Handle broken glass with forceps and place in sharps container.
9. Carefully retrieve any broken glass from inside the centrifuge with forceps and place in a sharps container. Smaller pieces of glass may be collected with cotton or paper towels held between the forceps. Carefully wipe the inside of the centrifuge with papers towels soaked in an appropriate disinfectant. Spray the inside of the centrifuge with an appropriate disinfectant and allow to air dry. If sodium hypochlorite solutions are used, rinse thoroughly with copious amount of water. Ensure no electrical hazard has resulted from this procedure.
10. Place contaminated items and disposable personal protective equipment in a biological waste bag and autoclave.
11. Wash hands with antiseptic soap and water.
12. Notify PI/supervisor of the incident immediately and report to AIMS within 24 hours here.

Disinfection of Blood and Body Fluid Spills

Spills containing clinical material are generally disinfected using a chlorine-releasing agent. More details can be found in the WHO Laboratory Biosafety Manual and elsewhere in this chapter. Material containing prions requires special consideration and appropriate information and advice should be sought.

Household bleach at certain dilutions has sometimes been recommended for this purpose. However it should be noted that the potency of such products cannot be guaranteed, particularly if old, inadequately sealed and/or partially emptied bottles are used, as hypochlorite concentrations drop over time in such circumstances.

Various commercial preparations (for example, “Presept” or “Haz-Tab” tablets) are available which may be dissolved for use when required. These provide fresh solutions and when dissolved according to the manufacturer’s instructions will provide available chlorine to described parts per million (ppm) levels. (Other workers quote available chlorine as g/l.) Powder/granule products based on similar principles which may be added directly to such spills in the initial part of the clear-up procedure may be used. Manufacturers provide guidelines in the use of such products for clearing up spills, general disinfection of surfaces, discard jars and so on. Attention should be paid to instructions provided: for example “Presept” and “Haz-Tab” tablets are made in several different sizes and once prepared the active solution should be discarded within the time limit specified by the manufacturer. (Do not confuse total tablet weight as supplied with available chlorine per tablet.)

Different workers recommend either 10,000 ppm (10g/l) or 5,000 ppm (5g/l) available chlorine for “dirty” conditions (e.g. blood spills).

Hypochlorite and other chlorine-releasing disinfectants may cause corrosion of metals and this must be taken into account when decontaminating equipment. Whatever the choice of agent, the first priority must be safe and effective decontamination. Further discussion may be found in the WHO Laboratory Biosafety Manual, 3rd edition, Chapter 14 – Disinfection and Sterilization.

Chemical Spill Response

Updated Oct 2018 Rev.2

Content of Chemical Spill Kit

The content of a chemical spill kit is dependent on the chemicals and their volumes used in the lab. A risk assessment should be conducted to identify and decide the appropriate mitigation measures, personal protective equipment (PPE) as well as the appropriate clean-up procedure. Generally, the kit should contain:

- Storage container for items;
- Paper towels or other suitable absorbent;
- Appropriate neutralizing agents, if applicable;
- Forceps or tongs, broom and dustpan, or other mechanical device for handling sharps;
- Plastic bags for the collection of contaminated spill clean-up items;
- Appropriate personal protective equipment, including disposable lab coats and goggles;
- Chemical spill response procedure and emergency contact numbers; and
- Spill sign to post as warning.

Chemical Spill Procedure

All spills shall be cleaned up promptly, efficiently and safely. All laboratory staff and students using hazardous chemicals/materials must be aware of the hazards involved and be trained on how to clean up a chemical spill. Consult the Safety Data Sheet of the spilled chemical for indication of emergency response and first aid procedures. Spill kits are required where chemicals are used or stored. They shall be kept within easy access in times of emergency. Spills involving chemicals/materials can be divided into minor and major spills.

Minor Spill

Spills of manageable volume that can be contained by laboratory personnel and does not present an immediate danger to personnel.

Cleanup procedure:

1. Evacuate and attend to any personnel who may have been contaminated. If these persons require medical attention, refer to Section 20.13 Medical Emergencies of this chapter.
2. Alert all personnel in immediate area of spill.
3. Evacuate all non-essential personnel from the spill area.
4. If the spilled material is flammable, turn off all ignition and heat sources.
5. Wear appropriate protective equipment – e.g. safety goggles, respiratory protection, gloves, long-sleeved lab coat.
6. Avoid breathing vapours from spill.
7. Confine spill to a small area. Do not let it spread.
8. For liquid spill – trace splatters from the spill. Use appropriate material to absorb the spill. Collect residue, place in a polyethylene bag and dispose as chemical waste. Label the waste accordingly.
9. For solid spill – use plastic scoop to place spilled solids into a polyethylene bag suitable for that chemical and dispose as chemical waste. Label the waste accordingly. Care should be taken so as not to create dust or cause the contaminated powder to become airborne. Wipe with appropriate wet towels or absorbent pads to remove residue.
10. Notify PI/supervisor of the incident immediately and report to AIMS within 24 hours here.

Major Spill

Spills of unmanageable volume or involving chemicals with potential explosion or fire risk. It could include air or water reactive chemicals or mercury ≥ mL volume or near heated surface which may pose a danger to the personnel involved.

Cleanup procedure:

1. Stop work. Alert all personnel from the affected and adjacent areas of spill.
2. Evacuate the area and close the door. Lock door (if possible) and post warning sign to prevent other persons from entering the contaminated area.
3. Attend to any injured persons – if you can do so without personal risk.
4. Call Campus Security at Tel: 6874 1616 to report the incident. Provide location of incident, brief description of incident including type of chemical involved, name and contact telephone number. Campus Security shall notify the Singapore Civil Defence Force (SCDF) and National Environment Agency (NEA) of the incident.
5. Evacuate to the designated Assembly Area.
6. Activate Department Emergency Response plan including notifying Emergency Coordinator and accounting for evacuated personnel.
7. Remain at Assembly Area until assistance arrives.

Radioactive Material Spill Response

Updated Oct 2018 Rev.2

Generally, the radiation spill kit should contain:

- Storage container for items;
- Radiation waste bags and radiation waste labels;
- Appropriate decontamination solution;
- Tongs or forceps for picking up sharps;
- Paper towels and absorbent pads;
- Markers and chalks for marking of contaminated area;
- "Caution: Radioactive" tape for barricade;
- Personal protective equipment (e.g., gloves, shoe covers, disposable coveralls, face shield, respirator, etc.);
- Radiation spill procedures and emergency contact numbers; and
- Spill sign to post as warning.

Radiation Spill Response Procedure

A major spill has occurred if the contamination limits (see Radiation Safety here for the contamination limits of various radionuclides) are exceeded by:

- 250 times in a fume cupboard;
- 50 times on any fixed laboratory surface, skin or clothing of a radiation worker;
- 2.5 times on any other worker; or
- 10 times in areas not designated as radiation work space.

A spill that could lead to ingestion or inhalation of Iodine-125 (125I) or Iodine-131 (131I) approaching 0.2MBq is also a major event.

The most important immediate action is to prevent the spread of the radioactive material (provided that it can be accomplished without creating any additional hazard). Two trained personnel are required in the cleanup to minimize the risk of spreading unforeseen contamination. One person remains gloved and handles the items to be checked while the other handles the radiation monitor ungloved.

Minor spill

1. Alert co-workers in the immediate area that a spill has occurred.
2. Contain the spread by covering the spill with absorbent plastic backed paper.
3. Clean up the spill using absorbent paper. Place all disposable materials known to be contaminated in a Radioactive Waste bag.
4. Check the work area with the radiation monitor on its most sensitive setting.
5. Then check all equipment and apparatus that have been used.
6. Remove all uncontaminated material, equipment and glassware.
7. Dispose of or, if necessary, decontaminate, items that have been contaminated.
8. Check the entire bench area that has been used and, if necessary, use wet absorbent paper (with foaming detergent if necessary) to wipe till the monitor readings are reduced to near background or pre-experiment levels.
9. Dispose all clean-up materials into the radioactive waste container.
10. Remove gloves, wash hands thoroughly and monitor hands, clothing and shoes.

11. If any radioactivity is detected on a worker, an investigation as to its source should be conducted once decontamination has been performed.
12. Record the post-clean-up bench, etc. readings and if necessary consider why they may have been increased and any items unexpectedly contaminated.
13. Notify PI/supervisor of the incident immediately and report to AIMS within 24 hours here.

Major spill

1. Clear the area. Notify all persons not involved in the spill to vacate the room. Post warning sign at the room door.
2. Contain the spread by covering the spill with absorbent plastic backed paper. Do not attempt to clean up.
3. Decontaminate contaminated personnel and/or shield the source if possible, depending on the relative hazards. This should be done only if further contamination or a significant radiation exposure is unlikely.
4. Close the room and lock or otherwise secure the area to prevent spread of contamination. Limit the movement of all personnel who may be contaminated.
5. Notify PI/supervisor of the incident immediately and report to AIMS within 24 hours here.
6. Departmental Safety Committee as well as the FSHO will also be notified immediately and they will determine the action to be taken for the clean-up of the spill.
7. A report shall be submitted to AIMS as well as to Radiation Protection and Nuclear Science Department (RPNSD).

Medical Emergencies

Updated Oct 2018 Rev.2

In medical emergencies, all personnel should follow these general guidelines:

- Remain calm;
- Initiate first aid treatment if required;
- Call for emergency response;
- Do not move injured person unless there is danger of further harm;
- Keep injured warm; and
- Notify PI/supervisor of the incident immediately and report to AIMS within 24 hours here.

Clothing on Fire (Stop, Drop, Roll)

- Cover person with fire blanket to smother flame.
- If fire blanket is not available, roll person around the floor.
- Drench with water under safety shower.
- Obtain medical attention. Call 6874 1616 for Campus Security to activate SCDF.

Minor Cuts and Punctures

- Wash injury with plenty of soap and water thoroughly. Squeeze out as much blood as possible.
- Apply a loose dressing to protect the wound.
- Obtain medical attention at the University Health Centre or other appropriate clinics.
- Inform medical personnel about the type of biological agent or chemical involved, if applicable.

Hazardous Material Splashed in Eye

- Immediately rinse eye and inner surface of eyelid with water continuously for at least 15 minutes.
- Ensure eye is held open for effective wash behind eyelids.
- Obtain medical attention at the University Health Centre or other appropriate clinics.

X-ray Burns

- Shut power for equipment. DO NOT adjust machine settings until inspection by maintenance/technical staff.
- Obtain medical attention at University Health Centre or other appropriate clinics.

Electric Shock

- Put on rubber gloves to switch off electrical supply.
- If breathing of the electrocuted person has stopped or is feeble, obtain immediate attention by calling ambulance through Campus Security (Tel: 6874 1616).
- If first aider is present, apply resuscitation when necessary.

First Aid Requirement

Updated Oct 2018 Rev.2

First-aid as defined under Workplace Safety & Health (First-Aid) Regulations 2006 means:

- in cases where a person needs help from a medical practitioner or nurse, treatment for the purpose of preserving life and minimizing the consequences of bodily injury until such help is obtained; or
- treatment of minor bodily injuries which does not require treatment by a medical practitioner or nurse.

First Aider

For a workplace in which more than 25 persons are working, it is recommended that a first-aider be appointed. The first aider shall be readily available during working hours and complies with the ratio of one first-aider for every 100 persons employed in the workplace or part thereof. The appointed first aider shall have successfully completed a training course accredited by Ministry of Manpower and attend subsequent re-training once every 2 years. The first aider shall maintain a record for treatment given by him/ her. Name of first aiders are to be displayed at the workplace.

Provision of First Aid Box

Under the Workplace Safety and Health (First Aid) Regulations, the number of first-aid boxes provided for a workplace must be sufficient. The number of first-aid boxes required on a floor of a building is determined by the layout of the premises and the number of personnel on that floor. According to the NUS First Aid and First Aiders Standard, a minimum of one first aid box per floor is required. Departments should conduct a risk assessment when deciding whether the current first aid boxes are sufficient. For further information, refer to NUS First Aid and First Aiders Standard here. Every first aid box must be clearly identified and placed in a location that is well-illuminated and easily accessible. The minimum content for a typical first-aid box is specified in the table below.

S/N	Description	Quantity
1	Individually wrapped sterile adhesive dressing	20
2	Crepe bandage 5.0cm	1
3	Crepe bandage 10cm	1
4	Absorbent gauze (packet of 10 pieces)	5
5	Hypoallergenic Tape	1
6	Triangular bandages	4
7	Scissors	1
8	Safety pins	4
9	Disposable gloves (pair)	2
10	Eye shield	2
11	Eye pad	2
12	Resuscitation mask (one way)	1
13	Sterile water or saline in 100 ml disposable container (only where tap water is not available)	1
14	Torch light	1

Based on the outcome of their risk assessment, personnel should supplement their kits with additional items such as antidotes for toxic or corrosive substance (e.g. calcium gluconate gel will serve as antidote for hydrofluoric acid burns). Medications are discouraged from being placed in a first aid box. Every first-aid box must be checked frequently to ensure that it is fully equipped and all the items in the box are usable. The content of the first- aid box must be replenished as soon as possible after use.

Inspection and Record Keeping

The contents of the first aid boxes should be inspected frequently to ensure that items are adequate. They should be re-stocked immediately when an item is utilized. Every first-aider shall maintain a record of all treatment rendered by him/ her. All incidents requiring first aid attention must be recorded.

Lift Entrapment

Updated Oct 2018 Rev.2

Action by the person(s) entrapped:

1. Remain calm.
2. Press the alarm button.
3. Communicate with the Security personnel through the intercom unit.
4. Be patient and wait for help.
5. Never try to force open the lift door or get out through the manhole at the ceiling of the lift car. Such attempts may result in fatal accidents.

Threats, Violence and Suicide-related Acts

Updated Oct 2018 Rev.2

General actions to be taken by the victim or witness when faced with the situation on campus:

- Remain calm;
- Avoid further risk; and
- Report the incident to Campus Security (Tel: 6874 1616) or the Police (Tel: 999) and provide the following information: nature of incident, location of the incident and description of person(s) involved.

Refer to OSHE's Guide For Responding to Threats, Violence and Suicide-Related Acts for Faculties/ Schools/ Departments/ Offices here for more details.

Bomb Threats and Explosion

Vigilance and adherence to procedures when encountered with such situations can help reduce loss of human lives and damage to assets and infrastructure. In the event of finding or receiving a suspicious object or an unexploded bomb:

- Keep away and do not touch or move the suspicious object or unexploded bomb;
- Move away and warn others of the object / bomb;
- Alert Campus Security (Tel: 6874 1616) or the Police (Tel: 999);
- Evacuate building by following the fire evacuation procedures.

In the event of receiving a bomb threat:

- Do not panic, stay calm;
- Get another person to alert Campus Security (Tel: 6874 1616) or Police (Tel: 999);
- Keep the caller talking for as long as possible while the police trace the call;
- Take note of the following: caller's voice and vocal characteristics, the manner of speaking, background noises, the person or authority the message should be conveyed, do not antagonise or taunt the caller in any way and do not spread rumours.

If an explosion occurs:

- Alert Campus Security (Tel: 6874 1616) or the Police (Tel: 999);
- If you witnessed an explosion, tell the Campus Security or Police what you saw;
- Stay far away from the affected and warn others;
- Evacuate from the affected areas as soon as safe in an orderly manner. Follow fire evacuation procedures;
- Beware of post blast hazards such as collapsed walls, overhanging slabs, damaged structures, buckled columns/ beams, craters in ground, shattered glass panels/ broken glass, sharp edged debris, fires due to heat of explosion, smoke and toxic fumes, water and gas leaks due to damaged utility pipes, exposed live electric cables, & potential secondary bomb devices.

If trapped in a building, stay put and protect head and face from shattered glass or falling object and move away from unstable object. For rooms without glass windows or mounted shelves, bracing against walls is possible. In the event of being trapped in debris, use a flashlight, if possible, or tap on a pipe or wall to signal location to emergency responders. Avoid any unnecessary movement. Periodically move fingers and

toes to ensure blood circulation. Use anything in hand as a filter to cover nose and mouth. Only use shouting as a last resort as it may weaken oneself and inhale dangerous amount of dust and smoke.

For more information on responding to bomb threats and explosion, refer to OSHE's guide here and SCDF Emergency Handbook here.

Pandemic & Crisis Response and Management

Updated Oct 2018 Rev.2

As defined by NUS, a crisis is a situation that has reached a critical phase for which dramatic and extraordinary intervention is necessary to avoid injury, loss of life, damage to major university buildings, installations and equipment and harm to the reputation of the University.

The four main principles in preparing for emergency or crisis are to save lives, minimize damage of property, safety guard reputation and business continuity. The university has classified all incidents into 3 levels:

- Level 1: Minor Incident e.g., localised chemical spill, small fire in lab
- Level 2: Emergency e.g., structural fire, accidents resulting in serious injuries
- Level 3: Crisis e.g., disease/ epidemics, major hazardous material release, any national level disasters such as haze etc

In order to manage the different level of incidents, all faculties and schools are tasked to prepare their crisis management plans and these plans are to be reviewed regularly through table-top exercises. Departments and PIs are to prepare their own business continuity plans to ensure their work can be recovered and continued after an emergency or crisis. Business continuity plans are to be reviewed annually through table-top exercises to ensure its continual robustness.

For more details, please refer to guidelines on OSHE's Emergency Management site here.

Safety Training

Updated Oct 2018 Rev.2

All staff, students and visitors (where applicable) shall participate in the training programmes that are required based on their job category. Safety training is important to provide staff and students with the knowledge and tools necessary to reduce the associated risks to a minimum.

Responsibilities

Staff and Students

All staff and students working in laboratories are required to:

- Attend safety training courses;
- Be familiar with the location and use of all safety devices and equipment including emergency showers and eyewashes;
- Be familiar with emergency escape routes, spill procedures, etc; and
- Read safety manuals and all updates.

Principal Investigators and Supervisors

Responsibilities of Principal Investigators (PIs) and Supervisors:

- Being trained and knowledgeable in the safety hazards which his/her staff and students may be exposed to;
- Ensuring that all staff and students under his/her charge receive the necessary safety training based on their job scope;
- Determine which safety training his/her staff and students are required to attend and update the Staff/Student Safety Training Record; and
- Provide Laboratory-Specific Safety Training for his/her staff and student.

Procedures

The Safety Training programme is implemented through two levels of training:

- General Safety Training conducted by OSHE, School or Departments; and
- Laboratory-Specific Safety Training provided by PIs.

The Laboratory-Specific Safety Training shall enhance the General Safety Training by providing training on the hazards of specific tasks which will be performed by the student/staff. These training are provided by the PIs or Supervisors. All Safety Training shall be recorded in the Staff/Student Safety Training Record.

General Safety Training

Safety Orientation

Safety Orientation must be conducted for the following groups:

New Staff and Students

A Safety Orientation shall be conducted by the PI or Supervisor for all new staff and students prior to

commencement of any laboratory work within two weeks of joining. A template for Safety Orientation is provided in the table below.

Staff / Student Name :			Staff / Student ID :	
Job Title :	Department :		Date :	
S/N	**Items to be briefed**	Briefed By	Date Completed	Remarks
a.	University's Safety and Health Policies including work outside normal working hours			
b.	Departmental Health & Safety Committee Members			
c.	Laboratory security - display of staff ID / badge prominently while at laboratories			
d.	Has undergone the necessary Occupational Health medical assessment			
e.	"Facility access exclusion of liability and indemnity form" for external (non-NUS) staff and students			
f.	NUS requirements for insurance for international students, if applicable			
g.	Location of nearest emergency equipment and escape routes and procedure to follow upon discovering a fire or hearing the fire alarm			
h.	Location of nearest first aid kit			
i.	Location and use of nearest eye wash station and emergency shower			
j.	Emergency contact persons and telephone numbers, roles of the Fire Evacuation Officer and Fire Wardens			
k.	Location where the Safety Data Sheets can be obtained			
l.	Proper use of common laboratory equipment			
m.	Requirement and location of personal protective equipment			
n.	Procedure for reporting defective or damaged PPE and obtaining replacements			
o.	Hazards that were identified during the risk assessment process and their control measures			
p.	Procedures for conducting risk assessments of laboratory activities			
q.	Appropriate waste management process			
r.	Accident/incident reporting process			
s	Safety and health training needs of the staff or student			

The Safety Orientation shall include, but not limited to, the following:

- Introduction of Departmental Safety Committee members;
- Location of nearest emergency equipment and escape routes;
- Location of nearest first aid kit and how to use them;
- Location and use of nearest eye wash station and emergency shower;
- Emergency response procedures;
- Emergency contact persons and telephone numbers;
- Location of the Safety Data Sheets;
- Proper use of laboratory equipment;
- Requirement and location of personal protective equipment;
- Hazards identified during the risk assessment process and their control measures;
- Appropriate waste management process; and
- Incident/accident reporting process.

Visitors

Visitors under escort will not be required to undergo a Safety Orientation. However, visitors who are not escorted shall be required to undergo a Safety Orientation at the time of their arrival. The orientation will provide a brief explanation of the laboratory's safety requirements like emergency escape routes,

requirement for personal protection equipment, etc. Visitors will be required to sign an Indemnity Form that indemnifies the university against any claims for injuries during their visit/ stay in NUS labs, workshops or animal facilities.

Introductory Laboratory Safety Course for Graduate Students

All new graduate students must attend the Introductory Laboratory Safety Course for Graduate Students conducted by the NUSMed Safety Committee prior to beginning their work in the laboratory. They are required to take a test after the course and must achieve a score of 80% and above to be allowed to work in a laboratory. A re-test will be conducted for those who fail to meet the passing requirement.

Structured Safety Training System

The university administration has made it mandatory for all staff working in laboratories to undergo safety training that is based on the job scope and work hazards of the respective staff.

The training provided under the Structured Safety Training System (SSTS) will be competency-based and managed by the Office of Safety, Health and Environment (OSHE) with support from the Office of Human Resources (OHR). The training system will be dynamic in nature with requirements for refresher training and incorporation of new training when the need arises.

PIs are to determine the appropriate required by the staff and students working in their laboratories. Course details can be found here. Some of the recommended courses for NUSMed staff and students are shown in the table below.

	Title of Training Course	Who should attend	Refresher requirement
Stage A: Induction Training			
1.	**An Introduction to Safety, Health and Emergency Management (e-Orientation module)**	E&P and non-academic staff: Compulsory online training module to be completed within one month upon joining the University. Academic staff: Compulsory IVLE training course (OSHGEN03) to be completed within one month upon joining the University.	N.A.
2.	Online Fire Safety Training Course	Compulsory for all NUS staff to be completed within one month upon joining NUS.	N.A.
3.	Laboratory Safety Induction Training (OSHGEN01)	Compulsory for all newly appointed staff working in laboratories and workshops. This training must be completed PRIOR to performing activities in the laboratory.	N.A.
4.	**Introduction to Laboratory Safety and Health in NUS - Policy, Principles and Practice (OSHGEN02)**	Compulsory for all students working in laboratories and/or workshops.	N.A.
Stage B: Hazard-Specific Training			
5.	Chemical Safety (OSHCHM01)	Compulsory for all lab and technical staff and students working with chemicals.	After 3 years
6.	Biological Safety for BSL2 Laboratories (OSHBIO08)	Compulsory for all technical staff, laboratory staff and students dealing with biological materials.	After 3 years
7.	Safe Handling of Radioactive Materials (OSHRAD04)	Staff and students working with ionizing radiation and/or equipment with radioactive materials.	After 3 years
8.	Laser Safety (OSHRAD02)	Staff and students using any equipment with Class 3b or Class 4 lasers	After 3 years
Stage B (Add-on): Hazard-Specific Training			
9.	Chemical Spill Response (OSHCM05)	Chemical Spill Responders	
10.	Biological Spills and Emergency Response (OSHBIO05)	Biological Spill Responders	
11.	Semi-Quantitative Risk Assessment (OSHCHM04)	Staff appointed to conduct Semi- Quantitative Risk Assessment	
Stage C: Appointment-based Training			
12.	**Safety and Health Management System (SHMS) – Tools & Techniques for Development, Implementation and Maintenance of SHMS (OSHSMS01)**	Principal Investigators (PIs) and Laboratory Supervisors, Research Fellows on how to conduct risk assessments and develop safety management systems.	N. A.

Laboratory Safety Training

Principal Investigators or Supervisors shall provide laboratory safety training to his/her staff and students. The following elements should be included:

- Review of the workplace-specific standard operating; and
- Specific training on the materials and equipment used as well as the associated risks and safety measures.

Additional training may be required where applicable:

- Responsible Care and Use of Laboratory Animals

All staff and students working with animals are required to attend the Responsible Care and Use of Laboratory Animals Course conducted by Laboratory Animal Centre. This course will familiarize staff and students with the regulations and standards of animal care before carrying out work with animals (link)

Documentation

All safety training shall be documented and records kept by the PI/Supervisor. Documentation should include attendance sheets with signature and staff numbers, registration slips, certificates or any other written records of such training. These records must be made available for inspection.

Others
Updated Oct 2018 Rev.2

Safety in Handling Research Animal
Updated Oct 2018 Rev.2

This section is applicable to staff and students involved in the use of animals for research and/or teaching. Safe procedures for personnel who handle the laboratory animals will be described as guidance to minimize the likelihood of injury or disease.

With effect from 2004, a licence for animal research facility from Animal & Veterinary Service (AVS) under National Parks Board (NParks) is required for any research facility that intends to use live animals for scientific purposes. Principal Investigators (PIs) are to ensure the AVS licence is obtained before commencement of any research activities involving live animals (link).

All researchers are strongly encouraged to conduct research activities that involve animals at the vivariums at the Comparative Medicine Department in NUS. Researchers should contact the Comparative Medicine Department (link) regarding the use of animals for research and the usage of the facilities there.

In the rare event that researchers are not able to work in the vivariums at the Comparative Medicine Department and intend to conduct research activities that involve animals at the YLL SoM central research facilities i.e., MD1, MD6 and MD11, they would have to obtain approvals from both the Institutional Animal Care and Use Committee (IACUC) and the Dean's Office, YLL SoM (medbox50@nus.edu.sg).

Protocol, Risk Assessment Submission and Approvals

PIs who intend to perform animal work must submit their protocols via the iORC (link).

All animal work protocols and risk assessments are to be submitted and reviewed by the (IACUC) and Institutional Bioethic Committee (IBC) via OSHE, respectively.

Refer to IACUC website for details here.

Training

All staff and students intending to work with live animals must attend the Responsible Care and Use of Laboratory Animals (RCULA) course conducted by Comparative Medicine (CM) and receive the RCULA certification before starting work with animal experiments.

For training dates and application forms, refer to details here.

Enrollment in the NUS Lab Animal Work Occupational Health Programme

All personnel who are in contact with laboratory animals are to enroll in the NUS lab animal work occupational health programme at OSHE. This applies to all those involved in:

- The direct care of animals;
- Direct contact with animals (live or dead), their tissues, body fluids, or wastes; and/or

- Working regularly within the animal facility who may not be in direct contact with animals but may be potentially exposed to animals, their tissues or fluids, cages and bedding along the course of their work.

Personnel are required to fill up the following forms available at Animal Work Health Questionnaire and Authorization Form.

These forms are to be submitted to the Occupational Health (OH) Clinic.

The OH doctor will recommend one of the following:

- Fit to work with animals (with a validity period);
- Need for further medical evaluation; or
- No requirement for medical surveillance.

The validity period depends on the type of work involved. One year for high risk work:

- Comparative Medicine Centre staff
- Work in ABSL 3 lab
- Work with Non-Human Primates
- Work with pigs
- Staff with pre-existing or new medical conditions (as declared in the AWHQ)
- High risk research protocol (biological agents, animals, hazardous chemicals) deemed by IACUC/OSHE

Three years for low risk work:

- All other researchers
- Re-certification of fitness is required when the validity period is up.

Handling Procedures and Precautions

In Biomedical Sciences, animals play a vital role as research materials. However, animals can act as vectors for pathogens (such as bacteria and viruses), which may be transmitted to man and cause diseases. Therefore, safety in handling laboratory animals is a prerequisite for all personnel working with animal specimens.

Zoonotic diseases are diseases that spread from animals to man. The use of specific pathogen-free (SPF) animals, which are animals of a defined health status, will ensure that the laboratory animals are free of zoonotic diseases at the start of any procedure.

Personal Protection

- Appropriate protective clothing should be worn at all times. Disposable gloves, surgical masks, head covers, shoe covers and long- sleeved disposable lab coats may be used. It is also advisable that when handling primates, eye/face shields be worn as well.
- Outer garments worn in the animal rooms should not be worn outside the animal facility.
- Personnel should not be permitted to eat, drink, smoke or apply cosmetics in rooms and laboratories where animals are housed.
- Anti-tetanus vaccinations are recommended for all staff who work with animals.

- All personnel should maintain a high standard of personal cleanliness especially before consuming their meals and after using the rest rooms.
- Persons who suffer from asthma and allergies should consult their personal physicians before working with/handling animals.
- Do not place personal items like stuffed toys, hand cream, potted plants, etc. on the work bench.

Physical Damage

- All bites and scratches should be considered as potential sources of infection and treated accordingly. Using the correct handling method(s) for each species and wearing of protective clothing, can help prevent such accidents from occurring. Particular care must be taken when handling primates - tranquillising them before handling may be necessary.
- Caging should be inspected regularly for sharp edges, wooden edges for splinters and metal components for weld which are not smooth as these can cause scratches and abrasions if accidentally knocked into.
- Animal holding racks should be stable, as they are liable to tip over if accidentally knocked into.
- Safe methods of animal handling should always be practised to avoid injury.
- All animals should be handled in a manner that provides both suitable restraint to the animal as well as safety to the handler. Specific methods of safe handling are available for all species of commonly used laboratory animals. If unsure of safe handling or if the animal is retractile, consider tranquillising the animal first before performing a procedure.
- Sharp objects for disposal (needles, butterfly catheters, scalpel blades) should be placed in appropriately-labelled puncture proof containers.

Accidental Infection by Micro-organisms

- Experimental animals should be housed in vivarium in a manner such so that potentially contaminated feed and bedding, faeces and urine can be handled and disposed in a controlled manner.
- Animals, animal tissue and secretions are potential reservoirs organisms which may be harmful to man. These may gain access to the human body through the skin (especially where abrasion of skin has occurred) or via the mouth, eyes and respiratory system. Some animal parasites are also capable of living on or in man (e.g., fleas and roundworm larvae). Therefore, all laboratory animals and their environment should be treated with care.

Animal Health

- If an animal develops any illness unrelated to the research protocol, it should be reported to the staff-in-charge of the animal unit.
- All purchases of animals should be made through accredited suppliers/approved breeders. A certified animal Health Certificate, counter-signed by an approved veterinary/health authority should accompany each shipment.

Animal Experimentation Involving Hazards

- Staff who conducts programmes that involve hazardous biological, chemical or physical agents (including ionising and non-ionising radiation) should be qualified to assess dangers associated with the programmes and take steps to select safeguards appropriate to the risks.
- Procedures for animal care and housing, storage and disbursement of the agents, dose preparation and administration, body-fluid and tissue handling, waste and carcass disposal, and personal protection should be given special attention. Facilities used for animal experimentation with

hazardous agents should be separated from other animal housing and support areas of other animals. Hazardous agents should be contained within the study environment.

- Infected animals or animal tissues should always be handled with some form of isolation. Units of flexible film isolator apparatus may be appropriate for some form of hazardous work with animals concerned, which must themselves be contained in properly labelled cages.

Office Safety

Updated Oct 2018 Rev.2

Employees working in an office setting must recognize and be aware of the safety and health hazards that are found in their environment. They should take the necessary precautions to prevent injury and ill-health by following appropriate safety rules and guidelines set out here.

Responsibility

The overall responsibility for safety in the workplace rests with the Head of Department (HOD) with the support from the office manager, supervisors and employees. A safe working environment contributes positively to office morale and productivity.

Injury Prevention

General Housekeeping

All internal thoroughfares and circulation routes should be clearly signed, outlined, free from obstructions, surface defects and litter to avoid collisions, trips and slips. Proper attention should be given to the following:

- Spills should be cleaned up or cordoned off immediately;
- Floor or carpeting must be slip-proof;
- Damaged floor surfaces such as chipped concrete floor or warping tiles, etc., should be reported to the Office Manager and/or Office of Facilities Management (OFM). The damaged areas must be effectively cordoned off;
- Aisles, walkways and stairs must be kept free from obstacles that impede traffic and fire escape; and
- Electrical and telephone cables must not trailed across aisles and walkways, and must be arranged so that they do not pose a tripping hazard.

Movement in the Office

Many accidents in the office occur simply when people are moving around the building. The following are some recommended precautions:

- Running is discouraged in the office;
- Reading while walking must be avoided;
- Doors at common areas should be constructed with viewing panels so that any person on the other side of a door can be seen;
- Transparent glass doors should have clear visible markings so that they can be noticed; and
- Self-closing doors with high spring tension should be reported to the Office Manager and/or OFM for appropriate adjustments.

Usage and Storage of Sharp Objects

- Equipment with sharp edges such as paper cutters and shredders must have guards and proper usage instructions for users. Ensure safety catch/ guards are secured before usage;
- Sharp objects must be properly placed inside drawers and/or away from traffic. When they are put inside a pen holder, the sharp ends must point downwards; and
- Pass a sharp object with the blunt end or handle facing towards the other person.

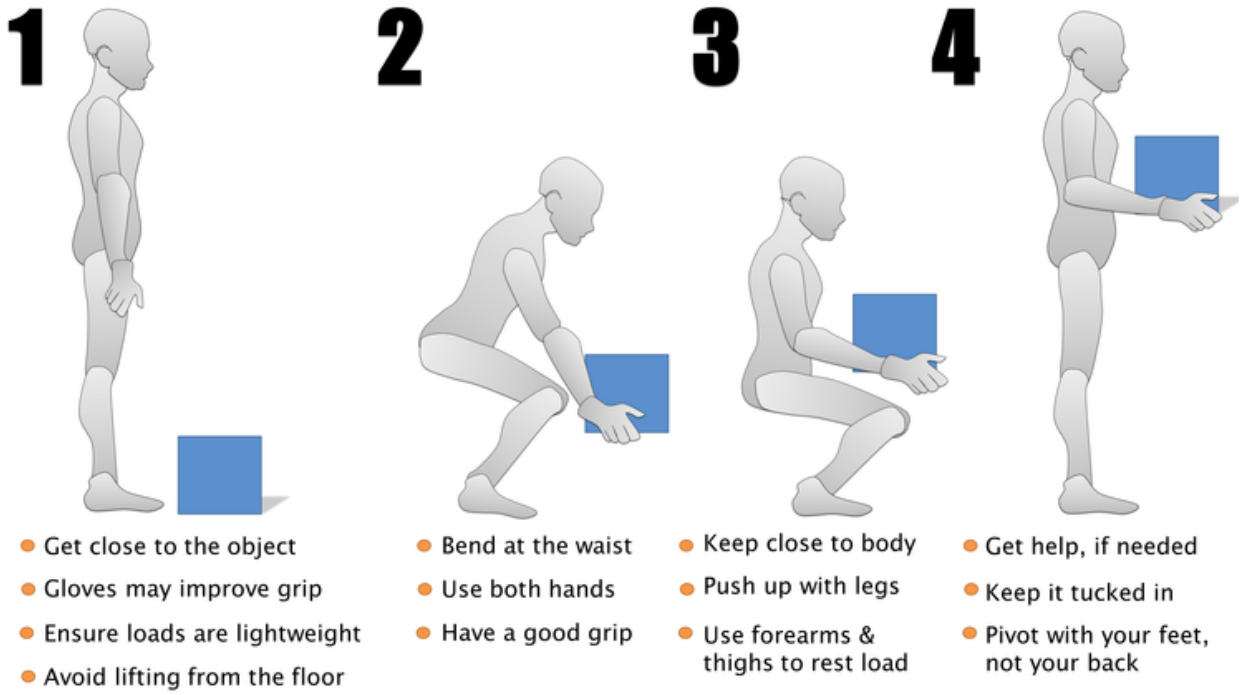
Storage and Filing

Proper filing and storage are important functions in the office. The following precautions shall be observed:

- Shelves should be securely fixed to prevent them from tipping over. When storing materials on shelves, heavier items should be stored at lower levels;
- When filling a filing cabinet for the first time, fill from the bottom up;
- Only one drawer of a file cabinet should be pulled out at any one time to prevent the cabinet from tipping over;
- All drawers of desks and cabinets must be closed as soon as things have been put in or taken out; and
- Proper ladders or steps should be used when reaching for top shelves. Users must not use swivel chairs on castors, boxes, drawers or other makeshift objects for such a purpose.

Carrying and Lifting

Improper lifting and carrying of heavy objects can cause injuries to back, neck, shoulders, arms and hands. These can be prevented by performing proper assessment of the activities and adopting appropriate control for the risks involved. Users should be trained on proper manual handling methods. The following proper lifting techniques can be adopted:



Source: UDC Safety Services

Burns and Scalds

Accidents can happen when handling hot drinks and food, especially in the pantry and using appliance such as microwave. Certain office equipment and machines produce heat that has the potential to cause burns.

- All heating surfaces and receptacles in the pantry should be regarded as hot if uncertain. Receptacles holding hot substances must not be left unattended for extended period of time without proper caution instructions.
- Avoid congestion inside the pantry. Keep pantry areas uncluttered at all times.
- Never heat foodstuff inside airtight containers in the microwave/microwave oven. Users must be presence when heating up their food regardless whether the timer has been set to process the food.
- Never put hot drinks in places where they can be easily knocked over. Sufficient warning should be given to the persons nearby when hot substances are being moved or handled.
- Never touch any hot machine parts (which are normally labelled in yellow). Users must be briefed on the proper use and possible risks associated with use of equipment and machine.

Use of Chemicals

Chemicals used daily in cleaning, lubricating, printing, developing, copying, toning and other activities are irritants to skin, eyes and mucous membranes and may cause drowsiness or intoxication or even present fire risks. Users must be briefed on hazards associated with usage these chemicals. The safety data sheets for these chemicals should be obtained wherever available.

Fire Safety and Emergency Response

The following are some of the fire safety precautions that should be observed in the office:

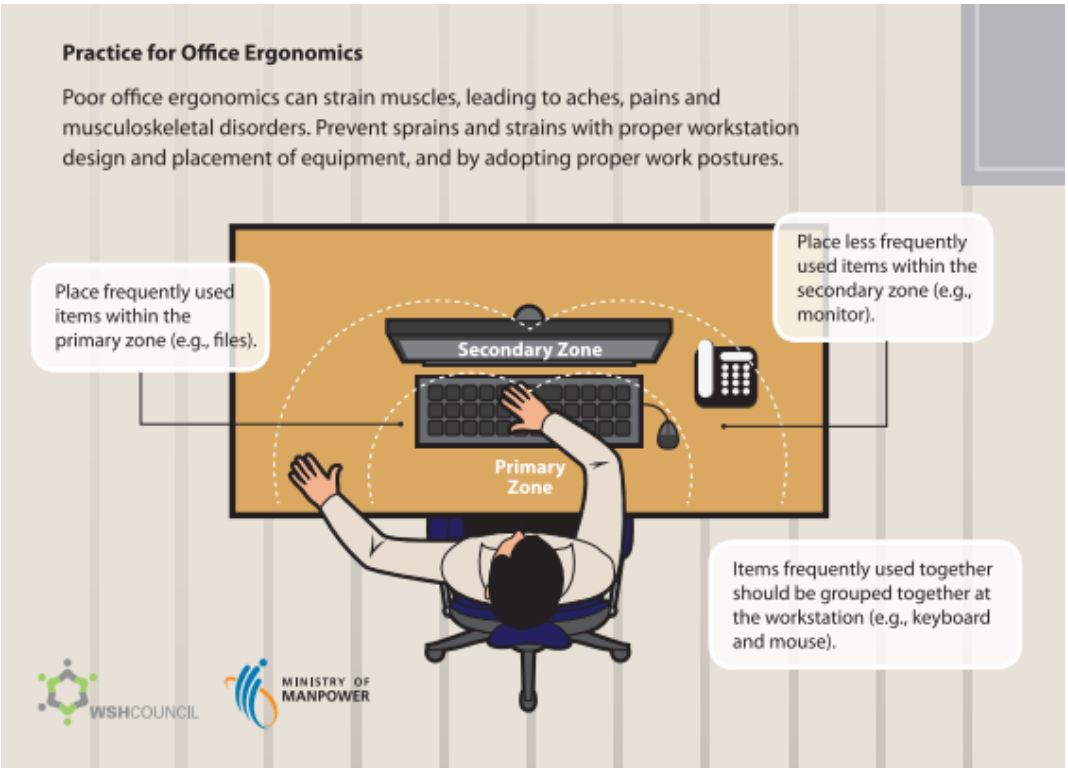
- Flammable fluids must be properly labelled and stored preferable not in the office area;
- Heat generating office equipment such as copying machines, etc., must not be blocked t prevent over-heating;
- Overloading of power sockets can lead to overheating and fire. Hence, the use of multi-adapters should be avoided as much as possible;
- All fire exits must be clearly marked and visible from any location in the office. To prevent the spread of fire and smoke during a fire, all fire doors must be kept closed. However, these doors must not be locked permanently but allow workers to exit during emergency, e.g., one-way lock;
- Fire evacuation plans, must show fire escape routes and fire assembly area, posted near the exits and communicated to all users and visitors to the office. An updated office floor register must be readily available to be taken to the fire assembly area for attendance taking;
- Hosereels, sprinkle heads and fire extinguishers must not be obstructed or obscured. A minimum clearance of 50 cm must be maintained below sprinkler heads. Refer to NUS Lab Design Standard here for more information; and
- At NUS, smoking is prohibited on campus ground and buildings.

Working at Workstations with Computers

Proper Working Postures

Office jobs usually involve long periods of sitting, writing, reading or operating computer. Improper working postures create various potential problems such as neck and back pains, other musculoskeletal problems, varicose veins, etc. The following guidelines should help to reduce these problems.

The workstation should be properly laid out so as to minimize the strains that will be imposed on the worker. Items used more frequently should be placed within reach of the users.

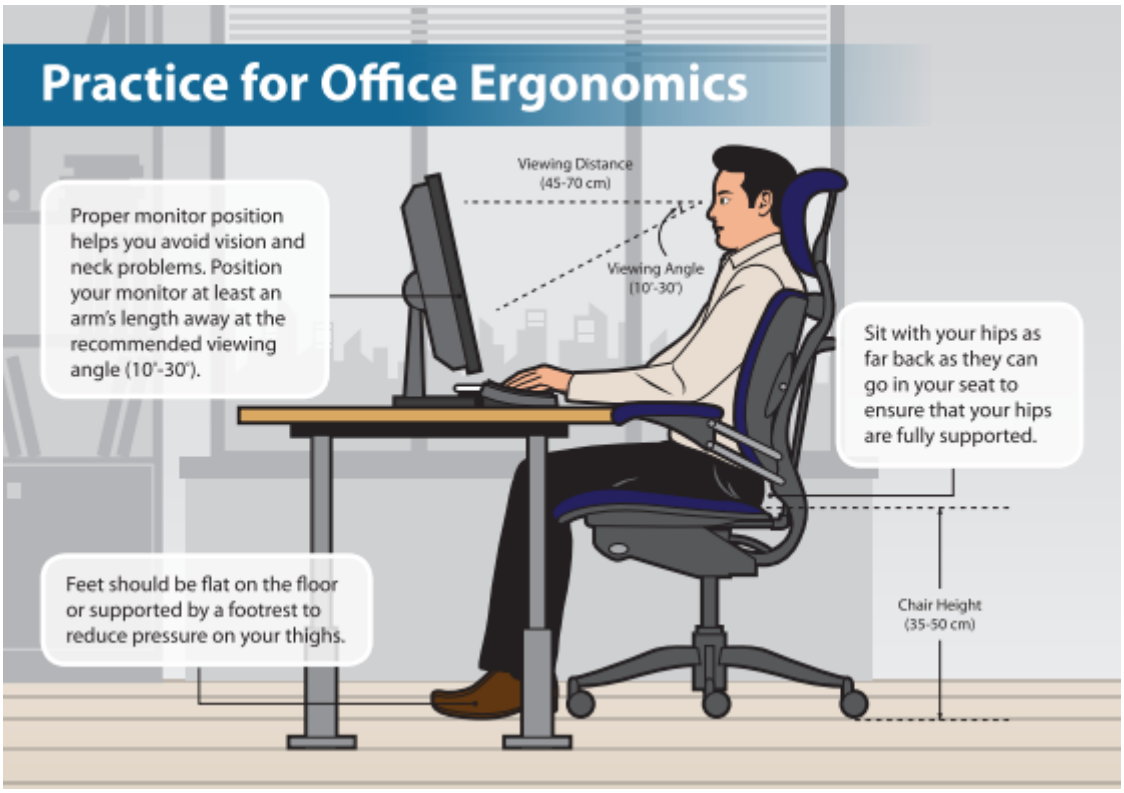


Source: Workplace Safety and Health Council

A comfortable and supportive chair is essential to reduce problems caused by long periods of sitting. Features of a good chair include adjustable seat height, lumbar support, stable wheel base and encourages posture changes.

Users should adopt best sitting posture to avoid musculo skeletal programs. Some good practices to adopt include:

- The wrists are kept straight while using the mouse and keyboard with space provided between the table edge and keyboard for wrist support;
- The feet should be flat on the floor or supported by a footrest to reduce pressure on the thighs; and
- Users should sit with their hips as far back as they can go in the seat to ensure hips are fully supported. Use a back support, if required.



Source: Workplace Safety and Health Council

Eye Strain

Visual problems such as eye strain and irritation are among the most frequently reported complaints by computer operators. Some good practices to adopt to reduce eye strain problems are:

- The display screen should be placed directly in front of the operator, at a height that is slightly below eye-level and should be 45 - 70 cm away from the operator;
- Workstations and lighting should be arranged so as to avoid direct and reflected glare in the field of sight, from the display screen, or surrounding surfaces;
- The screen should be properly adjusted to obtain a readable and stable image. The contrast on the screen should also be adjusted to a comfortable level;
- Background illumination for computer operation should be lower than that for general office work since high illumination level will promote glare and reduce the contrast and visibility of the screen image;
- The illumination level for screen-based work should be reduced to 500 lux or less since the recommended level for office work such as writing, reading and data processing is 500 lux;
- The source of document (if any) should be placed next to the screen, so that the user does not have to change focus frequently between the two surfaces which will aggravate the eye strain problem; and
- Users should take regular short break away from the monitor to rest their eyes or to so some simple eye exercise to relieve stress.

Work-related Musculoskeletal Problems

Users who are seated for prolonged periods of time in front of the computer may suffer from work-related musculoskeletal problems such as carpal tunnel syndrome and tendonitis. Work-related musculoskeletal

problems are injuries that resulted from the overuse of muscles, tendons and nerves due to frequent, repetitive or activities with awkward postures. Common complaints from users suffering from work-related musculoskeletal problems include pain to neck, shoulder, wrists and lower back.

In order to prevent work-related musculoskeletal problems, office users should identify and evaluate the potential ergonomic risks in their workplace and design their workstations to reduce such issues from occurring. It is important to consider that each user is different when eliminating ergonomic risks. Users can use the recommendations presented in the earlier sections as general guidelines for work station design before seeking professional help.

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