Health & Safety
Standard Operating Procedure

SOP-02

Electrical Safety

Produced by

Health & Safety – Facilities & GS Department

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SOP-02: Electrical Safety

1 Overview

1.1 Purpose

The purpose of this Health, Safety and Environment (**HS**) Standard Operating Procedure (**SOP**) is to provide a detailed procedure pertaining to electrical safety associated with activities undertaken at Qatar University (**QU**).

1.2 Hazards and Risks

1.2.1 Electrical Hazards

An electrical hazard is a dangerous condition such that contact or equipment failure can result in electric shock, arc flash burn, thermal burn, or blast.

Electrical hazards also include being exposed to live electricity through contact with live wires or working near high voltage overhead conductors, transformers or electrical switchgear.

1.2.2 Risks and Potential Outcomes

Major impacts of electrical hazards include electric shock, arc flash/blast, and fires. These impacts can result in explosions, burns, electrocution, and death.

The severity and effects of an electrical shock depend on a number of factors, such as the pathway through the body, the amount of current and the length of the exposure time. Other factors that may affect the severity of the shock are the voltage of the current, presence of moisture in the environment, the phase of the heart cycle when the shock occurs, and the general health of the person prior to the shock.

Arc flash/blast occurs when electric current flows through air gaps between conductors. Typical results from an arc flash/blast include:

- Burns (Non fire resistant clothing can burn onto skin)
- Fire (could spread rapidly through a building)
- Flying objects (often molten metal)
- Blast pressure (upwards of 9,750 kilogram-force / sq. meter)
- Sound Blast (noise can reach 140 dB – loud as a gun)
- Heat (upwards of 19,500 degrees C)

  Sparks from electrical devices can serve as an ignition source for flammable or explosive vapours or combustible material.

1.3 Key Terminology

Table 1. Key Terms

Term	Definition
Insulator	An insulator is a substance with such a high resistance that it can be used to prevent the flow of electrical current.
Grounding	Grounding refers to the process of connecting an object directly to ground, the earth, or to a conductive body that extends the ground connection.
Arc flash	A flashover of electric current leaves its intended path and travels through the air from one conductor to another, or to ground. The results are often violent and when a human is in close proximity to the arc flash, serious injury and even death can occur.
Qualified worker or person	One who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved.
Ground fault circuit interrupter (**GFCI**)	A device intended for the protection of personnel that functions to DE energize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established

2 Scope

The requirements outlined in this SOP are applicable to all QU workers, students, contractors, and visitors who are working for QU, and/or conducting work on QU premises. The following subsections outline some of routine and non-routine activities in which the conditions covered by this technical guidance may be encountered.

2.1 Routine

Electricity is integral to all areas of QU. It presents the greatest hazard and risk during the following routine activities:

- General office work involving electrically powered equipment
- Routine building maintenance
- Use of laboratory equipment
- Use of kitchen equipment

2.2 Non-routine

QU workers or contractors may be involved in or near non-routine activities that present electrical hazards. These could include:

- Testing or maintenance of building-wide or campus-wide electrical systems
- Opening of electrical panels, switchgear, or transformers
- Construction activities near overhead electrical wires
- Underground construction activities near buried electrical wires

3 Roles and Responsibilities

Each employee should be on the alert for hazardous conditions and promptly report any to the Health & Safety Section (**HS**).

The department is responsible for the correction of any operational deficiencies that are discovered. Facility deficiencies must be reported to the HS.

The QU Departments are the primary organization responsible to implement and maintain sound electrical safety practices and that assure safety compliance in their respective areas.

3.1 VPs, Deans, Directors, Managers, Head Sections

VPs, Deans, Directors, Managers, Head Sections/Units and Project Managers have the primary responsibility of directing and managing electrical safety and therefore have responsibility for assuring sound safety practices and compliance within the Department and Colleges. They are ultimately responsible for enforcing consequences arising from moderately serious and very serious incidents.

3.2 Employees, Contractors and Students

Employees, contractors and students are responsible for compliance with safety regulations and this SOP, as applicable.

3.3 Health & Safety Section (HSS)

The HSS is responsible for Electrical Safety Orientation on an annual basis or as need arises to all workers, faculties, and students.

4 Risk Prevention

4.1 General Prevention Requirements

The following prevention practices should be followed to minimize the potential risk associated with electrical hazards:

- Ensure a competent person is engaged / called to perform tasks on exposed live electrical components.
- Use double-insulated tools.
- Ground all exposed metal parts of a device.
- Use all equipment devices according to the manufacturer's instructions.
- Do not modify cords or use them incorrectly.
- Inspect wiring of equipment devices before each use.
- Replace damaged or frayed electrical cords immediately.
- Use safe work practices every time electrical equipment is used.
- Know the location and how to operate shut-off switches and/or circuit breaker panels. Use these devices to shut off the equipment in the event of a fire or electrocution.
- Limit the use of extension cords. Use only for temporary operations and only for short periods of time. In all other cases, request installation of a new electrical outlet.

- Multi-plug adapters must have circuit breakers or fuses.
- Place exposed electrical conductors behind shields.
- Minimize the potential for water or chemical spills on or near electrical equipment.
- Equipment and electronic systems must conform to the National Electric Code, National Fire Protection Association Code (NFPA) 70E and KAHRAMAA requirements. Compliance must be adjudicated by licensed electricians or duly trained personnel.
- Insulated tools or handling equipment shall be used by staff working near exposed energized conductors or circuit parts if the tools or handling equipment might make contact with such conductors or parts. If the insulating capability of insulated tools or handling equipment is subject to damage, the insulating material shall be protected.
- Protective shields, protective barriers, or insulating materials must be used to protect workers from shock, burns, or other electrically related injuries while staff are working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur. Under no circumstances may a non-qualified person be within the limited approach boundary of exposed energized equipment.
- When normally enclosed live parts are exposed for maintenance or repair, they are to be guarded to protect unqualified persons from contact with the live parts.
- Fuse Handling Equipment insulated for the circuit voltage shall be used to remove or install fuses when the fuse terminals are energized.
- Ropes and Hand-lines used near exposed energized parts shall be nonconductive.

4.2 Maintenance, Inspection and Testing

QU shall ensure that an appropriate inspection, maintenance and testing arrangements are in place for all electrical systems. Where a contractor is responsible for the electrical systems, QU shall ensure prior to engaging the contractor, that they an appropriate inspection, maintenance and testing program in place.

QU shall periodically review the effectiveness of their maintenance, inspection and testing provisions to determine on-going asset performance/condition, and maintenance effectiveness.

4.3 Specific Prevention Methods

4.3.1 Insulation

All electrical cords should have sufficient insulation to prevent direct contact with wires and should be checked prior to each use. Before each use, portable cord- and plug-connected equipment shall be visually inspected for external defects (such as loose parts or deformed and missing pins) and for evidence of possible internal damage (such as a pinched or crushed outer jacket).

If there is a defect or evidence of damage that might expose a worker to injury, the defective or damaged item shall be removed from service. No worker shall use it until a person(s) qualified to perform the repairs and tests necessary to render the equipment safe has done so.

4.3.2 Guarding

Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Plexiglas shields may be used to protect against exposed live parts.

4.3.3 Grounding

When properly done, current from a short or from lightning follows this path, thus preventing the buildup of voltages that would otherwise result in electrical shock, injury and even death.

System or service ground consists of a wire called “the neutral conductor” grounded at the transformer and again at the service entrance of the building. This is primarily designed to protect machines, tools and insulation against damage.

Equipment ground is intended to offer enhanced protection to the workers themselves. If a malfunction causes the metal frame of a tool to become energized, the equipment ground provides another path for the current to flow through the tool to the ground. Grounded equipment has a power cord equipped with a three-pronged plug.

4.3.4 Circuit Protection Devices

Circuit protection devices are designed to automatically limit or shut off the flow of electricity in the event of a ground-fault, overload or short circuit in the wiring system. Fuses, circuit breakers, and ground-fault circuit interrupters are three well-known examples of such devices.

Fuses and circuit breakers prevent over-heating of wires and components that might otherwise create fire hazards. They disconnect the circuit when it becomes overloaded. This overload protection is very useful for equipment that is left on for extended periods of time.

The ground-fault circuit interrupter, or GFCI, is designed to shutoff electric power if a ground fault is detected, protecting the user from a potential electrical shock. The GFCI is particularly useful near sinks and wet locations. Since GFCIs can cause equipment to shutdown unexpectedly, they may not be appropriate for certain apparatus. Portable GFCI adapters (available in most safety supply catalogs) may be used with a non-GFCI outlet.

4.3.5 Motors

Motor-driven electrical equipment should be equipped with non-sparking induction motors or air motors. These motors must meet National Electric Safety Code, NFPA 70E, Class 1, Division 2, Group C-D explosion resistance specifications and/or QCS 2010 Electrical Standards.

Avoid series-wound motors, such as those generally found in some vacuum pumps, rotary evaporators and stirrers. Series-wound motors are also usually found in household appliances such as blenders, mixers, vacuum cleaners and power drills. These appliances should not be used unless flammable vapors are adequately controlled.

5 Safe Work Practices

5.1 General Work Practices

The following practices may reduce risk of injury or fire when working with electrical equipment and must be followed by all workers unless specifically qualified:

- Avoid contact with energized electrical circuits. All electrical circuit conductors and circuit parts shall be considered energized until the source(s) of energy is (are) removed.
- Follow the buddy system when performing electrical works.
- Disconnect the power source before servicing or repairing electrical equipment/devices.
- When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear nonconductive gloves and shoes with insulated soles.
- Minimize the use of electrical equipment in cold rooms or other areas where condensation is expected. If equipment must be used in such areas, mount the equipment on a wall or on a vertical panel.
- If water or a chemical is spilled over equipment, shut off the power at the main switch or circuit breaker and unplug the equipment.
- If an individual has come in contact with a live electrical conductor, do not touch the equipment, cord or the individual. Disconnect the power source from the circuit breaker or pull out the plug using a leather belt.
- Avoid contact with known hazards such as “high voltage”, “high temperature”, “possible shock”, “wear protective equipment”, etc.
- Repairs of high voltage or high current equipment should be performed only by trained electricians.
- Before staff and contractors may be exposed to or work on or near live parts or circuits they must be de energized unless the employer can demonstrate that de-energizing introduces additional or increased hazards or is unfeasible due to equipment design or operational limitations.
- If the exposed live parts are not de-energized (i.e., for reasons of increased or additional hazards or unfeasibility), only qualified workers may perform work within the area. Additional safety related work practices shall be used to protect staff and contractors who may be exposed to the electrical hazards involved. Such work practices shall protect staff and contractors against contact with energized circuit parts directly with any part of their body or through some other conductive object. The work practices that are used shall be suitable for the conditions under which the work is to be performed and for the voltage level of the exposed electric conductors or circuit parts.

5.2 Specific Work Practices

A qualified worker is one who has demonstrated skills and knowledge related to the construction and operation of electrical equipment and installations and has received safety training to identify and avoid the hazards involved. Only qualified workers may work on electric circuit parts or equipment that has not been de-energized. Equipment or electric circuit parts should be de-energized following lock-out / tag-out procedures, if

possible, prior to performing work. Refer to HSEMS Technical Guidance TG-02 Lockout / Tagout for additional information.

If equipment cannot be de-energized and due to the unique hazards to which qualified workers may be exposed, the following safety precautions must be followed:

- Staff and contractors shall not enter spaces containing exposed energized parts, unless illumination is provided that enables the staff to perform the work safely.
- Staff and contractors are not to perform tasks on or near exposed energized parts where there is a lack of illumination or an obstruction which precludes observation of work to be performed.
- For confined or enclosed work spaces, prior to entry staff and contractors must be trained in the confined space entry requirements. For staff and contractors working in confined or enclosed spaces such as manholes or vaults that contain exposed energized parts, they shall be provided with protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Doors, hinged panels and the like shall be secured to prevent their swinging into staff and causing the staff and contractor to contact exposed energized parts.
- Conductive materials or equipment that is in contact with any part of a staff member or contractor's body shall be handled in a manner that will prevent the staff from contacting exposed energized conductors or circuit parts.
- If a worker must handle long dimensional conductive objects (such as ducts and pipes) in areas with exposed live parts, the employer shall institute work practices (such as the use of insulation, guarding, and material handling techniques) which will minimize the hazard.
- All portable ladders shall be non-conductive if to be used by staff and contractors exposed to energized parts.
- Staff and contractors are not allowed to wear conductive articles of jewellery and clothing such as watch bands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, or metal headgear if they might contact exposed energized parts. However, such articles may be worn if rendered non-conductive by covering or wrapping with an insulating material.
- Housekeeping duties shall not be performed close enough for possible contact with live parts, unless adequate safeguards such as insulating equipment or barriers are provided.
- Electrically conductive cleaning materials including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions shall not be used near energized parts unless procedures are followed which prevent electrical contact.
- Only qualified workers are allowed to defeat an electrical safety interlock following the above specified procedures for working on or near exposed energized parts, and then only temporarily while they are working on the equipment. Also, the interlock system will be returned to its operable condition when this work is completed and verified to be operational.

5.3 Use of Equipment

The following precautions apply when using electrically powered equipment.

5.3.1 General precautions

- All portable electric equipment and flexible cords used in highly conductive work locations, such as those with water or other conductive liquids, or in places where staff are likely to contact water or conductive liquids must be approved for those locations.
- Workers' hands shall not be wet when plugging and unplugging flexible cords and cord-and-plug connected equipment, if energized equipment is involved. If the connection could provide a conducting path to staff hands, (if, for example, a cord connector is wet from being immersed in water) the energized plug and receptacle connections must be handled only with insulating protective equipment. Locking-type connectors shall be properly locked into connector
- Where flammable or ignitable materials are present only occasionally, electric equipment capable of igniting them shall not be used unless measures are taken to prevent hazardous conditions from developing. Materials include, but are not limited to; flammable gases, vapours, or liquids; combustible dust; and ignitable fibers or filings.

5.3.2 Portable equipment

- Portable electrical equipment applies to the use of cord and plug connected equipment and flexible cord sets (extension cords).
- Portable equipment shall be handled in a manner which will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment.
- Flexible cords are not to be fastened with staples or otherwise hung in such a fashion as to damage the outer jacket or insulation.
- Portable cord and plug connected equipment and flexible cord sets (extension cords) shall be visually inspected before use on any shift for external defects such as loose parts, deformed and missing pins, or damage to outer jacket or insulation and for possible internal damage such as pinched or crushed outer jacket.
- When defects or evidence of damage which might expose staff to injury are detected, the defective or damaged item shall be removed from service and no person shall use it until it is repaired and tested to ensure it is safe for use.

5.3.3 Grounded equipment

- Flexible cords used with grounded equipment shall contain an equipment grounding conductor.
- Attachment plugs and receptacles may not be connected or altered in any manner which would prevent proper continuity of the equipment grounding conductor at the point where plugs are attached to receptacles. Additionally, these devices may not be altered to allow the grounding pole to be inserted into current connector slots. Clipping the grounding prong from an electrical plug is prohibited.
- Adapters which interrupt the continuity of the equipment grounding connection may not be used.

5.3.4 Electric Power and Lightings Circuits

- Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions.
- Cable connectors not of the load-break type, fuses, terminal lugs, and cable splice connections may not be used for opening, reversing, or closing circuits under load conditions except in an emergency.
- After a circuit is de-energized by a circuit protective device (e.g., blown fuse, tripped GFCI), the circuit may not be manually re-energized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual re-closing of circuit breakers or re-energizing circuits through replaced fuses is prohibited. When it can be determined from the design of the circuit and over current devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is re-energized.
- Over-current protection of circuits and conductors may not be modified, even on a temporary basis.

5.3.5 Test Equipment and Instruments

- Only qualified persons may perform testing work on electric circuits or equipment.
- Test instruments and equipment including all associated test leads, cables, power cords, probes and connectors shall be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose a worker to injury, the defective or damaged item shall be removed from service, tagged out of service and no staff may use it until repairs and tests necessary to render the equipment safe have been made.
- Test instruments, equipment, and their accessories shall be rated for the circuits and equipment to which they will be connected and designed for the environment in which they will be used.

5.4 Personal Protective Equipment (PPE)

Staff working in areas where there are potential electrical hazards shall be provided with and shall use electrical protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed.

The following general requirements apply to PPE used to guard against electrical hazards:

- Protective equipment shall be maintained in a safe, reliable condition, and periodically inspected or tested.
- If the insulating capability of protective equipment may be subject to damage during use, the insulating material shall be protected by covering with leather or other appropriate materials.
- Nonconductive head protection shall be worn whenever there is danger of head injury from electric shock or burn due to contact with exposed energized parts.

- Protective equipment for the eyes or face shall be worn whenever there is danger of injury to the eyes or face from electric arcs, flashes or flying objects resulting from electrical explosion.

5.5 Warning devices

The following alerting techniques are used to warn and protect staff from electrical shock hazards, burns, or failure of electric equipment parts.

- Safety signs, safety symbols, or accident prevention tags are to be used where necessary to warn staff about electrical hazards which may endanger them.
- Barricades are used in conjunction with safety signs where necessary to prevent or limit staff access to work areas exposing staff to un-insulated energized conductors or circuit parts. Conductive barricades may not be used where they might cause an electrical contact hazard.
- If signs and barricades do not provide sufficient warning from electrical hazards, an attendant is to be stationed to warn and protect staff.

6 Training

Workers exposed to an electrical hazard when the risk associated with that hazard is not reduced to a safe level by the applicable electrical installation requirements shall be trained.

QU shall ensure that no person is engaged in any work activity on or in the vicinity of electrical systems unless such person has the competency gained from training, technical knowledge and experience of the precautions to be taken against the risk of death or personal injury, and is under such degree of supervision as may be appropriate having regard to the nature of the work.

Refer to ***QU HSEMS Section 11.0: Training and Competency Procedure*** for additional information regarding training processes.

6.1 General Worker Training

The type and extent of training shall be determined by the risk to the worker and shall include:

- Sufficient information to provide the worker with an understanding of the specific hazards and risks associated with electrical energy.
- Safety-related work practices and procedural requirements, as necessary and as identified in the risk assessment / this procedure, to provide protection from the electrical hazards associated with their respective job or task assignments.
- Information to identify and understand the relationship between electrical hazards and possible injury.
- Reporting procedure in the event of incidents involving electrical systems.

The required training shall be classroom, on-the-job, or a combination of the two.

6.2 Specific Worker Training

In addition to the training requirements identified above in Section 6.1, a qualified worker, at a minimum, shall be:

- trained and knowledgeable in the construction and operation of equipment or a specific work method;
- trained to identify and avoid the electrical hazards that might be present with respect to that equipment or work method; and
- familiar with the proper use of the special precautionary techniques, applicable electrical policies and procedures, PPE, insulating and shielding materials, and insulated tools and test equipment.

A person can be considered qualified with respect to certain equipment and methods but still are unqualified for others.

6.3 Training Documentation

QU shall maintain a record of required training and attained competency with respect to electrical safety for all persons working on or in the vicinity of electrical systems.

7 Document Control

This SOP is a controlled document. The controlled version of this SOP is located on the QU Documentation Management System.

Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.

Refer to ***QU HSEMS – Document Control and Record Retention***.

8 References

NFPA 70E, Standard for Electrical Safety in the Workplace, National Fire Protection Association, 2015 Edition.

US Occupational Safety and Health Administration Regulations, 29 CFR 1910.

Health & Safety
Standard Operating Procedure

SOP- 03

Compressed Gas Cylinders

Produced by

Health & Safety – Facilities & GS Department

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SOP-03: Compressed Gas Cylinders

1 Overview

1.1 Purpose

To provide procedure for the safe handling and use of portable compressed gas cylinders. Compressed gases are unique in that they represent both a physical and potential chemical hazard (depending on the particular gas).

1.2 Hazards and Risks

1.2.1 Hazard Definition

The gases contained in these cylinders vary in chemical properties, ranging from inert and harmless to toxic and explosive. The high pressure of the gases constitutes a serious hazard in the event that the cylinders sustain physical damage and/or are exposed to high temperatures.

1.2.2 Potential Outcomes

Potential risks from mishandling compressed gases include leaks, fire and explosion.

1.3 Key Terminology

Term	Definition
Asphyxiate gas	A gas, usually inert, that may cause suffocation by displacing the oxygen in the air necessary to sustain life.
Compressed gas	A gas or mixture of gases having an absolute pressure exceeding 40 psi at 70 degrees F (21.1 degrees C); or, a gas or mixture of gases having an absolute pressure exceeding 104 psi at 130 degrees F (54.4 degrees C) regardless of the pressure at 70 degrees F; or, a liquid having a vapour pressure exceeding 40 psi at 100 degrees F (37.8 degrees C) as determined by ASTM D-323-72.
Corrosive gas	A gas that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the point of contact or is labelled by the DOT as Division 2.3 and Division 8 (Corrosive).
Cryogenic fluid	A refrigerated liquefied gas having a boiling point colder than -90 °C (130 °F) at 14.7 psi.
Fire Control Area	A Fire Area is an area enclosed and bounded by fire walls, fire barriers, exterior walls or fire-resistance rate horizontal assemblies of a building. Control Areas are spaces within a building and outdoor areas where quantities of hazardous materials not exceeding the maximum quantities allowed are stored, dispensed, used or handled Control areas must be separated from each other by not less than a 1 hour fire barrier.

Term	Definition
Flammable gas	A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or, a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
Oxidizer gas	A gas that is non-flammable but can support and vigorously accelerate combustion in the presence of an ignition source and a fuel.
Toxic gas	A gas that has a median lethal concentration (LC_{50}) in air of 2,000 parts per million or less by volume of gas (Highly Toxic has an LC_{50} of 200 ppm or less or a gas that has an NFPA Health Hazard Rating of 3 (Toxic) or 4 (Highly Toxic).

2 Scope

The requirements outlined in this SOP are applicable to all QU employees, students, contractors, and visitors who are working for QU, and/or conducting work on QU premises. The following subsections outline some of routine and non-routine activities in which the conditions covered by this SOP may be encountered.

The procedure covers the use, handling and storage of compressed gases in laboratories (research and academic) and non-laboratory areas (Maintenance, Chiller Plant, Workshop, Warehouse, etc.).

2.1 Routine

Compressed gas is routinely used, handled and stored in labs and maintenance areas.

2.2 Non-routine

Compressed gas may be used, handled and stored during non-routine activities such as construction activities (e.g. use of gas for welding).

3 Roles and Responsibilities

QU Top Management appropriate resources are allocated to ensure that employee and student exposure to compressed gases and hazardous materials/chemicals are within acceptable risk levels.

3.1 (VPs), Deans, Directors, Managers, Head Sections/Units and Project Managers

VPs, Deans, Directors, Managers, Head Sections/Units and Project Managers have the primary responsibility for ensuring that employees and students under their supervision and who may be exposed to compressed gas risks comply with the requirements of this SOP.

3.2 Employees, Contractors and Students

Employees, contractors and students are responsible for compliance with safety regulations and this SOP, as applicable.

Employees, contractors and students shall report any activity or defect relating to compressed gases which they believe is reasonably foreseeable to endanger their safety or that of another person.

Employees, contractors and students shall use appropriate equipment or safety devices in accordance with any training or instruction received in the use of the work equipment or device concerned.

Employees, contractors and students shall not perform any task requiring training until they have received the required training and it is documented.

Employees, contractors and students shall not operate any piece of equipment that they are not familiar with, competent to operate and/or appropriately trained on its use.

3.3 Health & Safety Section (HSS)

The HSS is responsible for the implementation of this procedure.

The HSS shall develop and implement an inspection, testing and preventative maintenance plan to ensure compressed gas systems are safe and working efficiently and according to manufacture specifications and applicable legal requirements.

The HSS shall ensure compressed gases systems are tested and inspected regularly (at a minimum annually) to ensure the system work in accordance with manufactures specifications.

The HSS shall monitor the use of compressed gases systems to ensure employees are using compressed gases appropriately.

3.4 HS Committee

The HS Committee shall be responsible for assisting in the implementation, maintenance and review of this procedure, as requested.

4 Risk Prevention

4.1 General Prevention Requirements

QU shall ensure that an assessment of the various risks is undertaken and systems of work are established which are safe to all parties involved or affected including the public.

QU shall ensure that appropriate control measures are implemented in order to manage activities safely and without risk to health.

4.2 Specific Prevention Methods

When performing risk assessments, the following shall be considered:

- the condition of the equipment being used (compressors, hoses, couplings etc.) and if they are rated by an appropriate International Standard for their intended use;
- the type, frequency and duration of the compressed air work;

- the environment in which the compressed air work is to be undertaken (e.g. dirty/dusty conditions, uneven work surfaces, cramped conditions);
- the pressure at which the compressor is operating at;
- the level of experience of the personnel involved in the work; and
- other identified hazards associated with the work.

When using compressed gas systems (to include pneumatic tools), the following requirements shall be met:

- Pipes, hoses, and fittings shall display the rating of the maximum pressure of the compressor. Compressed air pipelines shall be identified and tested to maximum
- Working pressure;
- Under no circumstances shall the pressure of the compressed air exceed the maximum working pressure of any of the components in use;
- Couplings shall have safety clips fitted to them to prevent inadvertent uncoupling when under pressure – makeshift tie-wire shall not be used;
- Ensure all components comply with the appropriate International Standard for their intended use and are regularly maintained in a fit for purpose condition;
- The setting of safety valves or reducing valves shall only be adjusted by a competent person;
- Air supply shutoff valves shall be located, as near as reasonably practicable, at the point-of-operation;
- Air hoses shall be kept free of grease and oil to reduce the possibility of deterioration;
- Hoses shall not be located across floors or aisles where they are liable to cause personnel to trip and fall. When reasonably practicable, air supply hoses shall be suspended overhead, or otherwise located to afford efficient access and protection against damage;
- Hose ends shall be secured to prevent whipping if an accidental cut or break occurs;
- Pneumatic impact tools, such as riveting guns, shall never be pointed at a person;
- Before pneumatic tools are disconnected (unless it has quick disconnect plugs), the air supply shall be turned off at the control valve and the tool bled;
- Compressed air shall not be used under any circumstances to clean dirt and dust from clothing or off a person' s skin;
- Air used for cleaning shall be regulated to 15 psi unless equipped with diffuser nozzles to provide lesser pressure;
- Static electricity may be generated through the use of pneumatic tools. This type of equipment shall be grounded or bonded if it is used where fuel, flammable vapors or explosive atmospheres are present;
- When used for cleaning, the compressed air equipment (air nozzle) shall reduce the outlet (working) air pressure to less than 30 pounds square inch (psi) at the discharge tip. In-line chip protection shall be used when airlines are connected directly to a compressed air system. This does not mean that the supply air or line

pressure be reduced to 30 psi as long as the static (dead head) pressure exiting the nozzle when restricted does not exceed the mandatory maximum 30psi;

- Reduction of air pressure for cleaning can be done with nozzles and tips designed for this purpose. Employees shall not remove, damage, cover (e.g. tape), replace or in any way alter the equipment provided for this purpose. Nozzles that have been altered or "home-made" and shall not be used;
- Goggles, face shields or other eye and hearing protection shall be worn by personnel
- Using compressed air for cleaning equipment; and
- All defects shall be immediately reported to the employer and the use of the defected
- Equipment shall be ceased.

5 Safe Work Practices

5.1 General Worker Safety

- Cylinders must be transported, stored and used upright (with the valve up), and must be securely fastened to prevent them from falling or being knocked over. Suitable racks, straps, chains or stands are required to support cylinders.
- Cylinder valves are to be protected with the standard cap when not in use (empty or full). Regulators are to be protected with covers where there is likelihood of damage.
- Never force a cap or regulator. The cap should only be hand tight.
- Cylinders should not be exposed to excessive dampness, or to corrosive chemicals or fumes.
- Cylinders are not to be exposed to temperature extremes nor stored in the vicinity of combustibles.
- Gases are not to be transferred from one vessel to another (except dry ice and cryogenic material). Do not try to refill compressed gas cylinders.
- Before using a cylinder, slowly "crack" the valve to clear dust or dirt, being sure the opening is not pointed toward anyone. Additional precautions must be taken when toxic or flammable gases are involved (see Section 4.4.) Do not stand in front of the regulator gauge glass when opening the valve.
- Never use a cylinder without a regulator. Always use the correct pressure regulator.
- After attaching the regulator, and before the cylinder is opened, check the adjusting screw of the regulator to see that it is released. Never permit the gas to enter the regulator suddenly.
- Never try to stop a leak between a cylinder and regulator by tightening the union nut unless the valve has been closed first.
- Never strike an electric arc on a cylinder.
- Never use a leaking, corroded or damaged cylinder. Remove the cylinder from service and contact the supplier for return.

Attaching a Regulator

- Use safety glasses and goggles.
- Before attaching the regulator, perform a visual inspection of the regulator. Check the condition of the inlet and outlet, look for worn threads and inspect gauges for damage.
- Visually inspect the cylinder before use to detect for any damage, cracks, corrosion or other defects.
- Wipe the outlet with a clean, dry, lint free cloth. The threads and mating surfaces of the regulator and hose connections should also be cleaned before the regulator is attached. A connection problem caused by dirty or damaged threads could result in leaks when the cylinder is used.
- Always use a cylinder wrench or other tight fitting wrench to tighten the regulator nut and hose connections. Using an oversized wrench, adjustable wrench, pliers or a pipe wrench may damage the fittings and make it impossible to tighten them properly.
- Attach the proper regulator to the cylinder of compressed gas (see Figure 1). Do not use Teflon TM tape on fittings when the seal is made by metal-to-metal contact. Under no circumstances is grease or oil to be used on regulator or cylinder valves because these substances may cause an adverse, dangerous reaction within the cylinder gas.
- Check for leaks using the gas leak detector.

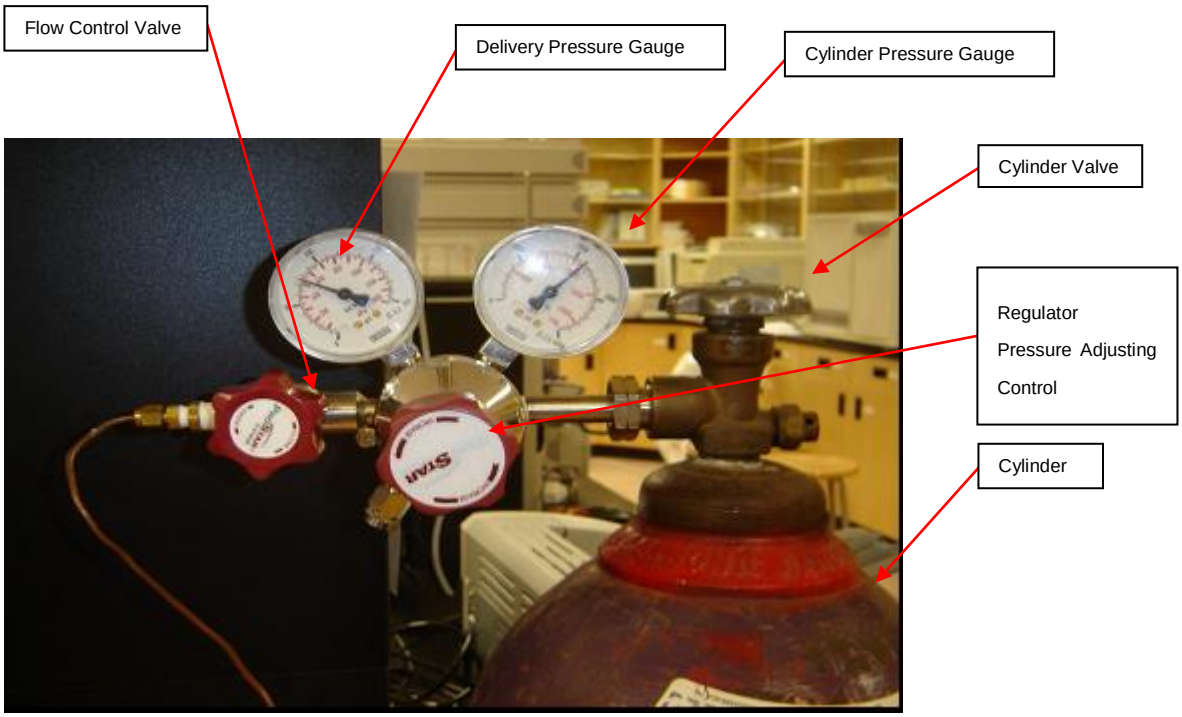

Figure1. Regulator attachment to compressed gas cylinder

5.2 Specific Gas Requirements

The following information regarding specific classes of gases is offered as additional requirements to be used in conjunction with the general usage requirements listed in preceding sections.

Flammable Gases

- Not more than 100 cubic feet of flammable gas can be used and stored (combined quantity) in a fire control area. In a laboratory 500 square feet or less, not more than 6 cubic feet, and larger laboratories, not more than 0.012 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).
- Flammable gases must be stored in well-ventilated areas away from flammable liquids, combustible materials, oxidizers, open flames, sparks and other sources of heat or ignition. A distance of 20 feet or a noncombustible barrier at least 18 inches above the tallest container, but not less than 5 feet and laterally not less than 18 inches beyond the sides of the containers and having a fire rating of at least ½ hour is the minimum separation requirement.
- Portable fire extinguishers (carbon dioxide or dry chemical type) must be available for fire emergencies where flammable gas is stored.
- Spark-proof tools should be used when working with flammable gas cylinders.
- "Flow" experiments with flammable gases are not to be left unattended; an explosive meter or combustible gas alarm must be used.
- In the event of an emergency involving a flammable gas, such as a gas leak, fire or explosion, personnel must immediately evacuate the area. Do not attempt to extinguish burning gas if the flow of product cannot be shut off immediately and without risk.
- All lines and equipment associated with flammable gas systems must be grounded and bonded.
- Acetylene should not be utilized in lines or hoses at a pressure exceeding 15 psi.
- Contact HSEO for additional information or concerns about flammable gas storage.

Asphyxiant Gases

- Do not store asphyxiant gases in areas without ventilation. This includes environmental chambers (e.g. cold boxes) that do not have a fresh air supply or exhaust system.
- Any gas that has the potential to displace oxygen in sufficient quantities can cause asphyxiation. Only persons trained, qualified and using a self-contained breathing apparatus (SCBA) with adequate back-up should respond to an inert gas leak or enter an area where an asphyxiant gas could be present. Shut off the source of the gas leak if there is no risk to personnel and ventilate the area. If a person has symptoms of asphyxiation, move the victim to fresh air and obtain proper medical attention.

Oxidizer Gas

- Not more than 1500 cubic feet of oxidizing gas can be used and stored (combined quantity) in a fire control area. In a laboratory 500 square feet or less, not more than 6 cubic feet, and larger laboratories, not more than 0.012 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).

- All equipment used for oxidizing gases must be cleaned with oxygen-compatible materials free from oils, greases, and other contaminants (hydrocarbons and neoprene are not oxygen-compatible; PTFE Teflon is compatible. The equipment will state that it is oxygen compatible). Do not handle cylinders with oily hands or gloves.
- Oxidizers shall be stored separately from flammable gas containers or combustible materials. A distance of 20 feet or a noncombustible barrier at least 5 feet high having a fire rating of at least ½ hour is the minimum separation requirement.

Corrosive Gas

- Not more than 810 cubic feet of corrosive gas can be used and stored (combined quantity) in a fire control area.
- Keep exposure to gas as low as possible. Use in fume hood or other vented enclosure when possible. Avoid contact with skin and eyes.
- Wear safety goggles when handling compressed gases which are corrosive.
- An emergency shower and eyewash must be installed within 50 feet where corrosive materials, including corrosive gases.
- An emergency response procedure must be in place and everyone working in the area must be trained on the procedures.
- Safety plugs in the valves of chlorine cylinders fuse at 157 degrees F. Care must be exercised to see that they are not exposed to steam, hot water, etc. which could produce this temperature. Chlorine leaks may be located using a cloth wet with aqua-ammonia which will produce white fumes (ammonia chloride) in the presence of chlorine. NOTE: This procedure may only be performed with appropriate respiratory protection. In order for any individual to wear a respirator, he/she must have written physician's approval, attend a respiratory protection training session, and pass a respirator fit test. Training and fit testing are provided by the HS.

Toxic and Highly Toxic Gas

- Not more than 1,620 cubic feet of toxic gas can be in storage and 810 cubic feet in use in a fire control area. Not more than 40 cubic feet of highly toxic gas can be in storage and 20 cubic feet in use in a fire control area. In a laboratory 500 square feet or less, not more than 0.3 cubic feet, and larger laboratories, not more than 0.0006 cubic feet per square feet of lab work area can be used and stored. In addition, lecture bottle cylinders must be limited to 25 (10 in instructional laboratories).
- Lecture bottle-sized cylinders for all gases that have a health hazard rating of 3 or 4 or a health hazard rating of 2 without physiological warning properties, must be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure. Larger cylinders of toxic or highly toxic gas must be stored in gas cabinets, exhausted enclosures or gas rooms.
- Toxic and highly toxic gases shall not be stored or used outside of academic or research laboratories.
- Keep exposure to gas as low as possible. Use in fume hood or other vented enclosure when possible. Avoid contact with skin and eyes.
- Wear safety goggles when handling compressed gases which are toxic or highly toxic.
- A gas detection system with visible and audible alarms to detect the presence of leaks, etc. must be installed for all toxic and highly toxic gases when the physiological warning

properties for the gas are at a level below the accepted permissible exposure limit or ceiling limit for the gas. Contact HS for specifics on installing the gas monitoring system.

- An emergency response procedure must be in place and everyone working in the area must be trained on the procedures.

Cryogenic

- Wear face shield and chemical safety goggles when dispensing from cylinder.
- Wear appropriate insulated gloves to protect from the extreme cold when handling cryogenic containers. Gloves need to be loose fitting so that they can be readily removed in the event liquid is splashed into them. Never allow an unprotected part of the body to touch uninsulated pipes or containers of cryogenic material.
- Keep liquid oxygen containers, piping, and equipment clean and free of grease, oil, and organic materials.
- Do not store cylinders in environmental chambers that do not have fresh air ventilation. A leak or venting from the container could cause an oxygen deficient atmosphere.
- Large stationary cryogenic systems and piping have additional requirements. Contact HSEO for guidance.
- First aid treatment for cold-contact burns.
- Remove any clothing not frozen to the skin that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. Obtain medical assistance as soon as possible.
- Place the affected part of the body in a warm water bath (not to exceed 40o C). Never use dry heat.

Pyrophoric Gas

- Not more than 250 cubic feet of pyrophoric gas can be in a storage area.
- Lecture bottle-sized cylinders for Pyrophoric (e.g. Silane) gases must be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure.
- Silane gas with a concentration of 2% or more by volume silane has additional safety requirements for flow control, exhausted enclosures or gas cabinets and emergency power. Contact HSEO for information.

5.3 Transporting Cylinders

- The cylinders' protective cap must be in place.
- Avoid dropping and striking cylinders together. The cylinder should not be lifted by the cap.
- Use a cradle for hoisting, never a lifting magnet or sling.
- Use a suitable hand truck with the cylinder firmly secured. Avoid dragging, sliding or rolling cylinders.
- Cylinders must be secured in a positive fashion with straps or chains while being transported and when in motor vehicles.

- Use the Freight Elevator when possible. If there is no Freight Elevator, do not use an elevator with people in it and do not allow other people to enter the elevator when transporting cylinders. When transporting Asphyxiant gas in elevators, send the cylinder up by itself and then follow in another elevator or stairs. This can only be done if the elevator can be made to not stop at any other floors before the cylinder is removed.

5.4 Storage

- Storage areas shall contain the appropriate safety signage.
- Storage areas shall be secured and only authorized persons will have access to compressed gases storage areas.
- Cylinder storage areas must be prominently posted with the names and hazard class of the gases to be stored.
- Cylinders not “in use” (“in use” means connected through a regulator to deliver gas to a laboratory operation, connected to a manifold used to deliver gas to a laboratory operation or a single cylinder secured alongside the cylinder as the reserve cylinder) must not be stored in the laboratory.
- When gases of different types are to be stored at the same location, cylinders should be grouped by type of gas and the groups arranged taking into account the type of gas contained (e.g., flammable gases may not be stored next to oxidizing gases). Empty cylinders should be stored separately from full cylinders.
- Storage rooms should be dry, cool, and well ventilated. Cylinders should not be stored at temperatures above 51 degrees C. (125 degrees F.) or near radiators or other sources of heat. Cylinders must be stored a minimum of 20 feet from incompatible materials and a minimum of 10 feet from combustible material.
- Cylinders stored outside must be protected against extremes of weather and combustible waste must be kept a minimum off 10 feet from the cylinders.
- Cylinders must be protected from any object that will produce a cut or other abrasion in the surface of the metal. Do not store near elevators or gangways, or in locations where heavy moving objects may strike or fall on them.
- All gas cylinders must be capped and secured when stored. Cylinders must be stored in the upright position, unless designed for use in the horizontal position. Each cylinder must be individually secured. Nesting of cylinders is not permitted. Cylinders shall always be secured to prevent them falling over. Chains or a clamp-plus-strap is an acceptable method of keeping cylinders upright. The chain or strap shall be placed above the midpoint of the cylinder to keep it from falling over.
- Do not store gas cylinders with pressure on the regulator.
- Storage, use and handling areas shall be secured against unauthorized entry or access to unauthorized personnel.

5.5 Functional Testing of Regulators

It is recommended that regulators be function tested every six months. Following, is a general procedure for function testing regulators.

- Close the regulator by turning the pressure adjusting screw counterclockwise until fully released.
- Close the cylinder valve. Ensure that lines leading from the regulator to equipment or apparatus are purged of pressure by opening the appropriate flow control valves.
- The regulator delivery pressure gauge should drop to a pressure reading of zero. Record the delivery pressure gauge reading. The cylinder pressure gauge will read full pressure. Record the initial high pressure.
- If the delivery pressure gauge does not read zero when all the pressure is removed, it may be damaged. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.
- Check the cylinder pressure gauge reading after at least 30 minutes. Record cylinder pressure gauge reading. Any pressure drop will indicate leakage. Send regulators suspected of malfunction to the manufacturer for repair, or replace the regulator.
- Release the pressure in the regulator by turning the pressure adjusting screw clockwise. After venting, close the regulator by turning the pressure adjusting screw counterclockwise.

5.6 Testing for Leaks

A leaking cylinder can pose a serious hazard to individuals working with the gas, and to the facility. Leak detection procedures should be implemented prior to the initial use of any system using compressed gas. Perform a leak test on a compressed gas system using the following procedure.

Testing for inert gas

- Prepare a soapy water solution. Ensure the solution to be used is not incompatible with the gas in the system.
- Pressurize the system.
- Apply the solution to all connections (e.g. cylinder valve, regulator connections, other connections) observing for the formation of bubbles. If bubbles formed, leak is present.
- Use gas leak detector equipment if available
- Inspect and secure connections that are observed to be leaking, and retest.
- If no bubbles are formed, the system is not leaking, and may be used. If a leak cannot be corrected, the system should not be used. Notify your supervisor.
- In instances where a cylinder valve is found to be leaking, the following should be adhered to. Never attempt to repair a cylinder valve.
- Contact the supplier and ask for response instructions. Contact HS at 4403 3999

  For flammable or toxic gases, use gas leak detector equipment for leak test.

When gas leak is detected:

- Remove the gas cylinder to an isolated, well ventilated area, away from incompatible materials, only if safe to do so.
- Allow it to remain isolated until the gas has discharged, making certain that appropriate warning signs have been posted.
- If the material is toxic, remove the cylinder to an isolated, well-ventilated area, but only if this is possible while maintaining personal safety. Evacuate the building by pulling a fire alarm.

5.7 Disposal of Cylinders

- When feasible, QU shall purchase compressed gas only from manufacturers that will agree to take back the empty cylinder.
- Refillable cylinders shall be returned to the authorized supplier or directly to the vendor. If a refillable cylinder is encountered that does not have a manufacturer label, contact the HS for advice on disposal. Or the supplier/vendor shall be contacted to obtain guidelines for the shipment of cylinders to be returned.
- Manufacturer labels shall be maintained and empty cylinders shall be labeled as **"Empty".**
- Appropriate identification of the contents of all cylinders is required and is the responsibility of the user.
- Close and tighten valves and replace safety caps on cylinders.
- Identify the gas that was in the container. Valves will be removed from empty nontoxic gas cylinders before disposal as metal scrap.
- Removal of cylinders that cannot be returned to the supplier/vendor or for disposal of orphaned cylinders shall be treated as hazardous waste. The following guidelines shall be used:
    - Laboratory In-charge shall properly store the hazardous waste at satellite accumulation area.
    - Laboratory In-charge shall prepare the Hazardous Waste Pickup Request Form, and shall be submitted to Environment Section for processing of waste disposal.
    - HSEO shall review the Hazardous Waste Pickup Request Form and conduct safety inspection on waste satellite accumulation area.
    - Upon verification and approval by HSEO, the accredited contractor shall be notified for pickup of hazardous waste.
    - Hazardous waste pickup request is process by HSEO during office hours, Sunday through Thursday, 8 AM to 2 PM.
    - Hazardous waste pick up is scheduled every Thursday starting at 9:00 AM.
    - In an emergency situation, the accredited contractor shall be asked to commenced packaging, manifesting, pick-up, transport, and final disposal activities within twelve (12) hours after notification by HSEO.
- Cylinders of hydrogen fluoride and hydrogen bromide should be returned to the supplier within two (2) years of the shipping date. Cylinders of corrosive or unstable gases should be returned to the supplier when the expiration date of the maximum recommended retention period has been reached. If no maximum recommended retention time is provided by the supplier, a 36 month (3 year) time limit should be used.

5.8 Inspection and Maintenance

Compression Units shall be inspected by a competent person at a minimum annually.

Gas cylinders shall be hydrostatically tested at a minimum every five years which shall be conducted by a qualified testing facility. The test date shall be stamped onto the cylinder each time the cylinder is tested.

Air Receiver shall be tested by a competent person or a skilled third party agency at a frequency defined by the applicable legal requirements, manufacturer recommendations and/or employer's inspection & maintenance scheme.

Pipework shall be tested by a competent person or a skilled third party agency at a frequency defined by the applicable legal requirements, manufacturer recommendations and/or employer's inspection & maintenance scheme.

Electronics shall be visually examined, function tested (to include protective devices), and continuity and resistance testing of any cables by the employer competent person or a skilled third party agency.

5.9 Emergency Response

Refer to ***QU HSMS - Emergency Management Procedure*** for requirements related to emergencies involving compressed gas cylinders include leaks, fire, explosions etc.

6 Training

6.1 General Worker

Employers shall ensure all relevant employees and contractors that perform tasks that work with or near compressed gasses receive training that includes at a minimum:

- physical hazards associated with compressed gases;
- design specification, capabilities and limitations of compressed gas storage systems and their uses at the work site;
- methods and procedures that will prevent exposure to compressed gases or hazards
- associated with compressed gases;
- the importance of control measures;
- safe work practices;
- required use, maintenance and storage of PPE;
- emergency response procedures;
- safe handling and storage;
- health hazards associated with compressed gases used at the work site;
- signs and symptoms of exposure to compressed gases used at the work site; and
- operator maintenance requirements for compressed gas systems.

6.2 Qualified Worker

Employers shall ensure managers and supervisors of operators of compressed gas systems requiring shall be trained on:

- requirements listed in Section 2(a);
- maintenance requirements of compressed gas system to ensure they are working appropriately and within specifications;
- how to recognize unsafe work practices when working with compressed gas; and
- how to identify when the compressed gas systems are not working appropriately.

6.3 Training Documentation

QU shall maintain a record of required training and attained competency with respect to hazardous materials for all persons handling or working in the vicinity of hazardous materials.

7 Document Control

This SOP is a controlled document. The controlled version of this SOP is located on the QU Documentation Management System.

Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.

Refer to ***QU HSMS – Document Control and Record Retention***.

8 References

UK HS HSG 39: Compressed Air Safety

OSHA Standards for General Industry 29 CFR 1910 - 1910.101 Compressed Gases (General Requirements)

Health and Safety Standard Operating Procedure

SOP- 04

Hazardous Waste Disposal

Produced by

HS – Facilities & GS Department

Table of Contents

SOP-04: Hazardous Waste Disposal

1 Overview

1.1 Purpose

The purpose of this Environmental, Health and Safety (**HS**) Standard Operating Procedure (**SOP**) is to provide general guidance for hazardous waste disposal as a result of activities undertaken at Qatar University (**QU**).

1.2 Hazards and Risks

1.2.1 Hazard Definition

Hazardous waste include elements, compounds, mixtures, solutions, and substances which, when released into the environment may present substantial danger to public health or welfare or the environment. At QU, hazardous waste consist primarily of hazardous chemicals, bio-hazardous materials, and radioactive waste

A hazardous chemical means:

- A chemical for which there is statistically significant evidence (based on at least one study conducted according to established scientific principles), that acute or chronic health effects may occur in exposed individuals; and/or
- A chemical that poses physical hazards such as flammability, corrosion, or reactivity.

Health hazard means:

A chemical which is classified as posing one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenicity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); or aspiration hazard.

Physical hazard means:

A chemical that is classified as posing one of the following hazardous effects: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid or gas); self-reactive; pyrophoric (liquid or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; or in contact with water emits flammable gas.

Technical Guidelines *TG-01 Chemical Safety, TG-02 Biological Safety* and *TG-03 Radiation Safety* present further information regarding specific hazards associated with this SOP

1.2.2 Potential Outcomes

Exposure to or a release of hazardous wastes can result in many outcomes.
Potential Health-related outcomes include:

- Acute toxicity
- Skin corrosion/irritation
- Serious eye damage/eye irritation
- Respiratory or skin sensitization
- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity
- Specific target organ toxicity – single and repeated exposure
- Aspiration hazard
- Asphyxiation

Potential physical outcomes include:

- Explosions
- Fire
- Corrosion

1.3 Key Terminology

Table1. Key Terms

Term	Definition
Chemical	Substance, or mixture of substances
Flammable liquid	Liquids with a flash point not exceeding 61˚C
Flammable solid	Solid materials which are readily combustible or may cause or contribute to fire through friction, or when in contact with water can discharge flammable gases.
Flammable gas	When at 20˚C and standard pressure at 101.3 kilo Pascal it is: • Flammable when mixed with 13% of air or less. • It flammable when exposed to air at 12% point regardless of the minima for explosion.
Corrosive	A chemical that produces destruction of skin tissue or materially damages or destroys metal
Simple asphyxiants	A gas that displaces oxygen and deprive tissues of oxygen
Chemical asphyxiant	A gas that renders the body incapable of maintaining an adequate oxygen supply
Explosive	A solid or liquid substance (or mixture) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
Oxidizer	A solid or liquid material, while in it is not necessarily combustible, may cause or contribute to combustion of other material generally by yielding oxygen.
Cryogenic liquid	Cryogenic liquids are pressurized liquids formed by compressing gases to a point where the temperature reaches - 60° C to - 270° C.

2 Scope

The requirements outlined in this SOP are applicable to all QU employees, students, contractors, and visitors who are working for QU, and/or conducting work on QU premises. The following subsections outline some of routine and non-routine activities and locations in which the conditions covered by this SOP may be encountered.

2.1 Routine

Hazardous waste can be encountered in many areas at QU. Most commonly, hazardous waste is found in:

- QU Laboratories
- Facilities maintenance
- Greenhouse
- Medical clinic

2.2 Non-routine

Hazardous waste may also be encountered:

- When hazardous materials are used by on-site contractors
- Accidents
- Delivery vehicles with other materials in them

3 Roles and Responsibilities

Each employee should be on the alert for hazardous conditions and promptly report any to the Health and Safety Section (HSS).

The department is responsible for the correction of any operational deficiencies that are discovered. Facility deficiencies must be reported to the HS.

The QU Departments are the primary organization responsible to implement and maintain sound hazardous waste management practices and assure safety compliance in their respective areas.

3.1 Vice Presidents (VPs), Deans, Directors, Managers, Head Sections

VPs, AVPs, Deans, Directors, Managers, Head Sections/Units and Project Managers have the primary responsibility for hazardous waste management and therefore have responsibility for assuring sound safety practices and compliance within their Department/College. They are ultimately responsible for enforcing consequences arising from moderately serious and very serious incidents.

3.2 Employees, Students and Contractors

Employees, contractors and students are responsible for compliance with safety regulations and this technical guidance, as applicable.

3.3 Health and Safety Section (HSS)

The HSS is responsible for the implementation of this procedure.

3.4 HS Committee

The HS Committee shall be responsible for assisting in the implementation, maintenance and review of this procedure, as requested.

4 Risk Prevention

4.1 General Prevention Requirements

The following prevention practices should be followed to minimize the risk from potential hazards associated with hazardous materials:

- Maintain an accurate inventory of the hazardous waste at QU facilities.
- Maintain up to date Safety Data Sheets (SDS) for all hazardous waste at QU facilities. These SDSs must be available to workers.
- Provide appropriate training to workers in areas where hazardous waste is stored, dispensed or handled. Refer to Section 6 of this guidance for specific training requirements.
- Wear appropriate protective gloves/clothing when handling hazardous waste.
- Provide adequate and appropriate storage facilities and ensure hazardous waste is stored in an orderly manner.
- Clearly identify and label hazardous waste containers and storage areas.
- Develop procedures to control and mitigate unauthorized releases of hazardous materials.
- Develop an emergency action plan for response to releases of hazardous waste.
- Establish appropriate disposal methods for hazardous wastes.
- Appropriate spill response and fire suppression materials must be readily accessible.

4.2 Specific Prevention Methods

In addition to the general risk prevention and mitigation measures outlined in section 4.1, the following measures should be applied for specific types of hazardous waste.

4.2.1 Chemical Waste

Chemical waste can be classified into the following classes:

- Irritants
- Asphyxiants
- Toxic substances
- Explosives
- Flammable Materials – Gases, Liquids, Solids
- Oxidizers
- Self-reactive
- Pyrophoric
- Cryogenic Liquids

Please refer to ***QU TG-01 Chemical Safety*** for the specific prevention methods associated with each class.

4.2.2 Biological Waste

Biological waste includes:

- Materials contaminated or potentially contaminated during the manipulation or cleanup of the material generated during research and/or teaching activities requiring Biosafety Level (BSL) 1, 2, or 3 or animal or plant biosafety level 1, 2, or 3.
- Human tissues and anatomical remains.
- Materials contaminated with human tissue or tissue cultures (primary and established) because these are handled at BSL-2.
- Any liquid blood and body fluids (human or animal).
- Animal carcasses, body parts and bedding from animals infected with BSL2 and BSL3 agents.

Biological waste can be classified into different BSLs. Please refer to *QU TG-02 Biological Safety* for the specific prevention methods associated with each BSL level.

4.2.3 Radioactive Waste

There are seven types of radioactive waste:

- Biological Materials and animal carcasses.
- Dry Solids.
- Liquids.
- Scintillation Vials.
- Source Vials.
- Mixed Wastes
- Lead containing materials.

Please refer to ***QU TG-03 Radiation Safety*** for the specific prevention methods

4.2.4 Waste Electrical and Electronic Equipment (WEEE)

WEEE is defined as any substance or object including all components, subassemblies and consumables in the prescribed categories thereof that are part of the products, which the holder discards or intends or is required to be discarded.

WEEE is categorized into 10 for reporting purposes, these are:

- Large household appliances (*large cooling appliances, refrigerators and freezers, electric heating appliances and electric radiators, and other fanning, exhaust ventilation and conditioning equipmen*t).
- Small household appliances (*vacuum cleaners and carpet sweepers, and equipment for opening or sealing containers or packages*).
- IT and telecommunications equipment centralized data processing devices including (*mainframes, minicomputers and printer units, personal computing mean, electrical and electronic typewriters, pocket and desk calculators*).
- Consumer equipment (*radio and television sets, video cameras and recorders, Hi-fi recorders, audio amplifiers and musical instruments*).
- Lighting equipment (*luminaires for fluorescent lamps, and high intensity discharge* lamps).
- Electrical and electronic tools (*drills, saws, sewing machines, tools for riveting, nailing or screwing*).
- Toys, leisure and sports equipment (*sports equipment with electric or electronic components, and coin slot machines*).
- Medical devices (*equipment for radiotherapy, cardiology, dialysis, and pulmonary ventilators, and appliances for detecting, preventing, monitoring, treating, alleviating illness, injury*).
- Monitoring and control instruments (*smoke detectors, heating regulators, thermostats, and appliances for measuring, weighing or adjusting laboratory equipment*).
- Automatic dispensers (*automatic dispensers for hot drinks, bottles or cans, solid products, money, and all appliances which deliver automatically all kinds of products*).

WEEE are classified as hazardous waste the disposal of which is regulated and achieved through the treatment, recovery and recycling of affected equipment.

Modalities of disposal

It shall be the responsibility of HS to remove WEEE from every primary source (point of generation), by collecting and transporting same through appropriate means for final disposal. These shall be done in accordance with the following steps:

- At the point of generation, WEEE shall be segregated, labelled as such, and kept in a safe condition and site under the control or supervision of individuals directly responsible for the waste stream.
- Thereupon, the responsible person shall fill the WEEE Pickup Request Form in the prescribed manner and submit it to the HS.
- HS shall authenticate the Pickup Request Form by conducting safety inspection of the accumulated WEEE.
- Thereafter, an accredited contractor shall be notified for pickup of WEEE from individual primary sources.
- Pickup of WEEE shall be carried out by contractor and coordinated by the HS.
- HS shall maintain an inventory of WEEE removed by the contractor for final disposal.
- Means and mode of final disposal of WEEE shall be carried out by contractor in agreement with HS.
- Relevant information pertaining to final disposal of WEEE shall be made available to HSE by the contractor.

Minimization of WEEE

For the purpose of minimizing the volume of WEEE, QU Information Technology Services (ITS) shall:

1. From time to time, carry out Critical Needs Assessment before the purchase of Electronic and Electrical Equipment (EEE).
2. Request the inclusion of Offer for Take-Back Option and/or detail design process relevant for product Reduce, Reuse, and Recycle (as the case may be) in every contract bids for further procurement of EEE.

5 Safe Work Practices

5.1 General Work Practices

The following work practices shall be implemented to reduce the risk of injury, illness, or property damage and must be followed by all workers and students.

- Workers shall familiarize themselves with the information provided in the MSDSs and other relevant user instructions provided by the manufacturer.
- Instructions for safe handling and use of the material and equipment, as presented on the MSDS and the user manual, shall be followed and appropriate personal protective equipment (PPE) used by workers handling the material.
- Wash hands immediately after completion.
- Eating, drinking, smoking, chewing gum, applying cosmetics and storing utensils, food and food containers are prohibited in areas where hazardous waste is stored or handled.
- If hazardous waste must be transferred from one container to another, appropriate spill response materials shall be in close proximity to the transfer area such that the worker can quickly control the release and, if safe to do so, clean up the released material.

5.2 Specific Work Practices

Specific safe work practices shall be based on the type and class of hazardous waste and the potential routes of exposure associated with the material. Chemical-specific safe work practices can be found on the MSDS and should be followed. The following presents the minimum safe work practices to be followed, by type and class of the hazardous waste, in addition to those presented in Section 5.1.

5.2.1 Chemical Waste Disposal

Potentially hazardous chemical wastes must be disposed of in accordance with the state's regulations and procedures established by the HS. Contact your supervisor or HS before discarding of any potentially hazardous chemical.

The following guidelines will assist chemical hazardous waste collection:

- Unless you have written approval from the HS, disposal of chemicals by way of the sanitary sewer system is prohibited.

- To determine if the chemical you want to be removed from your laboratory or work area is a regulated hazardous waste, contact HS, or consult the United States Environmental Protection Administration Regulation 40 CFR 261 - Identification and Listing of Hazardous Waste.
- All lab personnel must be familiar with the location and composition of all wastes produced in the laboratory.
- Waste containers must remain closed except when actually adding waste. Open containers violate state and federal waste regulations.
- For disposal information, call HS – Environment Section at 4403 6943.

Hazardous Waste Inspection

HS is responsible for identifying and removing waste from laboratories upon notification,

and transporting or shipping to approve treatment, storage, and disposal facilities.

Satellite accumulation areas (laboratories) shall follow the following requirements:

- Keep lids or caps securely in place and tight them except when adding materials. A funnel resting on the mouth of a bottle is not a lid; neither is a Para film.
- Be sure that gas-producing reactions (e.g. organics in acids) have worked to completion before transferring the material to a hazardous waste container.
- Remember: A closed container; when tipped over will not leak.
- Secondary containment is required for all glass containers of liquid hazardous materials stored on the floor.
- Secondary containment is required for all containers of liquid hazardous waste, with capacity of four (4) liters or less, regardless of storage location.
- The word “Hazardous Waste” labels shall be place in the container to identify the contents (e.g. “Acetone Waste”).
- Abbreviations such as H_2SO_4, HCl, EtBr, EtOH, etc. are not acceptable.
- Keep the waste container(s) at or near the point of generation and under control or the supervision of the individuals directly responsible for the waste-generating process. Do not store waste in a separate room or down the hall.
- Do not accumulate more than fifty-five (55) gallons (208) liters of hazardous waste or one (1) quart (0.95 liters) of acutely hazardous waste in the laboratory.

Hazardous Waste Containers

- Hazardous waste containers must be in good condition and chemically compatible with their contents.
- Waste containers must securely fitting lids; do not use corks or stoppers.
- Laboratory beakers, flask, or plastic milk cartons are not acceptable as waste containers.
- Metal containers are not acceptable unless they are the original containers. Glass and plastic reagent bottles are generally the most convenient ones.

- Before discarding materials, allow them to react completely and/or cool to ambient temperature before accumulating as waste, and tightly closing the lid. Until all reactions are completed, the contents of a container are not waste, but are instead the last step of the reaction procedure.
- Store glass waste containers in rubber safety carriers, buckets, or similar containers to protect against breakage and spillage. All holding four (4) liters or less of liquid hazardous waste, and all glass containers of liquid hazardous materials stored on the floor, require secondary containment.
- Liquid waste may be accumulated in glass reagent bottles compatible with the waste. If a large volume of liquid waste is generated, consider a 5-gallon carboys for solvent accumulation. Containers of liquids must have a ten (10) percent headspace to accommodate thermal expansion.
- Solid wastes are to go into a double-lined cardboard box. Liners must be 1.5 mil or greater polypropylene bags. Tie and seal each bag individually.
- Ethidium bromide containing solid and semi-solid waste (e.g. used gels) is also collected in double-lined bags within cardboard boxes. Save liquid ethidium bromide waste in carboys or bottles.
- Reactive chemicals must be disposed of in their original shipping containers.
- Hydrofluoric acid presents a special hazard and must be stored in Teflon containers or original containers.

Chemical Waste Segregation

- **Acids and Bases**

  Segregate containers of acids and bases from one another while accumulating for disposal / treatment. Collection of concentrated acids and bases for shipment will be arranged if neutralization in the laboratory is not practicable. Aqueous acid or base solutions with a pH between 5 and 9 can be released to the sanitary sewer without neutralization. Do not discharge acids and bases containing heavy metals to the sewer. Do not mix acids and bases containing heavy metals with other acidic or basic waste. Include neutralization of acids and bases as an end step in the laboratory procedures.

- **Oxidizers**

  Package oxidizers separately, and accumulate away from flammable materials.

- **Reactive wastes**

  Exercise special care to identify reactive waste. Although the process of using the reactive waste usually eliminates the reactivity characteristics, some have dangerous residual properties. For example, residual metallic sodium, added to a solvent to remove water, could result in a fire or explosion if that solvent mixed with aqueous waste.

  Label solutions containing sulfides and/or cyanides to alert personnel not to ix these with acid waste. Mixing could release lethal amounts of toxic gases.

- **Used Solvents**

  Collect halogenated and non-halogenated solvent waste in separate containers. Separate those containing heavy metal. Those containing acids or bases are to have the pH adjusted to 6-8 prior to pick up.

Waste Minimization

The Laboratory Supervisors/ In-charge are encouraged to consider ways to reduce the volume of waste or preserve the reuse of materials through the redesign of experiments. Keep recyclable materials separate from other waste. Make every effort in the laboratory to decontaminate, detoxify, neutralize, or neutralize the non-hazardous research materials as the last step in each experiment.

Disposal of the Sewage System

Do not use the sanitary sewer for the disposal of hazardous materials, with the exception of trace quantities associated with cleaning and washing operations, e.g. glassware. The following discharges to the sanitary sewer are prohibited:

- Materials that may create a fire or explosion hazard.
- Corrosive materials with pH less than five (5)
- Solid or viscous materials in amounts to obstruct flow or interfere with operations.
- Discharge of any toxic material in volume or strength to cause interference with waste treatment process.

Disposal to General Waste – Sharps

Place non-contaminated and/or decontaminated glassware and sharp objects in a plastic bag within a cardboard box. This manner of disposal is recommended for all glass items. Housekeeping will pick up these boxes if they are sealed and identified with a label indicating: “CAUTION, GLASS AND SHARPS, and NON-HAZARDOUS MATERIAL ONLY”.

5.2.2 Biological Waste

The QU Biological Waste Disposal guideline stipulates proper procedures for the collection, decontamination, and disposal of laboratory-generated biohazard waste. This has been developed in order to minimize the risk of exposure to those who may come into contact with biohazard waste generated in a research laboratory, specifically:

- The laboratory workers generating and collecting biohazardous waste during research,
- support staff retrieving, transferring, and autoclaving the biohazardous waste,
- The housekeeping staff responsible for transporting autoclaved waste in buildings that house research laboratories,
- facilities staff (plumbers, electricians, HVAC, welders, etc.), emergency personnel, and visitors who visit the lab infrequently,
- The contractors' staff responsible for collecting, hauling and final disposal of all waste that is generated in research laboratories.

Biohazardous waste generated and collected in the research laboratories is to be properly autoclaved according to procedures outlined below. This process changes the biological character of the waste to reduce or eliminate its potential for causing disease. Laboratories with biohazardous wastes not specifically addressed by this document (such as waste with multiple hazards, e.g. radioactive biohazardous waste) should consult with HS – Environment section for alternative treatment and disposal methods.

Defining Laboratory Generated Biohazard Waste

All biohazardous waste generated in the research laboratories will be properly autoclaved and tagged prior to its collection by hazardous waste treatment company. This biohazard waste includes:

- Materials contaminated or potentially contaminated during the manipulation or cleanup of the material generated during research and/or teaching activities requiring biosafety level 1, 2, or 3 or animal or plant biosafety level 1, 2, or 3.
- Human tissues and anatomical remains.
- Materials contaminated with human tissue or tissue cultures (primary and established) because these are handled at BSL-2.
- Any liquid blood and body fluids (human or animal).
- Animal carcasses, body parts and bedding from animals infected with BSL2 and BSL3 agents.

Biohazard Waste Collection Methods

Contaminated Sharps Include items such as:

- razor blades
- scalpels
- lancets
- syringes with/without needles
- slide covers
- specimen tubes

Sharps shall be collected directly into one gallon metal cans. Metal cans used to collect sharps contaminated under the definition of biohazardous waste (above) must bear the biohazard symbol marked with an “x” using autoclave indicator tape. Laboratories should minimize their use of sharps whenever possible and that needles are not recapped, purposely bent, broken, or otherwise manipulated by hand. To avoid accidents related to overfilling the cans, remove the cans for decontamination or disposal when they are 2/3 full. Cans of contaminated sharps are to be autoclaved. After autoclaving, containers of sharps are disposed of in a cardboard box lined with a plastic bag, clearly marked with the "GLASS AND SHARPS" label, figure 1.

Figure 1. Cans of contaminated sharps

While small shards of contaminated broken glass can be placed into the sharps cans identified above, large contaminated broken glass items must be autoclaved separately in a hard walled container (such as a cardboard box) lined with a biohazard bag bearing an autoclave tape indicator “x” , figure 2. The autoclaved glass waste is to be disposed of in a larger cardboard box lined with a plastic bag, clearly marked with the "GLASS AND SHARPS" label.

The metal solvent cans are about 9” long, allowing for a majority of glass pipette disposal when the cans are laid on their side as shown, figure 3, with the opening at the top. Never allow the cans to fill more than 2/3 full and, when removing from a biosafety cabinet, decontaminate the exterior of the can.

Figure 2 - Cardboard Box

Figure 3 - Can laid on side

Pipetting

For large-scale collections of Glass (Pasteur) and plastic pipettes contaminated under the definition of biohazardous waste, line a puncture resistant outer container (such as the package the pipettes came in) bearing the biohazard symbol marked with a heat sensitive autoclave tape “x with an orange autoclave bag. To avoid handling a bag full of pipettes, place the indicator tape “x” over the bag’s biohazardous symbol prior to loading the bag with pipettes. The universal biological hazardous symbol must be displayed on the inner and outer container. The outer container may also be contaminated so it too should be autoclaved to reduce handling of the pipettes which tend to puncture the bag during treatment handling.

For frequently removed small scale collection (such as sterile pipetting in a biological safety cabinet), line a small orange autoclave bag inside a long, thin, hard-walled collection container. Plan to fill this container with appropriate disinfectant upon beginning (may require liquid disposal authorization) or, when finished, loosely close the bag, spray down with proper disinfectant, and transfer it to your larger scale pipette collection container located outside of the cabinet.

Pipette tips are to be collected on the bench top in a small autoclave bag lining a wire stand or other container bearing the biohazardous symbol. Loosely close the bag to allow for steam penetration and place with other solid biohazardous waste.

Figure 4 - Pipette Container

Contaminated Solids

Biohazardous solids consist of:

- Culture dishes, flasks
- Petri dishes
- Solid waste cultures/stocks from the testing and production of biologicals
- Gloves, gowns, masks
- Other solid material potentially contaminated under the definition of biohazardous waste (above). The outer collection container must be durable, leak proof, have a lid and be of such a design so as not to be mistaken by the Housekeeping as regular trash. This container must be labelled with a biohazard sticker. Wire cages cannot be used as the outer container.

Figure 5 - Container for contaminated solids

Line the outer collection container with a red or orange autoclavable biohazard bag. Waste bags with universal biohazard symbols are only to be used for biohazardous waste that will be autoclaved before disposal. Before lining the collection container with the biohazard bag, crisscross the bag's biohazard symbol and/or markings with heat sensitive autoclave tape. The biohazard collection container should be covered with its lid when not in use. Remove bags at 2/3 full and never place glass in these containers.

Liquids

Even though the rules and definitions for liquid biohazardous waste vary somewhat from solid waste procedures, autoclaving is the method of choice for disinfection of the following:

- Liquid human blood
- Animal blood/body fluids
- Human tissue culture, human cell lines (primary or established)
- Human body
- Liquid growth media removed from human tissue cultures

Autoclaved liquid wastes may be discharged directly into the sanitary sewer.

Chemical disinfection may be an acceptable alternative to autoclaving liquid biohazard waste generated in research laboratories such as bleach treatment. When this is done, care must be taken to avoid splash and the drains are to be flushed with copious amounts of water. Chemical disinfection of regulated liquids followed by disposal to the sanitary sewer is not allowed unless approval has been obtained from the Business Operations Department.

Contaminated animal carcasses

Animal carcasses are disposed of through a licensed pathological incinerator. Animal carcasses from transgenic animals or animals inoculated with infectious agents are disposed of by autoclaving (small animals only) or by incineration. These materials are to be placed in boxes and marked for incineration. (No needles or other type of metal and no PVC plastic are to be placed in the collection boxes. Use only non PVC plastic bags.)

Loading and Unloading the Autoclave for Waste Decontamination

Contaminated materials should not be left in hallways or other public spaces prior to the autoclave decontamination. Biohazard bags must be left in the laboratory until they are to be placed in the autoclave. Do not leave them sitting next to the autoclave whether or not it is occupied by another laboratory materials. Biohazard bags may not be left on the floor. Bags that are closed and ready for autoclaving must be placed in secondary containment as shown. Waste materials that are to be decontaminated at a site away from the laboratory are to be transported in closed, hard-walled secondary containers.

Figure 6 - Proper location of contaminated materials

Always minimize contact with biohazardous waste as much as possible. Use a cart to transport the waste from the laboratory to the autoclave. Never crush or push down biohazardous waste; biohazardous waste containers should be removed for autoclaving when they are 2/3 full. Indicator tape should be applied when placing the new autoclave bag into the hard walled outer container; this will reduce handling of the biohazard waste during removal. The heat sensitive autoclave tape should be placed in an “X” pattern over the biohazardous symbol. The heat sensitive tape is to be of the type that changes color,

such as the type that the word "autoclaved" appears after treatment. Once the autoclave disinfection is complete, the tops of the bags may be sealed tightly with lab tape.

After the proper autoclave waste decontamination steps are followed as listed below, the decontaminated waste is then placed in a 44 gallon or 32 gallon (with a drum dolly), lined with black plastic garbage bags, and located in the vicinity of the autoclave. These containers are to be labeled "AUTOCLAVED/ DECONTAMINATED WASTE ONLY". Biohazard bags placed in the containers and marked with the heat sensitive tape which signals that the waste can be removed from the laboratory for disposal.

Figure 7- Autoclaved / Decontaminated Waste Containers

Each department is responsible for providing these containers. Some departments may need several containers depending on the amount of biohazardous waste generated. Overflowing waste or waste in untreated, untagged biohazard bags shall not be picked up.

5.2.3 Radioactive Wastes

It is important to dispose of radioactive wastes in accordance with the radiation protection regulations. This would avoid radioactive exposure to personnel and contamination of the environment. It also avoids regulatory penalties and the possible loss of radioactive material use privileges. Radioactive wastes are not permitted to be disposed of in the sanitary landfill and must not be placed in any container used for the collection of non-radioactive waste, no matter how temporary the use is intended.

Disposal to the Sewer

Only trace quantities of radioactive material associated with glassware cleaning may be discarded to the sewer. Specific authorization from the HS is required for any exceptions. All authorized releases must occur in a designated, posted drain. Records of each release, including radionuclide, quantity, chemical and/or physical form, date, and time must be documented and maintained.

Segregation and Packaging Radioactive Waste for Pickup

The HS provides all the radioactive waste containers and removes all radioactive wastes from the laboratories. Each container requires the completion of a Radioactive Waste Disposal Record (Appendix A). Blank records are delivered with empty containers and are also available from HS. Three standard containers are used; specially marked cardboard

boxes for dry waste, 4 liter glass bottles for liquid waste, and 30-gallon drums for scintillation vials. Specific authorization from the HS is required for any exceptions.

All waste must be segregated by half-life category**:**

- Short-lived, half-life ≤ 165 days.
- Long-lived, half-life ≥ 165 days.

The following packaging requirements must be met for waste removal.

Biological Waste

- Segregate wastes according to half-life category:
  - Short-lived, half-life ≤ 165 days.
  - Long-lived, half-life ≥ 165 days.
  - H-3, C-14, and I-125 in concentrations less than 0.05 uCi/g.
- Place waste in a clear plastic bag in a freezer.
- Each bag must be labeled with a radioactive materials sticker, listing the Authorized User's name, radionuclide, activity and date.
- The serial number from the Radioactive Waste Disposal Record must be written directly on the plastic bag, using a "permanent" marker.

Dry Waste

- Segregate wastes according to half-life category.
- No free liquids, lead shielding, scintillation vials or organic solvent are allowed.
- Sharps that must be placed in a hard-walled plastic or cardboard container before being placed in the dry waste box.
- Infectious dry wastes must be sterilized by autoclaving before placement in radioactive waste containers. Autoclaving radioactive infectious waste must be specifically approved by the HS.
- Source vials containing short-lived radionuclides may be placed in the short-lived dry waste box after first removing any lead shielding material. Do not place source vials in the dry waste box if they create unacceptable radiation levels (> 2 mrem/hour at 1 foot from a box).
- Empty source vials for long-lived radionuclides may be placed in the long-lived dry waste. Residual liquids, up to a few milliliters, may be absorbed on a pad or towel and added to the dry waste container. This procedure may be used only for source vials containing less than 10 mCi.
- Minimize the amount of glass and metal by washing these materials and disposing of them as ordinary trash.
- Prior to requesting pickup, the box must be close by sealing the bag with tape and taping the lid in place. Tape the Radioactive Waste Disposal Record to the top of the box.

Liquid Waste

- The bottle is delivered with a blank yellow tag attached.
- This tag must contain the following before waste is added:

- Authorized User's name.
- Radioactive Waste Disposal Record Serial Number.
- Radionuclide(s),
- When the bottle is full, the tag must also include activity.

- Date of recording the activity Segregate wastes according to half-life category.
- Do not mix biodegradable and non-biodegradable liquids.
- No solids, including filters, pipette tips, stir bars, gels and vials, are allowed.
- Use only the four-liter bottles provided by HS unless other arrangements have been made with HS.
- The glass bottles must have secondary containment (rubber safety bucket or plastic container).
- Leave at least a 10% headspace.
- Chemical constituents, including water and scintillation media trade names, and their percentages must be listed on the Radioactive Waste Disposal Record.
- Remove external contamination prior to waste pickup.

Scintillation Vials

- Use only drums provided by HS.
- Segregate by half-life category.
- Vials must be packed upright in flats or sealed plastic bags containing no more than 100 vials. Place these bags in a lined drum.
- Segregate vials according to the type of scintillation media:
  - Biodegradable or non-hazardous media that do not meet the criteria of a hazardous waste.
  - Non-biodegradable or ignitable which becomes a mixed waste during use.
- Chemical constituents or scintillation trade names must be listed on the Radioactive Waste Disposal Record.
- No dry vials, test tubes, dry wastes or non-scintillation fluids are allowed.
- Vials must have tight, secure tops to prevent leakage during storage and waste handling.

Source Vials

- The source vials containing short-lived radionuclides may be placed in the short-lived dry waste box. Do not place source vials in the dry waste if they emit unacceptable radiation levels (>2 mrem/hr. at 1 foot from the box).
- Empty source vials for long-lived radionuclides may be placed in the long-lived dry waste. Residual liquids, up to a few milliliters, may be absorbed on a pad or towel and added to the dry waste container. This procedure may be used only for source vials containing less than 10 mCi. Otherwise, the residual contents must be emptied into the appropriate liquid waste container.
- Contact HS for removal of:
  - Long-lived sources with activities greater than 10 mCi.
  - Short-lived sources which yield surveys of > 2 mrem/hour at 1 foot from a vial or source.

Mixed Wastes

Liquids and scintillation vials are subject to Ministry of Environment regulation if they possess characteristics of hazardous waste. These characteristics include ignitability (flashpoint < 140 0 F) and corrosivity (pH < 2 or > 12.5).

- All containers of mixed waste must be labeled or marked with the words "Hazardous Waste".
- All containers of mixed waste must remain closed at all times except when waste is being added or removed to the container.

Lead-Containing Materials

Lead-containing materials must not be placed in the radioactive waste containers. The lead will be picked up and recycled. These items must be wipe-tested for removable contamination prior to calling for a pickup. A copy of the survey results, in DPM, must be attached to a Radioactive Waste of Disposal Record. While the removable contamination must not exceed 600 DPM.

Radioactive Waste Disposal Records

The terms of the University's Radioactive Materials License would require detailed records of the receipt, use and disposal of radioactive materials. To facilitate maintenance of disposal records, a Radioactive Waste Disposal Record (Appendix A) is provided for use by Authorized Users.

Radioactive Waste Pickup

Call the HS, to request a pickup of radioactive waste and replacement of containers. Provide the following information:

- Authorized User's name
- Caller's name
- Building name and room number
- Phone number
- Type of waste (biological, dry, liquid, scintillation vials, source vials, lead-containing materials)
- Serial numbers for each waste container to be picked up.
- The number and type of replacement containers needed.

Radioactive Waste Readiness Checklist

Before requesting a pickup of waste, check to ensure the following has been done:

- Dry Waste
  - Liner sealed.
  - Lid taped on box.
  - Radioactive Waste Disposal Record is completed.
- Biological Waste
  - Sealed in clear plastic bag.
  - Frozen.
  - Labeled with permanent marker.
  - List weight of waste.
  - List activity / weight in uCi/g.
  - Radioactive Waste Disposal Record is completed.
- Scintillation Vials
  - Liner sealed.
  - Lid placed on drum.
  - List name of media or chemical constituents.
  - Radioactive Waste Disposal Record is completed.
- Liquids
  - Lid in place.
  - 10% head space.
  - Radioactive Waste Disposal Record and yellow tag is completed.

5.3 Request of Hazardous Waste Pickup

Disposal of Hazardous chemical and biological waste generated at Qatar University shall be the responsibility of HS. Hazardous waste shall be disposed according to the following guidelines:

1. Laboratory In-charge shall properly store hazardous waste at satellite accumulation area.
2. Laboratory In-charge shall prepare the Hazardous Waste Pickup Request Form, http://www.qu.edu.qa/offices/businessop/forms/waste_pickup_request.php and shall be submitted to HS for processing of waste disposal.
3. HS shall review the Hazardous Waste Pickup Request Form and conduct safety inspection on waste satellite accumulation area.
4. Upon verification and approval by HS, the accredited contractor shall be notified for pickup of hazardous waste.
5. Hazardous waste pickup request is process by HS during office hours, Sunday through Thursday, 8 AM to 2 PM.
6. Hazardous waste pick up is scheduled every Thursday starting at 9:00 AM.
7. In an emergency situation, the accredited contractor shall be asked to commenced packaging, manifesting, pick-up, transport, and final disposal activities within twelve (12) hours after notification by HS.

Hazardous Waste Container Color Code

- Yellow Bag – Infectious waste contaminated with chemicals
- Orange Bag – Infectious waste (not containing chemicals or Medical contamination)
- Red Bag – Anatomical waste for incineration

Personal Protective Equipment

- Safety Goggles
- Respirator
- Disposable Chemical Suite
- Disposable Gloves

Emergency Equipment

- Chemical Spill Kit
- Biological Spill kit
- Fire Extinguisher
- Self-Contained Breathing Apparatus

6 Training

QU shall ensure that no person handles hazardous waste unless such person has the competency gained from training, technical knowledge and experience of the precautions to be taken against the risk of personal injury or illness, and is under such degree of supervision as may be appropriate having regard to the nature of the work.

Refer to ***QU HSEMS Section 11.0 Training and Competency*** procedure for additional information regarding training processes.

6.1 General

Training must be provided to workers and students that may be exposed to hazardous waste. The level of training will be dependent upon the degree of exposure. Information and training may be designed to cover categories of hazards (e.g., flammability, carcinogenicity) or specific types. The following general requirements apply to all levels of training.

- Workers should be informed of the hazards associated with hazardous waste at their workplace.
- Workers should be instructed about how to obtain and use the information provided on labels and safety data sheets.
- Workers should be trained in the correct and effective use of the control measures, in particular the engineering control measures and measures for personal protection provided, and should be made aware of their significance.
- Employers should use safety data sheets, along with information specific to the workplace, as a basis for the preparation of instruction to workers, which should be in writing if appropriate.
- Workers should be trained on a continuing basis in the working systems and practices to be followed and their significance for safety in the presence of hazardous waste at work, and in how to deal with emergencies.

6.2 Specific / Retraining

For workers that handle hazardous waste the following additional training should be provided:

- Methods and observations that may be used to detect the presence or release of a hazardous material in the work area (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
- The physical, health, simple asphyxiation, combustible dust, and pyrophoric gas hazards, as well as hazards not otherwise classified, of the chemicals in the work area;
- The measures workers and students can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous waste, such as appropriate work practices, emergency procedures, and personal protective equipment to be used

6.3 Training Documentation

QU shall maintain a record of required training and attained competency with respect to hazardous materials for all persons handling or working in the vicinity of hazardous materials.

7 Document Control

This SOP is a controlled document. The controlled version of this Guidance is located on the QU Electronic Documentation Management System.

Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.

Refer to ***QU HSEMS Section 16.0 – Document Control and Record Retention***.

8 References

Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Fifth Edition, United Nations, 2013

NIOSH Pocket Guide to Hazardous Chemicals, http://www.cdc.gov/niosh/npg

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The European Parliament and The Council of the European Union, (2012). DIRECTIVE 2012/19/EU; Waste Electrical and Electronic Equipment (WEEE): Official Journal of The European Union. 24:7:2012.

Appendix A – Radioactive Waste Disposal Form

Radioactive Waste Disposal Form

Serial No. ____ Page ___ of ____

QATAR UNIVERSITY RADIOACTIVE WASTE DISPOSAL RECORD

Survey Results: _____ mrem/hr Estimated weight: _____ kg.

Waste Classification: ____ NON ____

D001 _____ F003 _____ F005 _____ (Other:_____)

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked and labeled and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

_____

HSE – Radiation Safety Specialist/officer - Representative

SECTION 1: AUTHORIZED USER (AU)

User Name: _____ Title: _____ Dept. : _____

Contact Details: Email Address: _____ Tel: _____

Location: Building Code: _____ Building Name: _____ Room No: _____

INSTRUCTIONS:

1. Do not mix types of wastes or long-lived and short-lived wastes.
2. Use a separate container for each waste type and half-life category.
3. Use a separate copy of this form for each container.
4. List specific scintillation brand name.

SECTION 2: WASTES TYPES

Dry (Check) ___ Paper ___ Glass ___ Plastics ___ Empty source vials)	Liquids ____	Scintillation Vials ____	Carcasses ____	Lead-containing and Shielding contamination test required attach survey results nuclide used _____

SECTION 3: WASTE INVENTORY

DATE	NUCLIDE	ACTIVITY (mCi)	CHEMICAL CHARACTERISTICS/ COMPOSITION No abbreviations or chemical formulas LIST SPECIFIC SCINTILLATION BRAND NAME

SECTION 4: SUMMARY BY NUCLIDE

		Total activity for each nuclide in mCi. Include sheets (1 mCi = 37 MBq)

SECTION 5: LAB CERTIFICATION

I certify that the WASTE INVENTORY above is correct. Infectious materials have been sterilized. All needles and sharps have been packaged in hard-walled plastic containers.

_____

Authorized User Telephone No. CB#

For waste pickup, call – Environment Section at 4403 6934 or 4403 6940

Health & Safety Technical Guidelines

TG - 01

Chemicals Safety

Produced by

Health & Safety – Facilities & GS Department

Table of Contents

Appendices

1 Purpose

The purpose of this document is to protect the health and well-being of all Qatar University (**QU**) staff, students, and visitors, and to prevent damage to property, equipment, facilities, and the environment associated with the usage of chemicals as part of the university's activities.

This document provides guidelines on the application of the requirements and principles of the QU Health & Safety Management System (HSMS) to activities associated with these QU workplaces.

2 Scope

This H & S Technical Guideline applies to all operations and activities associated with QU activities where chemicals are involved, including laboratories, workshops, storage areas and other QU work sites, to enable the effective management of H & S risks within these workplaces.

3 Responsibilities

3.1 Top Management

QU top management shall allocate sufficient resources for the effective implementation of the HSMS, including the application of this H & S Technical Guideline, and ensure that QU employees, students, contractors and visitors are aware of their responsibilities through appropriate regulation, delegation and communication.

The QU Top Management is also accountable for monitoring and reporting H & S performance and appropriate programs and actions to ensure compliance with the QU H & S Policy.

3.2 Other Accountabilities

The QU H & S and the H & S Committee are accountable to the QU Top Management for the implementation of this H & S Technical Guideline.

Vice President (VPs), Deans, Directors, Managers, Head Sections/Units and Project Managers are accountable to the QU Top Management for the application of this H & S Technical Guideline in areas under their supervision.

All QU staff is responsible for performing their duties by complying with the requirements of this H & S Technical Guideline as it applies to their activities and workplaces, observing and obeying safety postings and rules, and promptly reporting all incidents and accidents to their supervisors.

4 Guidelines

4.1 Types of Hazards

Irritants

Irritants are materials that cause inflammation of the body surface with which they come in contact. The inflammation results from concentrations far below those needed to cause corrosion. Common irritants include substances such as:

- ammonia
- alkaline dusts and mists
- hydrogen chloride
- hydrogen fluoride*
- halogens
- ozone
- phosgene*
- nitrogen dioxide
- phosphorus chloride
- arsenic trichloride

* These materials also have other hazardous properties.

Irritants can also cause changes in the mechanics of respiration and lung function. These include:

- sulfur dioxide
- acetic acid
- formaldehyde*
- formic acid
- sulfuric acid
- acroleins
- halogens

* These materials also have other hazardous properties.

Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

A primary irritant exerts no systemic toxic action, either because the products formed on the tissue of the respiratory tract are non-toxic or because the irritant action is more severe than any systemic toxic action. Example: hydrogen chloride.

A secondary irritant's effect on mucous membranes is overshadowed by a systemic effect resulting from irritant absorption. These include:

- hydrogen sulfide
- aromatic hydrocarbons

Exposure to a secondary irritant can result in pulmonary edema, hemorrhage and tissue necrosis.

Asphyxiants

Simple Asphyxiants deprive the tissue of oxygen. Simple asphyxiants are inert gases that displace oxygen. These include:

- nitrogen
- nitrous oxide
- carbon dioxide
- helium

Chemical asphyxiants render the body incapable of maintaining an adequate oxygen supply. They are active at very low concentrations (few ppm). These include:

- carbon monoxide
- cyanides

Hepatotoxic Agents

Hepatotoxic agents cause damage to the liver. These include:

- carbon tetrachloride
- tetrachloroethane
- nitrosamines

Nephrotoxic Agents

Nephrotoxic agents damage the kidneys. These include:

- halogenated hydrocarbons
- uranium compounds

Neurotoxic Agents

Neurotoxic agents damage the nervous system. The nervous system is especially sensitive to organometallic compounds and certain sulfide compounds. These include:

- trialkyl tin compounds
- tetraethyl lead
- methyl mercury
- carbon disulfide
- organic phosphorus insecticides
- manganese
- thallium

Some toxic agents act on the blood or hematopoietic system. The blood cells can be directly affected or the bone marrow can be damaged. These include:

- nitrites
- aniline
- toluidine
- nitrobenzene
- benzene

There are toxic agents that produce damage of the pulmonary tissue (lungs) but not by immediate irritant action. Fibrotic changes can be caused by free silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis.

Carcinogens

The term carcinogen describes any agent that can initiate or speed the development of malignant or potentially malignant tumors, malignant neoplastic proliferation of cells, or cells that possess such material. A select carcinogen is any substance that meets one of the following criteria:

- It is regulated by the United States Occupational Safety and Health Administration as a carcinogen.
- It is listed under the category, "known to be carcinogens" in the United States National Toxicology Program (NTP).
- It is listed under Group 1, "carcinogenic to humans" by the International Agency for Research on Cancer Monographs (IARC).
- It is listed under Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals according to any of the following criteria:
- After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime, to doses of less than 10 mg/m3.
- After repeated skin applications of 300 mg/kg of body weight per week.
- After oral doses of less than 50 mg/kg of body weight per day.

Reproductive Hazards

Reproductive hazards are chemicals that affect the reproductive capabilities including chromosomal damage (mutagens) and effects on the fetus (teratogens).
A mutagen affects the chromosome chains of exposed cells. The effect is hereditary and becomes part of the genetic pool passed on to future generation.
A teratogen (embryo toxic or fetotoxic agent) is an agent that interferes with the normal embryonic development without damage to the mother or lethal effect on the fetus. Effects are not hereditary.
A sensitizer causes the majority of the exposed population to develop an allergic reaction in normal tissues after repeated exposure to the chemical. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock.
A list of reproductive hazards can be found in Appendix B.

Highly Toxic Chemicals

High toxic compounds have the ability to cause harmful effects which can be local or systemic after a single exposure. Among the most useful parameters for assessing the risk of acute toxicity of a chemical are its LD_{50} and LC_{50} values, the mean lethal dose or lethal concentration causing death in experimental animals. A substance is highly toxic if:

- the oral LD_{50} for albino rats is less than 50 mg/kg
- the topical LD_{50} for albino rabbits is less than 200 mg/kg
- the LC_{50} in albino rats is less than 200 ppm for one hour

The list of highly toxic chemicals is in Appendix C. A chemical's absence from this list does not necessarily mean that it is not highly toxic. Always refer to the chemical's Material Safety Data Sheet (**SDS**).

Explosive Chemicals

Explosives are solid, liquid, or gaseous chemicals that can cause a sudden, almost instantaneous release of pressure, gas and heat when subjected to shock, pressure or high temperature. Their acquisition, storage, use and disposal are highly regulated and these materials demand the highest safety precautions.
Coordinate with the H & S for proper handling of explosive materials in the laboratory.

Reactive Chemicals

The variety of chemicals commonly present in the laboratory poses the potential for accidental hazardous chemical reactions or explosions. A hazardous reaction occurs when two or more incompatible chemicals combine, resulting in an undesirable or uncontrolled reaction with adverse consequences. Such reactions may result when incompatible chemicals spill by accident, inadvertently mix as chemical waste, or combine unwittingly during experimental procedures.
Hazardous reactions may cause any one or more of the following:

- Heat generation
- Fire
- Explosion
- Formation of toxic vapors
- Formation of flammable gases
- Volatilization of toxic or flammable substances
- Formation of substances of greater toxicity
- Formation of shock or friction sensitive compounds
- Pressurization in closed vessels
- Solubilization of toxic substances
- Dispersal of toxic dusts, mists, particles
- Violent polymerization

A reactive chemical is any solid, liquid or gaseous chemical substances that have the potential to react rapidly to release relatively large amounts of energy and/or dangerous by products (e.g. toxic gases). Some of these chemicals are:

- **Acetylenic Compounds** are explosive in mixtures of 2.5- 80% with air at pressures of two or more atmospheres. Acetylene (C_2H_2) subjected to an electrical discharge or high temperature decomposes with explosive violence. Dry acetylides detonate on receiving the slightest shock.
- **Aluminum Chloride** ($AlCl_3$) is a potential dangerous material because if moisture is present, decomposition can produce hydrogen chloride (HCl) and build up considerable container pressure. When opening a bottle that has been stored for a long time, completely enclose it in a heavy towel.
- **Ammonia** (NH_3) reacts with iodine to produce nitrogen tri-iodide (which is explosive) and with hypochlorite to produce chlorine. Do not mix ammonia-based cleaners with bleach. Mixtures of ammonia and organic halides sometimes react violently when heated under pressure.
- **Aqua Regia** is a mixture of nitric acid and hydrochloric acid and is sometimes used for dissolving noble metals or as glassware cleaner. Try to avoid using aqua regia. If needed, use only what is needed in a laboratory fume hood and destroy it within the hood after use. Do not store it in closed containers; attempts to store aqua regia will most likely rupture the storage container. Upon generation, the nitric acid begins to reduce, with evolution of toxic nitrogen dioxide gas.
- **Bensoyl Peroxide** ($C_6H_5CO_2$) is easily ignited and sensitive to shock. It decomposes spontaneously at temperature above 50^{o}C but a cab be desensitized by addition of 20% by volume of water.
- **Carbon Disulfide** (CS_2) is highly toxic and highly flammable; when mixed with air, its vapors can ignite by a steam bath or pipe, a hot plate, or a glowing light bulb. Carbon disulfide catches fire spontaneously upon contact with a hot surface at a temperature approximating or exceeding 80 ^{o}C.
- **Chlorine** (Cl_2) may react violently with hydrogen (H_2) or with hydrocarbons when exposed to sunlight.
- **Diazomethane** (CH_2N_2) and related diazo compounds require extreme caution. They are very toxic and the pure forms (gases and liquids) explode readily. Diazald (a precursor to diazomethane) is a high explosive. Solutions in ether are safer and are rendered harmless by drop wise addition of acetic acid.
- **Diethyl, Isopropyl and other Ethers** (particularly the branched-chain type) may explode during heating or refluxing due to the presence of peroxides. Ferrous salts or sodium bisulfate can decompose these peroxides and passage over basic active alumina will remove most of the peroxide material. Mark containers with the date received, date opened, and date to be discarded, and discard them before they are out of date.
- **Diethylzinc** [$(C_2H_5)_2Zn$ is a violently pyrophoric (air reactive), water-reactive and light sensitive liquid and is generally sold in mixture with toluene, hexane, or other organic solvents. At concentrations above 1.1 molar, store diethylzinc in an inert atmosphere at or below room temperature. Do not use water for extinguishing fires; use dry powder, soda ash or lime.
- **Dimethyl Sulfoxide** [$(CH_3)SO$] decomposes violently on contact with wide variety of active halogen compounds. Explosions from contact with active metal hydrides have been reported. Its toxicity is still unknown, buy it penetrates and carries dissolved substances through the skin membrane.
- **Dinitrophenols** [$(NO_2)_2C_6H_3OH$] such as 2,4-DNP and 2,6-DNP are sensitive to light, heat, friction and shock and should never be allowed to dry out. 2,4-DNP form explosive salts with alkalis and ammonia. Oxidative decomposition can produce nitrogen oxides. At water concentrations less than 15%, DNPs are explosive.

- **Dry ice**, a solid carbon dioxide (CO_2) is not to be kept in a container that is not designed to withstand pressure. Containers of other substances stored over dry ice for extended periods generally absorb carbon dioxide unless sealed with care. When removing such containers from storage and allowing them to come rapidly to room temperature, the CO_2 may develop sufficient pressure to burst the container with explosive violence. On the removal of such containers from storage, loosen the stopper, or wrap the container in towels and keep it behind a shield. Dry ice can produce serious burns. Do not store dry ice in walk-in cold rooms, as this may result in an oxygen deficient atmosphere.
- **Drying Agents-Ascarite** must not mix with phosphorus pentoxide (P_2O_5) because the mixture may explode if warmed with a trace of water. Since organic solvents may extract the cobalt salts used as moisture indicators in some drying agents, the use of these drying agents shall be restricted to gases
- **Ethylene Oxide** (C_2H_4O) can explode when heated in a closed vessel. Carry out experiments using ethylene oxide under pressure behind suitable barricades.
- **Fulminic Acid** (HCNO), metal salts and other compounds that contain the fulminate ion ($C\Xi N^+\text{-}O^-$) are highly unstable due to the weak single N-O bond. Fulminates are friction-sensitive primary explosives.
- **Grignard Reagents** (R-Mg-X) are alkyl- or aryl- magnesium halides that are highly reactive with oxygen and carbonyls. They can spontaneously ignite in most air; handle Grignard reagents under inert gases such as argon or nitrogen, or in solvents such as tetrahydrofuran or ethyl ether.
- **Halogenated Compounds** such as chloroform ($CHCl_3$), methylene chloride (CH_2Cl_2), carbon tetrachloride (CCl_4), and other halogenated solvents shall not be dried with sodium, potassium, or other active metals; violent explosions can result.
- **Hydrogen Peroxide** (H_2O_2) stronger than three percent (3%) can be dangerous; in contact with the skin, it may cause severe burns. Thirty percent H_2O_2 may decompose violently if contaminated with iron, copper, chromium, other metals or salts. Stirring bars may inadvertently bring metal into a reaction, so use with caution.
- **Liquid-Nitrogen Storage Cooled Traps**, when opened into the atmosphere, it rapidly condenses liquid air. With coolant removal, a pressure buildup may occur and be sufficient to shatter glass equipment. Only cool sealed or evacuated equipment with liquid nitrogen.
- **Liquid Nitrogen Storage Dewars** are common for cryopreservation of samples. Cryopreservation vials stored in the liquid phase of liquid nitrogen can rupture upon warming if liquid nitrogen has infiltrated them, as the liquid nitrogen expands more than 600 times during evaporation. Store vials in the gaseous state go above the liquid nitrogen to avoid infiltration.
- **Lithium Aluminum Hydride** ($LiALH_4$) shall not be used to dry methyl ethers or tetrahydrofuran. The products of its reaction with CO_2 can be explosive. Do not use carbon dioxide or bicarbonate extinguishers against $LiAlH_4$ fires; use sand or a class D extinguisher.
- **Nitric Acid** (HNO_3) is a powerful oxidizing agent that ignites on contact or reacts explosively with a variety of organic substances including acetic anhydride, acetone, acetonitrile, many alcohols, benzene, DMSO, and methylene chloride. Do not store nitric acid with combustible organic acids such as acetic acid or formic acid. Nitric acid can also react violently with many inorganic substances including bases, reducing agents, alkali metals, copper, phosphorus, and ammonia.
- **Nitrocellulose** [$(C_6H_7O_{11}N_3)n$] in dry, unstabilized form becomes explosive when heated or subjected to sudden shock. Store moist, away from heat sources and sunlight, and segregated from other materials. Nitrocellulose in membrane filters with polyester backing and mixed cellulose ester (MCE) filters is more stable, but can still

spontaneously combust when exposed to oxidizing agents or sources of heat. Do not store filters where exposure to direct sunlight could occur.

- **Nitroglycerin** [$(C_3H_3(NO_3)_3$] for research purposes it is usually in tincture form, mixed with alcohol. Do not allow the carrier to evaporate, as this will result in high explosive nitroglycerin.
- **Oxygen Tanks** can explode due to contact between oil and high pressure oxygen. Do not use oil in connections with an oxygen cylinder or regulator. Do not use soap-based leak detector compounds on the connection that threads of an oxygen cylinder.
- **Ozone** (O_3) is a highly reactive and toxic gas. It forms by the action of ultraviolet light on oxygen (air) and, therefore, certain ultraviolet sources may require venting to the exhaust hood.
- **Palladium or Platinum on Carbon, Platinum Oxide, Raney Nickel, and other Catalysts**, must be carefully filtered from catalytic hydrogenation reaction mixtures. The recovered catalyst is saturated with hydrogen and highly reactive; thus, it will ignite spontaneously on exposure to air. Particularly for large-scale reactions, do not allow the filter cake to dry. Place the funnel containing the still-moist catalyst filter cake into a water bath immediately after completion of the filtration. Another hazard in working with such catalysts is the potential of explosion when adding additional catalyst to a flask in which hydrogen is present.
- **Parr Bombs** used for digestions or hydrogenations have failed and exploded. Handle all high-stress equipment such as bomb calorimeters with care behind bench top shields, and wear proper eye protectors.
- **Perchlorate** use should be avoided whenever possible. Do not use perchlorates as drying agents if there is a possibility of contact with organic compounds, or in proximity to a dehydrating acid strong enough to concentrate the perchloric acid ($HClO_4$) to more than 70% strength (e.g., in a drying train that has a bubble container containing sulfuric acid). Use safer drying agents. Seventy percent (70%) $HClO_4$ can be boiled safely at approximately 200 ^{o}C, but contact of the boiling undiluted acid or the hot vapor with organic matter, or even easily oxidized inorganic matter (such as compounds or trivalent antinomy), will lead to serious explosions. Do not allow oxidizable substances to contact $HClO_4$. Use beaker tongs, rather than rubber gloves, when handling fuming $HClO_4$. Carry out perchloric acid evaporations and digestions in a dedicated hood that has a good draft, and that is washable. Frequent washing out of the hood and ventilator ducts with water is necessary to avoid the danger of metal perchlorate buildup, which could lead to spontaneous combustion or explosion.
- **Permanganates** are explosives when treated with sulfuric acid. When both compounds are in an absorption train, place an empty trap between them.
- **Peroxides (inorganic)**, when mixed with combustible materials, barium, sodium, and potassium, form explosives that ignite easily.
- **Phosphorus** (P), both red and white, forms of explosive mixtures with oxidizing agents. White (also called yellow) P should be stored under water, in glass, because it is pyrophoric. The reaction of P with aqueous hydroxides gives phosphine (PH_3), a highly toxic gas that can also ignite or explode spontaneously in air.
- **Phosphorus Trichloride** (PCl_3) reacts with water to form phosphorous acid, which decomposes on heating to form phosphine, which may ignite spontaneously in the air or explode. Take care when opening containers of PC13, and do not heat samples that were exposed to moisture without adequate shielding to protect yourself.
- **Picric Acid** [$(NO_2)_3C_6H_2OH$], also known as 2,4,6,-trinitrophenol, can form explosive compounds with many combustible materials. Do not store in metal containers, as this can cause the formation of highly explosive metal picrate salts. Picric acid in saturated aqueous solution is relatively stable, but becomes less stable with age; in solutions of 10% to 40% water, it is considered a flammable solid. If picric acid dries, to less than

10% water), it is a high explosive and must not be touched or disturbed except by the trained high-hazard removal specialists.

- **Piranha Solutions** (mixtures of sulfuric acid and hydrogen peroxide) used for the removal of organic materials which must never be stored, as they are likely to pressurize and explode their container. Make only what you need, and discard immediately after use. Solutions are very energetic and heat to over 100 ^{o}C during mixing; handle with care.
- **Potassium** (K) is in general more reactive than sodium, and ignites quickly on exposure to humid air; therefore, handle it under the surface of a hydrocarbon solvent such as mineral oil or kerosene (see Sodium). Potassium may also form peroxides even while stored under oil.
- **Propargyl Bromide** (C_3H_3Br), is also known as 3-bromopropyne, and unstable water-insoluble compound that is usually stored in a solvent such as toluene. Do not allow propargyl bromide to dry out, do not store it in an area near the heat sources, and do not expose it to mild mechanical shocks.
- **Residues from Vacuum Distillations** (for example, ethyl palmitate) have exploded when the still was vented to the air before the residue was cool. Avoid such explosions by venting the still pot with nitrogen, cooling it before venting, or restoring the pressure slowly.
- **Sodium** (Na) shall be stored in a closed container under kerosene, toluene or mineral oil. Destroy scraps or Na or K by reaction with n-butyl alcohol. Avoid contact with water, as sodium reacts violently with water to form hydrogen with the evolution of sufficient heat to cause ignition. Use sand or Class D extinguishers on alkali metal fires. Do not use CO_2 fire extinguishers.
- **Sodium Amide** ($NaNH_2$) can rapidly absorb water and carbon dioxide from humid air. Oxidation can produce sodium nitrite in a mixture that is unstable and may explode. Store sodium amide in a cool, dry place in a tightly-sealed container under inert gas blanket.
- **Sodium Azide** (NaN_3) can react with copper and lead (including copper and lead in plumbing) to produce explosive copper or lead azide. Use caution when drain disposing substances that contain any amount of sodium azide. Even the trace amounts (‹1%) used as an antimicrobial chemical mixtures and reagents test kits can react with copper or lead in areas such as P-traps; there is the potential for prolonged contact between the azide and lead/copper that might be in these traps. If you drain dispose any substances with trace amounts of sodium azide, flush with copious amounts of water. Sodium azide is also highly toxic, and can decompose explosively due to heat, shock, concussion, or friction. Do not mix with sulfuric or nitric acid.
- **Sulfuric Acid** (H_2SO_4) should be avoided, if possible, as a drying agent in desiccators. If used, place glass beads in it to prevent splashing when the desiccators is moved. Avoid using H_2SO_4 in melting point baths, use silicone oil instead. To dilute H_2SO_4), add the acid slowly to cold water.
- **Tollens Reagents**, which contain an aqueous diamine silver complex $[Ag(NH_3)_2^+]$ and are used to test for aldehydes, must be freshly prepared and NEVER stored for longer than 1-2 hours. Stored Tollens Reagent can form explosive fulminating silver (Ag_3N). Acidify with dilute acid before disposal.
- **Trichloroethylene** (Cl_2CCHCl) reacts under a variety of conditions with potassium or sodium hydroxide to form dichloroacetylene ($ClC\equiv CCl$), which ignites spontaneously in the air and detonates readily even at dry-ice temperatures. The compound itself is toxic, so take suitable precautions when using as a degreasing solvent. Methyl chloroform (1,1,1-trichloroethane) is a less toxic substitute.

4.2 Safe Usage of Chemicals

All chemicals can have toxic effects at some dose level and particular route(s) of exposure. It is therefore wise to minimize exposure to chemicals. Chemicals can have local or systematic effects. Local toxicity refers to the direct action of chemicals at the point of contact. Systematic toxicity occurs when the chemical agent is absorbed into the bloodstream and distributed throughout the body, affecting one or more organs. Health effects can be acute or chronic. Acute effects last for a relatively short time and then disappear. Chronic effects are not reversible.

Acute exposures to chemicals are for short periods. Chronic health effects can develop from acute exposures depending on the properties and amounts of the chemical. Acute or chronic adverse health effects can occur with chronic (repeated) exposure to chemicals, even at low concentrations.

4.2.1 Routes of Exposure

Dermal Contact

Skin contact is one of the most common chemical exposure routes in the laboratory settings. Spills and splashes can result in overt skin contamination. In addition, laboratory personnel may unknowingly contaminate themselves when they touch work surfaces, glassware, or equipment contaminated during experiments. A common result of skin contact is localized irritation or dermatitis. However, a number of materials are absorbed through the skin are the hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the outer layers of the skin. The follicles and the glands contain blood vessels, which facilitate the absorption of chemicals into the body. Chemicals can also enter the body when contaminated hands touch the mouth, nose, eyes, sores or cuts.

Inhalation

Inhalation of toxic vapors, mists, gases, or dust can produce poisoning by absorption through the mucous membrane of the mouth, throat and lungs, and can seriously damage these tissues by local action. Inhaled gases or vapors may pass rapidly through the capillaries of the lungs and enter the circulatory system. The degree of injury through the inhalation of toxic substances depends on the material's toxicity, solubility in tissue fluids, concentrations, and the durations of exposure.

Although inhalation hazards are more often associated with gases and volatile chemicals, both solids and non-volatile liquids can also present an inhalation hazard for laboratory personnel. Laboratory chemicals in the form of dust and particulates can become airborne when transferred from one container to another. Grinding and crushing procedures can also produce aerosols. Splashes created from spills and vigorous shaking and mixing form aerosols. Many of these generated particulates do not settle out but remain suspended in the air and travel along air currents in the room. Some of these particulates can be inhaled and they deposit in the respiratory tract. All laboratory operations involving an open vessel will result in aerosol release. Such operations include weighing, stirring, pouring, pipetting, injections with a needle and syringe, and removing caps and stoppers.

Ingestion

Ingestion of toxic materials in the laboratory can occur when contaminated hands come in contact with mouth or with food stuff. The laboratory environment can contaminate food stuff and utensils. Do not mouth pipette, as this can result in aspiration of toxic materials.

Injection

Accidents involving needles and syringes can result in injection of toxic and/or infectious materials through the skin. Needles and syringes are among the most hazardous items used in the laboratory. Containers of toxic chemicals may break, resulting in hazard from contact with contaminated broken glass.

Ocular Exposure

The eyes are of particular concern, due to their sensitivity to irritants. Ocular exposure can occur via splash, or rubbing eyes with contaminated hands. Few substances are innocuous with eye contact, and several can cause burns and loss of vision. The eyes have many blood vessels, and rapidly absorb many chemicals.

4.2.2 Safe Handling Practices

Access Control

The Laboratory Supervisor or work area supervisor must control access to laboratories or other work places that contain chemicals. Keep the laboratory door closed while experiments are in progress. This practice not only protects persons who might otherwise enter the laboratory, it reduces interruptions to laboratory staff that could lead to accidents. Laboratory fume hoods work best and offer the most worker protection, when the door to the laboratory is closed.

Personal Practices

- Wash your hands immediately after completion of any procedure involving chemicals, and when leaving the laboratory. Soap must be in liquid form, with a pump dispenser.
- Eating, drinking, smoking, chewing gum, applying cosmetics and storing utensils, food and food containers are prohibited.
- Use mechanical pipetting aids for all pipetting procedures. NEVER MOUTH PIPETTE.

Decontamination of Work Surfaces

Protect work surfaces from contamination by using “bench paper” (disposable plastic-backed absorbent paper) or stainless steel trays. Place plastic side down and the absorbent side facing up. Change worn or contaminated bench paper and dispose properly. Decontaminate other items and equipment with appropriate solvents when contaminated during experiments.

Minimizing Aerosols

- Discharge liquids from pipettes as close as possible to the fluid level of the receiving vessel or allowing the contents to run down the wall of the receiving vessel. Dropping the contents from a height generates more aerosols.
- Avoid rapid mixing of liquids with pipettes by alternate suction and expulsion, or forcibly expelling material from a pipette.
- Take extra care when discarding contaminated gloves or plastic-backed absorber paper used to cover the work surface, to avoid aerosolizing contaminants.
- Clean floors with a wet mop or with a vacuum cleaner equipped with a HEPA filter, as dry sweeping or dry mopping contaminated laboratory floors could aerosolize contamination.

Carcinogens

- Appropriate pre-employment and periodic medical examinations should be provided for persons handling or potentially being exposed to chemical carcinogens. The pre-employment examination should include a personal history review of the individual, his family and his occupational background, with emphasis on genetic and environmental factors known to be associated with an increased incidence of cancer.
- Persons having reduced immunological competence, those undergoing treatment with steroids, pregnant women and chronic tobacco users should be cautioned against access to areas where chemical carcinogens are processed.
- The Laboratory In-charge is responsible for the preparation of general safety protocols for each carcinogen to be handled in a test. The protocols should include specific details identifying the physical and toxicological properties of the carcinogen and the use, storage, emergency treatment and disposal procedures.
- When working with carcinogens, wear protective apparel, including eye protectors. A change area and shower must be readily available.
- Thoroughly wash hands, forearms, face and neck after each episode of handling.
- Work should be performed in a regularly maintained hood with an average linear face velocity of 100 - 120 feed per minute, with complete filtering or treatment of the air before release.
- Housekeeping and cleanup should stress aerosol suppression and preclude dry sweeping.
- Carcinogen waste shall be collected, labeled, and disposed of by a licensed chemical disposal company.
- All containers of carcinogen should be clearly labeled and kept in a hood designated only for carcinogen use.
- In the case of any carcinogenic spill or contamination, shower immediately.

Cryogenic Liquids

Cryogenic liquids are pressurized liquids formed by compressing gases to a point where the temperature reaches-60 degrees C to -270 degrees C). They are particularly hazardous because they can explode or cause structural materials to become fatigued and brittle.

The low boiling points of cryogenic liquids (-60 C to -270 C) require that they be kept liquefied under pressure. Many are used at room temperature which means that they are at their boiling point when actually used. Carelessness at this point may result in frostbite and frozen skin tissue through body contact or asphyxiation if inhaled directly from the pressurized cylinder.

Please refer to *QU SOP-03 Compressed Gas Cylinders* for the safety practices to be considered when using or handling cryogenics.

4.2.3 Storage

Inventory and Inspection

- Each laboratory shall maintain an inventory of the chemicals stored in the laboratory.
- Designate a storage place for each chemical, and return it to that storing place after each use.
- Store chemicals by hazard class, not alphabetically, and post storage areas the exact location of the chemical groups.
- Inspect chemical storage areas at least annually for outdated or unneeded items, illegible labels, leaking containers, etc.

Proper Sealing of Chemical Containers

- To prevent leakage, odors, or reaction with air, tightly seal all containers of highly toxic, highly volatile, malodorous, carcinogenic or reactive chemicals.
- Make sure that the caps and other closures are tight on all hazardous chemicals.
- A limited exception is freshly-generated mixtures such as acids and organics that may generate gas pressure sufficient to burst a tightly sealed bottle. Keep the lids loose until sufficient time passes to complete the reactions, and then tightly close the caps.
- Use a screw-cap with a conical polyethylene or Teflon insert.
- Seal the caps with tape or Para film as further precaution.
- Additional protection include wrapping in an absorbent paper & sealing inside plastic bag & and storing the bag inside a metal can with a friction-fitting lid.

Segregation of Chemicals

The storage of hazardous materials should be supervised by a competent, trained person to ensure that the materials are properly segregated. Incompatible materials shall be segregated to prevent accidental contact with one another. Dry materials, liquids, and gases should be stored separately from each other. Further separation of the materials based on hazard class should be made. Once separated into hazard classes, chemicals may be stored alphabetically. Only use approved storage containers and safety cans for flammable liquids. Always use spill trays under containers of strong corrosive reagents. Do not store liquids above eye level. The following are guidelines for hazardous material segregation:

Group A – Acids, Inorganic

- Store large bottles of acids in special cabinets or on low shelves.
- Place acids in plastic trays for secondary containment in case of breakage.
- Segregate inorganic and oxidizing acids from organic compounds including organic acids and other combustible materials.
- Store acids separate from bases and other reducing agents.
- Inorganic salts, except of heavy metals, may be stored in this group.
- Segregate nitric acid (> 40%) from inorganic acids.
- Glacial acetic acid should be stored with flammable and combustible materials since it is combustible.

Group B – Bases

- Segregate bases from acids and oxidizers on shelves near the floor.
- The preferred storage container for inorganic hydroxides is polyethylene instead of glass.
- Place containers in trays for secondary containment

Group C – Organic Chemicals

- Segregate organics compounds from the inorganics.
- Organic and inorganic materials with National Fire Protection Association (NFPA) 704 or Workplace Hazardous Material Information System (WHMIS) reactive rating of two (2) or less may be stored together. Chemicals with a reactive hazard rating of three (3) or four (4) are to be stored separately.

Group D – Flammable and Combustible Organic Liquids

- No more than 230 liters of Class 1 flammable liquids (flash point below 37.8° C) or Class II combustible liquids (*flash point between 37.8° C and 60° C) may be stored in flammable liquid storage cabinets. The 230-liter limit per room is based on two storage cabinets, with a maximum of 115 liters per cabinet*).
- No more than 460 liters of a Class III combustible liquid (*flash point between 60° C and 93° C*) may be stored in a flammable-liquids storage cabinet.
- Store flammable and combustible materials away from oxidizers.

Group E – Inorganic Oxidizers and Salts

- Store inorganic oxidizers away from combustible alkaline metals, formic acid and other reducing agents.
- Inorganic salts may also be stored in this group.
- Store ammonium nitrate separately.

Group F – Organic Peroxides and Explosives

- Organic peroxides and explosives are shock and heat sensitive chemicals, and should be stored in a dedicated cabinet.

Group G – Reactive

- Store water reactive chemicals in a cool dry place away *from water sources.*
- *Alkali metals (lithium. Sodium, potassium, rubidium and cesium*) should be stored under mineral oil or in waterproof enclosures such as glove boxes.
- Store white or yellow phosphorous under water in glass-stopper bottles inside a metal can for added protection.

Group H – Cyanides and Sulfides

- Isolate from acids and other oxidizers.

Flammable Liquids Storage outside a Cabinet

- Storage of flammable liquids outside a storage cabinet shall be avoided when possible. Flammable liquids that are not in use should be stored in an appropriate cabinet.
- The maximum quantity of flammable liquids permitted to be stored in a laboratory outside the flammable-liquids cabinet varies depending on the design of the research building.
- Flammable liquids should not be stored in refrigerators unless it is UL approved for flammable liquid storage. Storage of flammable liquids in household grade refrigerators is a fire hazard. Household grade refrigerators should be labeled: "No food or flammable liquid storage".

4.2.4 Disposal

Ensure that all chemicals are disposed in accordance with *QU SOP-03 Hazardous Waste Disposal*.

4.2.5 Transportation

The transportation of hazardous chemicals in laboratory buildings provides the greatest potential for chemical exposure to the building occupants. Spills occurring outside storerooms and laboratories may lead to hazardous concentrations of vapors and gases being distributed throughout the building.

Freight elevators shall be used where available to transport hazardous materials. Under no circumstances should passenger elevators be used for the transportation of hazardous materials if freight elevators are available.

Flammable liquids shall be transported in rugged pressure-resistant safety cans.

Original containers of flammable liquids shall be placed in an outside container or acid-carrying bucket.

No more than 5 gallons of flammable liquids in glass containers shall be transported on the freight elevator unless the original shipping carton (box) is used and the materials are on an appropriate cart.

4.3 Special Handling for Hydrofluoric Acid

Hazards

Hydrofluoric acid (HF) differs from other acids because it readily penetrates the skin and dissociates into fluoride ions, causing destruction of deep tissue layers, including bone. The fluoride ion affects tissue integrity and metabolism by liquefaction necrosis, decalcification and destruction of bone, and production of insoluble salts. Loss of calcium (hypokalemia) results from precipitation of calcium from the blood as CaF_2. This results in calcium loss from the bones to equilibrate the decreased serum calcium. The development of hypokalemia can be rapidly fatal because calcium is important for muscles, including the cardiac muscle (heart), to function properly. Fluoride ions might also combine with potassium and magnesium ions, leading to myocardial and arrhythmia. Death from metabolic acidosis, hypokalemia, or ventricular arrhythmia can occur several hours after exposure.

Pains associated with skin exposure to HF may not occur for 1-24 ours. Unless HF is rapidly neutralized and combines with the fluoride ions, tissue destruction may continue for days and result in limb loss or death. HF is similar to other acids in that the initial extent of burn depends on the concentration, temperature, and duration of contact with the acid. Eye exposure to concentrations of HF greater than 0.5 % can result in severe ocular damage, with delayed signs and symptoms.

Hydrofluoric acid vapors are also hazardous. Ocular irritation and injury can occur from working with HF outside a vented enclosure (laboratory fume hood). Inhalation can cause severe throat irritation, cough, dyspnea, cyanosis, lung injury and pulmonary edema. In severe exposure cases, these can result in death.

Handling

Familiarize yourself with the hazard specific to HF before handling. Consult the SDS and label information. Always handle HF in a properly functioning laboratory fume hood and in an area equipped with an eyewash and emergency shower.

Required Personal Protective Equipment:

- Goggles
- Face shield (plastic)
- Gloves: Thin disposable gloves (*such as 4, 6, 8 mil blue nitrile gloves*) used laboratory operations provide a contact barrier only and should be disposed immediately when contamination is suspected. Thicker (10-12 mil) PVC or neoprene gloves provide better resistance to HF but do not provide the necessary dexterity. Thinner PVC or poly gloves can provide some resistance to HF, but shall require immediate changing at the first sign of contamination. Do not wear disposable gloves without double gloving because of the potential for exposure through pinholes.
- Acid resistant apron
- Long pants and sleeves
- Closed toe shoes

Incompatibilities and Storage

- Store HF in a cool, dry place away from incompatible materials.
- HF reacts with many materials; avoid contact with glass, concrete, metals, water, other acids, oxidizers, reducers, alkalis, combustibles, organics and ceramics.
- Store in containers made of polyethylene or fluorocarbon plastic, lead, or platinum.
- Place storage bottles in polyethylene secondary containment trays.
- Never store HF, of HF waste in glass containers.

4.4 Compressed Gases Handling

Refer to *QU SOP-03 Compressed Gas Cylinders* for the safety procedures when dealing with compressed gases.

4.5 Workplace Hazardous Materials Information System (WHMIS)

Workplace Hazardous Materials Information System (WHMIS) is a communication system that provides information to all staff, faculty and students about hazardous materials used within workplaces.

The system has three components that provide information about the materials you work with, about the physical agents you are exposed to and the hazards that exist in the working environment.

Material Safety Data Sheet - Basic information about the specific material including: how it should be handled and/or stored, protective measures, and emergency procedures.

Labels - A label displayed on each package or container of a controlled product used in the workplace. Standardized warning symbols are part of the WHMIS Classification System.

Worker Education - Training programs must be provided to everyone who works with the hazardous materials.

4.5.1 Hazard Classification System

The WHMIS Hazard Classification System identifies six types, or broad classes of hazardous materials. Divisions are provided in some classes to separate different groups of hazardous materials within a class. The classification system determines whether a product meets the criteria for inclusion in any of the WHMIS classes or is subject to the WHMIS information requirements. Classification affects whether the product is included within WHMIS, but also the:

- Content of labels, particularly hazard symbols, risk statements and precautionary measures.
- Content of material safety data sheets, and
- Instruction provided to workers.

A system of standardized symbols on WHMIS labels, each with a circular border, provides a uniform way to identify hazards.

Class A: Compressed Gas

The symbol for compressed gas is the outline of a compressed gas cylinder. A compressed gas product is in a gaseous state and is kept under pressure.
Class A materials include compressed gases, dissolved gases or gases liquefied by compression or refrigeration.

Some compressed gases are also flammable and combustible. Others are also materials causing immediate and toxic effects. Whenever a controlled product falls into two or more classes, two or more hazard symbols are provided.

Class B: Flammable and Combustible Material

The symbol for Flammable and Combustible is a flame. This classification refers to a solid, liquid or a gas that will ignite and continue to burn if exposed to a flame or ignition.

Flammable materials will burn easily at or about room temperature (Flash point 38 degrees C or below) and Combustible material will burn when heated.
Six types of materials belong to this class:

- Flammable Gases: Examples - propane and hydrogen.
- Flammable Liquids: Example - gasoline.
- Combustible Liquids: Examples - paint thinner and diesel fuel.
- Flammable Aerosols: Examples - hair spray, engine starter fluid and penetrating oil.
- Reactive Flammable Materials: Examples - celluloid and metallic sodium.
- Combustible Solids: Examples - Wood and paper.

Class C: Oxidizing Materials

The symbol for Oxidizing Materials is a flame above an "O", which stands for "Oxygen". Oxidizing materials will cause or assist to cause fires in surrounding materials by supplying oxygen. Oxygen is required for all fires, and any substance that increases the supply of oxygen will increase the chance of fire. Examples include: peroxide bleach, nitrites and chlorates.

Class D Poisonous and Infectious Material

Materials that fall into Class D are further divided into three separate divisions:

Class D1: Materials Causing Immediate and Serious Effect

The symbol is the familiar skull and crossbones. Examples include bleach, hydrogen sulphide, chlorine, strychnine and cyanides.

Class D2: Materials Causing Other Toxic Effect

The symbol is a "T" made into an exclamation mark that stands for "TOXIC". These are materials that may cause harmful effects usually sometime after the first or repeated exposures. Examples include: vapors of solvents, mercury, some herbicides and aromatic solvents.

Class D3: Biohazardous and Infectious Material

This symbol looks like a cell that is dividing. Biohazardous infectious materials are organisms (and the toxins of organisms) that cause diseases such as viruses, bacteria and fungi. Examples include: vaccines and science laboratory classes.

Class E: Corrosive Material

The symbol for Corrosive material is liquid being poured onto a hand and a piece of solid material causing damage to the hand and to the material itself. Corrosive materials may cause burns and destroy tissues. They can also destroy other materials. Examples: sulphuric acid, hydrochloric acid and anhydrous ammonia.

Class F: Dangerously Reactive Materials

The symbol is an exploding test tube inside a capital "R", which stands for "REACTIVE". A substance is considered to be dangerously reactive when it will:

- React with water to produce a poisonous gas.
- Self-react if the container is heated, pressurized, or shaken; or
- Self-react because of age.

4.5.2 Safety Data Sheet

Safety Date Sheet is a report prepared by manufacturers containing useful information to ensure their chemicals are handled and stored properly and identifying the types of precaution, protective equipment, emergency preparedness that must be used for staff and students' safety.

Safety Data Sheet (SDS) is required for all type of chemicals (liquid, solid, gases) in the University. Storage area for chemicals will be provided with Safety Data Sheet (SDS).

The OSHA Hazard Communication Standard (29 CFR 1910.1200) requires manufacturers to provide SDS at no cost. The following information is to be included:

Section I of the SDS lists information identifying the manufacturer and the product. It includes:

- Manufacturer's name, address and telephone number
- Number to call in case of emergency
- Chemical name and synonyms
- Trade name and synonyms
- Chemical family and formula
- Chemical Abstract Service (CAS) number that is a unique identification number for chemical reagents.
- Date of preparation

Section II describes the various hazardous ingredient(s) contained in the product, the percentages of ingredient(s), and exposure limits when appropriate. This will include all hazardous chemicals that comprise 1% or greater of the mixture will be identified. Carcinogens must be listed if the concentrations are 0.1% or greater.

Section III describes the physical properties of the material. Physical properties include:

- Boiling point
- Specific gravity
- Vapor pressure
- Percent volatile
- Vapor density
- Evaporation rate
- Solubility in water
- Appearance and odor

Section IV describes the fire and explosion hazard data for the material and other fire and explosion data. The appropriate extinguishing agent for fires involving the material will be listed. Special firefighting procedures may also be listed.

Section V describes the known health hazard data for the material and exposure limits. Symptoms or the health effects of an overexposure are listed. This information will help the user and medical personnel recognize if an overexposure has occurred.

- Threshold limit value (TLV)
- Existing medical conditions that may be aggravated by exposure
- Effects of overexposure (e.g., headache, nausea, narcosis, eye irritation, Weakness, skin rashes, etc.)
- Primary routes of exposure (i.e., inhalation, skin, ingestion)
- Cancer or other special health hazards
- Emergency and first aid procedures

Section VI describes reactivity data; that is, the material's ability to react and release energy or heat under special conditions or when it comes in contact with certain substances.
Section VII gives instructions for the steps to be taken in case of an accidental release or spill. The steps normally include information on containment, evacuation procedures, and waste disposal. The statements on the SDS are general; more specific information is available from the appropriate Work Instruction.
Section VIII describes the protective equipment for the individual who might have to work with such substances. This section normally describes worst case conditions; therefore, the extent to which personal protective equipment is required as task dependent. Always review the appropriate Standard Operating Procedure. Equipment may include:

- Respiratory equipment
- Ventilation
- Protective gloves
- Eye protection
- Other protective equipment (i.e., special clothing).

Section IX describes handling and storage procedures to be taken with the material. Information may include statements such as: keep container closed; store in a cool, dry, well ventilated area; keep refrigerated; avoid exposure to sunlight.
Section X describes any special precautions or miscellaneous information regarding the material. In some cases, manufacturers may choose to withhold certain information on a SDS provided the information is trade secret. Regardless of the existence of trade secrets, the SDS must still contain all relevant hazard, protection, and health information.
Some SDS may not contain all the ten sections or the information may be in a slightly different order. However, the basic information defined above must be provided.
Some SDSs are more complete than others. Do not assume everything you need to know is contained on the SDS. Do not assume if a section is left blank that there is no risk.

4.5.3 WHMIS Labels

Supplier Labels

Suppliers of WHMIS controlled products to workplaces at Qatar University, whether importing, producing, or selling these products, must affix a supplier label**.** Supplier labels must:

- Have the distinctive cross-hatch border in a color that will contrast with the background on which it appears.
- Be placed on the hazardous material or container so that it is visible under normal storage and use.

Supplier labels must include:

- **Product Identification**
  The common name, chemical name, trade name, generic name, brand name, code name, or code number of a hazardous material.
- **Hazard Symbol**
  A specific WHMIS symbol that represents one or more of the hazard classifications that applies to the product.
- **Risk Phrase**
  A brief description of the hazard and the effects of harmful exposure to the body.
- **Precautionary Measures**
  Brief instructions for the safe use of the material.
- **First Aid Measures**
  A brief description of treatment for exposure to the material.
- **Supplier Identifier**
  The name of the suppler.
- **Reference to the SDS**
  A statement indicating that a copy of the applicable SDS is readily available in the workplace.

Workplace Labels

Workplace label must be placed on containers that are filled from suppliers' containers, and/or when a supplier label becomes illegible or is removed from the product.

Workplace labels are designed, attached and required for:

- Portable containers into which product has been transferred.
- Supplier containers with illegible labels (unless a supplier label is available).
  These labels must include:
  - **Product Identification**
    The common name, chemical name, trade name, generic name, brand name, code name, or code number of a hazardous material.
  - **Safe Handling Instructions**
    This includes unique risks associated with the normal use of the controlled product and the possible emergencies.
  - **Reference to the SDS**
    A statement indicating that a copy of the applicable SDS is readily available in the workplace
    The workplace label may be any size, shape or color and there are no language requirements, but it must be clearly visible and easy to read.
    The cross-hatch border, WHMIS symbols and phrases may appear on the workplace label, but they do not constitute requirements.
    Both labels below are acceptable.

4.5.4 Worker Education

Refer to *QU HSMS - Training and Competency* for training requirements related to chemical safety.

4.6 National Fire Protection Association (NFPA) 704 Diamond

The NFPA 704 Diamond is a standard placard used to identify the level of chemical hazard at fixed locations, such warehouses, storage tanks, and storage sheds. The NFPA diamond also is used on some transported containers. It's sometimes called the "fire diamond."
The NFPA 704 diamond (shown below) is divided into four colored quadrants. Each quadrant provides information about the materials inside:

Within the blue, red, and yellow quadrants is a number from 0 to 4. The number indicates the degree of risk associated with the material. The higher the number, the higher the risk. For some materials, the white quadrant contains symbols indicating special hazards. The meaning of each code number and symbol is shown below.
If more than one chemical is present at a facility, the NFPA diamond indicates overall hazard at that location, *not* the hazard posed by a particular chemical. It shows the highest of each of the four hazards present. For example, it may be that one chemical poses the highest health hazard while another one poses the highest fire hazard.
If there's no NFPA diamond at a facility, don't assume that there are no dangerous chemicals present. Sometimes, a diamond may be missing or displayed in a location where it isn't visible to responder.

Blue Represents health hazards	**Red Represents fire hazards** (Flash Point)
4 – Deadly **3** – Extreme Danger **2** – Hazardous **1** – Slightly Hazardous **0** – Normal Material	**4** Below 73 °F **3** Below 100 °F **2** Above 100 °F ≤ 200 °F **1** Above 200 °F **0** Will not burn
Yellow Represents reactivity hazards	**White Represents specific hazards**
4 – May detonate **3** – Shock and heat may detonate **2** – Violent chemical change **1** – Unstable if heated **0** – Stable	Oxidizer - OX Acid - ACID Alkali - ALK Corrosive - CORR Use NO WATER - W Radioactive - ☢

4.7 Safe Work Practices & Procedures for Labs Equipment

4.7.1 Refrigerators and Freezers

The potential hazards posed by the laboratory refrigerators and freezers involve vapors from the contents, the possible presence of incompatible chemicals and spillage.

- Only refrigerators and freezers specified for laboratory use should be utilized for the storage of chemicals. These refrigerators have been constructed with special design factors, such as heavy-duty cords and corrosion resistant interiors to help reduce the risk of fire or explosions in the lab.
- Standard refrigerators have electrical fans and motors that make them potential ignition sources for flammable vapors. Do not store flammable liquids in a refrigerator unless it is approved for such storage. Flammable liquid-approved refrigerators are designed with spark-producing parts on the outside to avoid accidental ignition. If refrigeration is needed inside a flammable-storage room, you should use an explosion-proof refrigerator.
- Frost-free refrigerators should also be avoided. Many of them have a drain or tube or hole that carries water and possibly any spilled materials to an area near the compression, which may spark. Electric heaters used to defrost the freezing coils can also spark.
- Only chemicals should be stored in chemical storage refrigerators; lab refrigerators should not be used for food storage or preparation. Refrigerators should be labeled for their intended purpose: “No Food or Drink should be Stored in this Refrigerator” or “Refrigerator For Food Only”.
- All materials in refrigerators or freezers should be labeled with the contents, owner, date of acquisition or preparation and nature of any potential hazard. Since refrigerators are often used for storage of large quantities of small vials and test tubes, a reference to a list outside of the refrigerator could be used. Labels and ink used to identify materials in the refrigerators should be water-resistant.
- All containers should be sealed, preferably with a cap. Containers should be placed in secondary containers, or catch pans should be used.
- Loss of electrical power can produce extremely hazardous situations. Flammable or toxic vapors may be released from refrigerators and freezers as chemicals warm up and/or certain reactive materials may decompose energetically upon warming.

4.7.2 Stirring and Mixing Devices

The stirring and mixing devices commonly found in laboratories include stirring motors, magnetic stirrers, shakers, small pumps for fluids and rotary evaporators for solvent removal. These devices are typically used in laboratory operations that are performed in a hood, and it is important that they are operated in a way that precludes the generation of electrical sparks.

- Only spark-free induction motors should be used in power stirring and mixing devices or any other rotating equipment used for laboratory operations. While the motors in most of the currently marketed stirring and mixing devices meet this criterion, their on-off switches and rheostat-type speed controls can produce an electrical spark because they have exposed electrical conductors. The speed of an induction motor operating under a load should not be controlled by a variable autotransformer.
- Because stirring and mixing devices, especially stirring motors and magnetic stirrers, are often operated for fairly long periods without constant attention, the consequences of stirrer failure, electrical overload or blockage of the motion of the stirring impeller should be considered.

4.7.3 Heating Devices

Most labs use at least one type of heating device, such as ovens, hot plates, heating mantles and tapes, oil baths, salt baths, sand baths, air baths, hot-tube furnaces, hot-air guns and microwave ovens. Steam-heated devices are generally preferred whenever temperatures of 100° C or less are required because they do not present shock or spark risks and can be left unattended with assurance that their temperature will never exceed 100° C. Ensure the supply of water for steam generation is sufficient prior to leaving the reaction for any extended period of time.

A number of general precautions should be taken when working with heating devices in the laboratory. When working with heating devices, the following should be considered:

- The actual heating element in any laboratory heating device should be enclosed in such a fashion as to prevent a laboratory worker or any metallic conductor from accidentally touching the wire carrying the electric current.
- Heating device becomes so worn or damaged that its heating element is exposed; the device should be either discarded or repaired before it is used again.
- The external cases of all variable autotransformers have perforations for cooling by ventilation and, therefore, should be located where water and other chemicals cannot be spilled onto them and where they will not be exposed to flammable liquids or vapors.
- Fail-safe devices can prevent fires or explosions that may arise if the temperature of a reaction increases significantly because of a change in line voltage, the accidental loss of reaction solvent or loss of cooling. Some devices will turn off the electric power if the temperature of the heating device exceeds some preset limit or if the flow of cooling water through a condenser is stopped owing to the loss of water pressure or loosening of the water supply hose to a condenser.

4.7.4 Ovens

Electrically heating ovens are commonly used in the laboratory to remove water or other solvents from chemical samples and to dry laboratory glassware. Never use laboratory ovens for human food preparation.

- Laboratory ovens should be constructed such that their heating elements and their temperature controls are physically separated from their interior atmospheres.
- Laboratory ovens rarely have a provision for preventing the discharge of the substances volatilized in them. Connecting the oven vent directly to an exhaust system can reduce the possibility of substances escaping into the lab or an explosive concentration developing within the oven.
- Ovens should not be used to dry any chemical sample that might pose a hazard because of acute or chronic toxicity unless special precautions have been taken to ensure continuous venting of the atmosphere inside the oven.
- To avoid explosion, glassware that has been rinsed with an organic solvent should be rinsed again with distilled water before being dried in an oven.
- Bimetallic strip thermometers are preferred for monitoring oven temperatures. Mercury thermometers should not be mounted through holes in the top of ovens so that the bulb hangs into the oven. Should a mercury thermometer be broken in an oven of any type, the oven should be closed and turned off immediately, and it should remain closed until it is cooled off. All mercury should be removed from the cold oven with the use of appropriate cleaning equipment and procedures in order to avoid mercury exposure.

4.7.5 Hot Plates

Laboratory hot plates are normally used for heating solutions to 100° C or above when inherently safer steam baths cannot be used. Any newly purchased hot plates should be designed in a way that avoids electrical sparks. However, many older hot plates pose an electrical spark hazard arising from either the on-off switch located on the hot plate, the bimetallic thermostat used to regulate the temperature or both. Laboratory workers should be warned of the spark hazard associated with older hot plates.

In addition to the spark hazard, old and corroded bimetallic thermostats in these devices can eventually fuse shut and deliver full, continuous current to a hot plate.

- Do not store volatile flammable materials near a hot plate.
- Limit use of older hot plates to flammable materials.
- Check for corrosion of thermostats. Corroded bimetallic thermostats can be repaired or reconfigured to avoid spark hazards.

Heating mantles are commonly used for heating round-bottomed flasks, reaction kettles and related reaction vessels. These mantles enclose a heating element in a series of layers of fiberglass cloth. As long as the fiberglass coating is not worn or broken, and as long as no water or other chemicals are spilled into the mantle, heating mantles pose no shock hazard.

- Always use a heating mantle with a variable autotransformer to control the input voltage.
- Be careful not to exceed the input voltage recommended by the mantle manufacturer. Higher voltages will cause it to overheat, melt the fiberglass insulation and expose the bare heating element.
- If the heating mantle has an outer metal case that provides physical protection against damage to the fiberglass, it is a good practice to ground the outer metal case to protect against an electric shock if the heating element inside the mantle shorts against the metal case.

4.7.6 Oil, Salt and Sand Baths

Electrically heated oil baths are often used to heat small or irregularly shaped vessels or when a stable heat source that can be maintained at a constant temperature is desired. Molten salt baths, like hot oil baths, offer the advantages of good heat transfer, commonly have a higher operating range (e.g., 200 to 425°C) and may have a high thermal stability (e.g., 540°C).There are several precautions to take when working with these types of heating devices:

- Handle hot oil baths carefully so as not to generate smoke or have the oil burst into flames from overheating.
- Always monitor oil baths by using a thermometer or other thermal measuring devices to ensure that its temperature does not exceed the flash point of the oil being used.
- Fit the oil baths that are left unattended with thermal measuring devices that will turn off the electric power if the bath overheats.
- Mix oil baths well to ensure that there are no “hot spots” around the elements that take the surrounding oil up to unacceptable temperatures.
- Contain heated oil in a vessel that can withstand an accidental strike by a hard object.

- Mount baths carefully on a stable horizontal support such as a laboratory jack that can be raised or lowered without danger of the bath tipping over. Iron rings are not acceptable supports for the hot baths.
- Clamp equipment high enough above a hot bath that if the reaction begins to overheat, the bath can be lowered immediately and replaced with a cooling bath without having to re-adjust the equipment setup.
- Provide secondary containment in the event of a spill of hot oil.
- Wear heat-resistant gloves when handling a hot bath.
- The reaction container used in a molten salt bath must be able to withstand a very rapid heat-up to a temperature above the melting point of salt.
- Keep the salt baths dry since they are hygroscopic, which can cause hazardous popping and splattering if the absorbed water vaporizes during heat-up.

4.7.7 Hot Air Baths and Tube Furnaces

Hot air baths are used in the lab as heating devices. Nitrogen is preferred for reactions involving flammable materials. Electrically heated air baths are frequently used to heat small or irregularly shaped vessels. One drawback of the hot air baths is that they have a low heat capacity. As a result, these baths normally have to be heated to 100^{o}C or more above the target temperature. Tube furnaces are often used for high-temperature reactions under pressure. Consider the following when working with either apparatus:

- Ensure that the heating element is completely enclosed.
- For air baths constructed of glass, wrap the vessel with heat resistant tape to contain the glass if it should break.
- Sand baths are generally preferable to air baths.
- For tube furnaces, carefully select glassware and metal tubes and joints to ensure they are able to withstand the pressure.
- Follow safe practices outlined for both the electrical safety and pressure and vacuum safety systems.

4.7.8 Microwave Ovens

- Microwave ovens used in the laboratory may pose several different types of hazards.
- As with most electrical apparatus, there is the risk of generating sparks that can ignite flammable vapors.
- Metals placed inside the microwave oven may produce an arc that can ignite flammable materials.
- Materials placed inside the oven may overheat and ignite.
- Sealed containers, even if loosely sealed, can build up pressure upon expansion during heating, creating a risk of container rupture.

To minimize the risk of these hazards:

- Never operate microwave ovens with doors open in order to avoid exposure to microwaves.
- Do not place wires and other objects between the sealing surface and the door on the oven's front face. The sealing surfaces must be kept absolutely clean.
- Never use a microwave oven for both laboratory use and food preparation.
- Electrically ground the microwave. If use of an extension cord is necessary, only a three-pronged cord with a rating equal to or greater than that for the oven should be used.
- Do not use metal containers and metal-containing objects (e.g., stir bars) in the microwave. They can cause arcing.

- Do not heat sealed containers in the microwave oven. Even heating a container with a loosened cap or lid poses a significant risk since microwave ovens can heat material so quickly that the lid can seat upward against the threads and containers can explode.
- Remove screw caps from containers being microwaved. If the sterility of the contents must be preserved, use cotton or foam plugs. Otherwise plug the container with Kim wipes to reduce splash potential.

4.7.9 Ultrasonicators

Human exposure to ultrasound with frequencies between 16 and 100 kilohertz (kHz) can be divided into three distinct categories: airborne conduction, direct contact through a liquid coupling medium, and direct contact with a vibrating solid.

Ultrasound through airborne conduction does not appear to pose a significant health hazard to humans. However, exposure to the associated high volumes of audible sounds can produce a variety of effects, including fatigue, headaches, nausea and tinnitus. When ultrasonic equipment is operated in the laboratory, the apparatus must be enclosed in a 2-cm thick wooden box or in a box lined with acoustically absorbing foam or tiles to substantially reduce acoustic emissions (most of which are inaudible).

Direct contact of the body with liquids or solids subjected to high-intensity ultrasound of the sort used to promote chemical reactions should be avoided. Under mono-chemical conditions, cavitation is created in liquids, and it can induce high-energy chemistry in liquids and tissues. Cell death from membrane disruption can occur even at relatively low acoustic intensities.

Exposure to ultrasonically vibrating solids, such as an acoustic horn, can lead to rapid frictional heating and potentially severe burns.

4.7.10 Centrifuges

- Use only tubes designed for centrifuging.
- Carefully adjust all tubes to equal weight before loading them into the high-speed centrifuge. Have a balanced number of tubes; make up a blank with water if needed, and place them opposite each other in a symmetrical pattern so as to balance the centrifuge.
- Be sure that stoppers in the tube places in a pivot-head centrifuge will clear center (not hit each other) when the tubes swing into horizontal position.
- Keep centrifuge speeds (RPM) within the test specifications, the tube manufacturer's recommendations, or the centrifuge manufacturer's recommendations.
- Do not open the centrifuge until it stops completely.
- Turn electrical switch to "OFF" before removing tubes.
- Do not pick up any broken glass with bare hands.
- Explosion- proof centrifuges should be used when using flammable or explosive liquids. The centrifuge should be under negative pressure to a suitable exhaust system.

4.7.11 Rotary Evaporators

Glass components of the rotary evaporator should be made of Pyrex or similar type of glass. Glass vessels should be completely enclosed in a shield to guard against flying glass should the components implode. Increase in rotation speed and application of vacuum to the flask whose solvent is to be evaporated should be gradual.

4.7.12 Glassware

Although glass vessels are frequently used in low-vacuum operations, evacuated glass vessels may collapse violently, either spontaneously from strain or from an accidental blow. Therefore, pressure and vacuum operations in glass vessels should be conducted behind adequate shielding. It is advisable to check for flaws such as star cracks, scratches and etching marks each time a vacuum apparatus is used. Only round-bottomed or thick-walled (e.g., Pyrex) evacuated reaction vessels specifically designed for operations at reduced pressure should be used. Repaired glassware is subject to thermal shock and should be avoided. Thin-walled, Erlenmeyer or round-bottomed flasks larger than 1 L should never be evacuated.

4.7.13 Vacuums

Vacuum pumps are used in the lab to remove air and other vapors from a vessel or a manifold. The most common usages are on rotary evaporators, drying manifolds, centrifugal concentrators (“speed/vacs.”), acrylamide gel dryers, freeze dryers, vacuum ovens, tissue culture filter flasks and aspirators, desiccators, filtration apparatus and filter/degassing apparatus. The critical factors in vacuum pump selection are:

- Application of the pump will be used on.
- Nature of the sample (air, chemical, moisture).
- Size of the sample(s)

When using a vacuum pump on a rotary evaporator, a dry ice alcohol slurry cold trap or a refrigerated trap is recommended. A Cold Trap should be used in line with the pump when high vapor loads from drying samples will occur. Consult manufacturer for specific situations. These recommendations are based on keeping evaporating flask on rotary evaporator at 400 C. Operating at a higher temperature allows the Dry Vacuum System to strip boiling point solvents with acceptable evaporation rates.
Vacuum pumps can pump vapors from air, water to toxic and corrosive materials like Trifluoroacetic Acid (TFA) and methylene chloride. Oil seal pumps are susceptible to excessive amounts of solvent, corrosive acids and bases and excessive water vapors. Pump oil can be contaminated quite rapidly by solvent vapors and mists. Condensed solvents will thin the oil and diminish its lubricating properties, possibly seizing the pump motor. Corrosives can create sludge by breaking down the oil and cause overheating. Excess water can coagulate the oil and promote corrosion within the pump. Proper trapping (cold trap, acid trap) and routine oil changes greatly extend the life of an oil seal vacuum. Pump oil should be changed when it begins to turn a dark brown color.

Diaphragm pumps are virtually impervious to attack from laboratory chemical vapors. They are susceptible to physical wearing of the membrane if excessive chemical vapors are allowed to condense and crystallize in the pumping chambers. A five minute air purge either as part of the procedure or at day’s end will drive off condensed water vapors or further prolong pump life.
Hazardous chemicals can escape from the vacuum pump and the pump should be placed in the hood then cold traps and acid traps can be helpful,

4.7.14 Fume Hoods

Laboratory fume hoods are the most important components used to protect laboratory workers from exposure to hazardous chemicals and agents used in the laboratory. Functionally, a standard fume hood is a fire-and chemical-resistant enclosure with one opening (face) in the front, with a movable window (sash) to allow user access into the interior. Large volumes of air are drawn through the face and out the top to contain and remove contaminants from the laboratory.

Fume Hood safe practices are as follows:

- Recommended face velocity is 80 – 120 feet per minute.
- Keep fume hood exhaust fans on at all times.
- If possible, position the fume hood sash so that work is performed by extending the arms under or around the sash, placing the head in front of the sash, and keeping the glass between the worker and the chemical source. The worker views the procedure through the glass, which will act as a primary barrier if a spill, splash, or explosion should occur.
- Avoid opening and closing the fume hood sash rapidly, and avoid swift arm and body movements in front of or inside the hood. These actions may increase turbulence and reduce the effectiveness of fume hood containment.
- Place chemical sources and apparatus at least 6 inches behind the face of the hood. In some laboratories, a colored stripe is painted on, or tape applied to, the hood work surface 6 inches back from the face to serve as a reminder. Quantitative fume hood containment tests reveal that the concentration of contaminant in the breathing zone can be 300 times higher from a source located at the front of the hood face than from a source placed at least 6 inches back. This concentration declines further as the source is moved farther toward the back of the hood.
- Place equipment as far to the back of the hood as practical without blocking the bottom baffle.
- Separate and elevate each instrument by using blocks or racks so that air can flow easily around all apparatus.
- Do not use large pieces of equipment in a hood, because they tend to cause dead spaces in the airflow and reduce the efficiency of the hood.
- If a large piece of equipment emits fumes or heat outside a fume hood, then have a special-purpose hood designed and installed to ventilate that particular device. This method of ventilation is much more efficient than placing the equipment in a fume hood, and it will consume much less air.
- Do not modify fume hoods in any way that adversely affects the hood performance. This includes adding, removing, or changing any of the fume hood components, such as baffles, sashes, airfoils, liners, and exhaust connections.
- Test the airflow alarm prior to use the fume hood to ensure it is operating properly.
- Check the sash height. H & S affixes stickers to vertical-sash laboratory fume hoods to remind users not to work above the recommended sash height. Try to keep the sash closed unless you are setting up or actively using the fume hood. You can raise and lower a correctly operating sash smoothly and with minimal effort. If you have difficulty operating the sash, or you cannot lower it completely, contact H & S. Do not place equipment, cords, tubing, etc. so that you can lower the sash quickly and completely.

- Do not work with your head breaking the front panel of the fume hood. Sashes at the proper working height generally create a physical barrier between the operator's head and the inside of the fume hood. Working with your head in the fume hood means that the sash is too high.
- Use chemical storage cabinets for long term storage, not your fume hood. Items in a fume hood will impede and disturb the exhaust airflow and potentially reduce or eliminate the safety factor.
- Remove electrical units or other spark sources from the fume hood when flammable liquids or gases are present. Do not place power strips or surge protectors in the fume hood. Plug in all electrical equipment outside of the hood.
- The use of a laboratory fume hood does not sidestep the University guidelines on eye protection. Eye protection is required for all faculty, staff, students, and visitors in the laboratories during experimental procedures that could produce liquid or solid projectiles.
- Face velocity monitoring of fume hoods shall be the responsibility of the H & S.

4.8 Personal Protective Equipment

Provision for new or additional Personal Protective Equipment shall be the responsibility of each Department/ College.

4.8.1 Safety Glasses

- Do not use ordinary prescriptions as they no provide adequate protection from injury to the eyes.
- Use hardened-glass or plastic spectacles with sideway shields.
- Safety glasses use must comply with the Standard for the Occupational and Educational Eye and Face Protection (Z87.1).
- Wearing of contact lenses is allowable provided only if wearing additional eye protection.

4.8.2 Goggles

- Wear goggles when there is a hazard from splashing chemicals or flying particles, e. g. when using glassware under reduced or elevated pressure, or using glass apparatus in combustion or other high temperature operations.

4.8.3 Face Shields

- Wear face shield when there is a need for greater protection from flying particles and harmful liquids to protect face and neck.
- Consider using a face shield when operating a vacuum system (which may implode), or when conducting a reaction with potential for mild explosions.

4.8.4 Gloves

- Wear proper protective gloves for potential contact with corrosive or toxic material, materials of unknown toxicity, sharp edged object, and very hot or cold materials.
- Select gloves based on material handled, the particular hazard involved and their suitability for the operation conducted.
- Consider double gloving (the wearing of two gloves on each hand) when handling highly toxic or carcinogenic materials.
- Before each use, inspect gloves for discoloration, punctures and tears.
- Before removal, wash gloves if the material is impermeable to water.
- Do not reuse single-use disposable gloves.
- Store gloves properly.
- Dispose gloves if already old; shelf life is stamped on the box.
- Dispose gloves on regular trash if they are not contaminated with blood borne pathogens, radionuclides, highly toxic chemicals, or select carcinogens.
- Dispose contaminated gloves in the proper waste stream.
- Do not wear gloves outside the laboratory as this may contaminate surface if touch such as doorknobs, elevator buttons or rest fixtures.
- Wear sturdier gloves such as leather for handling broken glassware, inserting glass tube into rubber stoppers, and similar operations where there is no need protection from chemicals.
- Do not use gloves containing asbestos for high temperature operation, use synthetic material such as Kevlar.
- Do not wear woven gloves while working with cryogens as the liquid may work its way through the glove to the hand. Use glove specifically designed for work with cryogens.

4.8.5 Laboratory Clothing and Protective Apparel

- Wear laboratory coats or protective aprons at all times in the laboratory. Do not wear laboratory coats into food areas or outside of the building where the laboratory is located. If infectious organisms are involved, do not wear outside of the laboratory.
- Do not wear loose (e.g. saris, dangling neckties, oversized or ragged laboratory coats) in the laboratory. Loose or torn clothing and unrestrained long hair can easily catch fire, dip into chemicals, or became ensnared.
- Wear disposable laboratory coat for handling appreciable quantities of known carcinogenic materials.

4.8.6 Respiratory Protection

- Respiratory protection is necessary when working with highly toxic chemicals, biological hazards, or dust known to cause asthma or pulmonary fibrosis. However, respirators are a “last line” of defense, and should not be used until all engineering controls (e.g. ventilation) and work practice controls are exhausted.
- Respirators to be used shall comply with the Respiratory Protection Standard 29 CFR 1910.134.
- Do not use “comfort masks” or surgical masks.

4.9 Emergency Showers and Eyewash Fountains

- Each laboratory area must be equipped with at least one emergency shower and eyewash and shall be located at no more than 10 seconds or 100 feet (walking distance, not a straight line) from any location in the room.
- The shower and fountains must be kept clear of obstruction and clearly labeled by signage on the wall.
- Emergency shower water flow shall be at least 30 gallon-per-minute.
- Eyewash fountains should provide a copious and gentle flow of temperate aerated potable water at 0.4 gallon per minute for a period of 15 minutes (15 minutes of cold water is intolerable.
- Small, hand-held portable eyewash is discouraged since they cannot provide a supply of water sufficient to copiously flush two eyes for at least 15 minutes. Also, the small units provide an environment for the growth of microorganisms. If portable eyewash is use, maintain sterility of the contained water, and use eyewash fountains immediately.
- Some chemicals, even in small amounts, can irritate or damage skin upon contact, flush affected areas with water as soon as possible. Remove personal protective equipment and clothing in the areas of contact once you or your co-workers activated the shower. Fellow workers may need to help remove contaminated clothing. Contact the Medical Clinic (485 1660) immediately. Remain in the shower or continue flushing the eyes for no less than 15 minutes.
- Laboratory in-charge shall be responsible for ensuring that emergency eyewash facilities, both within its laboratory space and in nearby common areas, remain operational and accessible. Check at least a week. A quick (5 second) activation of the eyewash verifies water pressure, and flushes rust, scale, and other debris out of the system.
- H & S shall check the emergency shower and eyewash fountain every week.
- For shower and eyewash that lack floor drains, use buckets, secondary containment trays, or other collection devices to prevent discharge of water directly onto the floor during the test.

4.10 Laboratory Air Quality

- Ensure that the laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day.
- All air from chemical laboratories shall be exhausted outdoors and not re-circulated. Thus, the air pressure in chemical laboratories should be negative with respect to the rest of the building unless the laboratory is also a clean room.
- Laboratory air shall flow from low-hazard to high-hazard use area. Laboratories must be maintained at 47 L/s per module negative relative to non-laboratory spaces. When flow from one area to another is critical to emission and exposure control, airflow monitoring devices shall be installed to signal or alarm a malfunction.
- Relative volumes of supply air and exhaust air to each room should be such that air flows through the opening, including open doorways, at a minimum velocity of 50 fpm and a preferred velocity of 100 fpm in the desired direction.
- Air locks (i.e. vestibules with a door at each end arranged and provided with door-closing mechanisms so that both doors are not open at the same time). They may be used to minimize the volume of supply air required.
- Laboratories in which chemicals and compressed gases are used generally require non-recirculating or 100 % outside air supply systems.

- The release of chemicals into the laboratory shall be controlled by enclosure(s) or captured to prevent any flammable and/or combustible concentrations of vapors from reaching any source of ignition.
- The minimum air-change rate for laboratory space is six air changes per hour regardless of space cooling load.
- Use fume hood device when working with any appreciably volatile substance with a threshold limit value of less than 50 ppm.
- Automatic toxic multi gas monitoring devices shall be installed in new and existing laboratory facilities connected to a local audiovisual alarm within the laboratory area.
- Leave the fume hood “ON” when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate laboratory ventilation will be maintained when it is off.
- Maintain laboratory temperature between 68^{o}F to 75^{o}F and a humidity of 40% to 60%. Measuring equipment shall be installed to maintain the required temperature and humidity.
- Fume hoods in new laboratory facilities shall have a pressure-independent flow-monitoring device connected to a local audiovisual alarm within the laboratory area. For existing facilities the implementation of airflow devices for fume hoods occurs during the renovation phase.
- Air exhausted from the general laboratory space can be recirculated if the following criteria are met:
  - There are no extremely dangerous or life-threatening materials used in the laboratory.
  - The concentration of air contaminants generated by the maximum credible accident will be lower than short-term exposure limits.
  - The system serving the exhaust hoods is provided with installed spares, emergency power, and other reliability features as necessary.
  - Recirculated air is treated to reduce contaminant concentrations.
  - Recirculated air is monitored continuously for contaminant concentrations or provided with a secondary backup air cleaning device that also serves as a monitor (i.e. HEPA filter in a series with a less efficient filter, for particulate contamination only)
  - Air cleaning and monitoring equipment is maintained and calibrated under a preventive maintenance program.
  - A bypass to divert the recirculated air to atmosphere is provided.

4.11 Unattended Operations

An unattended operation is any unmonitored laboratory activity that has the potential to release water, gas, chemical substances, electrical energy, or chemical energy during foreseeable failures of equipment or utility services.

Frequently, laboratory operations must run continuously or overnight. Equipment and experiments that run unattended to during the day or overnight can cause significant problems and harm to personnel, facilities and equipment. If unattended operations are necessary, it is essential to plan for potential interruptions in utility services such as electricity, water and gas. Perform a hazard analysis to identify potential consequences of failures in utility services or equipment. Design operations to be “fail-safe”, so that one malfunction will not cause a propagation of additional failures.

If necessary, arrange for routine inspection of the operation. If appropriate, leave laboratory lights on during unattended operations, and place a sign on the entrance door. The sign will

convey critical information to personnel (such as other laboratory personnel, students, and maintenance, housekeepers, or incident / accident responders) who might encounter the unattended operations.

Report or advice of the Campus Facilities Department for the specific areas that need monitoring for the normal power supply to laboratory equipment would enable them to conduct frequent inspections during the unattended operations.

4.12 Laboratory Closeout Procedures

Whenever a Laboratory Supervisor (or a person under their charge performing work with hazardous materials in their laboratory) leaves the university or is transferred to a different location, proper disposition of hazardous materials, glassware, benches, laboratory equipment, fume hoods, etc. are required. Laboratory closeout is also required for renovations or constructions taking place in the laboratory. This undertaking shall be properly coordinated with the Campus Facilities Department prior to the start of laboratory close out.

If proper management of hazardous materials at close-out requires removal services from an outside contractor, the responsible department will be charged for this service.

5 Document Control

This Technical Guideline is a controlled document. The controlled version of this guideline is located on the QU Electronic Documentation Management System.

Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.

Refer to *QU HSMS Section 16.0 – Document Control and Record Retention*.

6 Appendices

Appendix A: List of Carcinogens

Appendix A: Reproductive Hazards

Appendix C: List of Highly Toxic Chemicals

Appendix A – List of Carcinogens

- **Acetaldehyde**
- **Acetamide**
- **Acetylaminoflu orene, 2-**
- **Acrylamide**
- **Acrylonitrile**
- **Adriamycin (doxorubicin hydrochloride)**
- **Aflatoxins**
- **Aflatoxin M1**
- **Alcoholic beverages (consumption)**
- **Alpha-Chlorinated toluenes**
- **Aluminum production**
- **Amino-2,4-dobromoanthraquinone, 1-**
- **Amino-2-methylanthraquinone, 1-**
- **Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole, 2-**
- **Amino-9H-pyridol[2,3-beta]indole), A-alpha-C(2-**
- **Aminoanthraquinone, 2-**
- **Aminoazobemzene, para-**
- **Aminoazotoluene, ortho-**
- **Aminobiphenyl, 4-**
- **Amitrole**
- **Amsacrine**
- **Analgesic mixture containing phenacetin**
- **Androgenic (anabolic) steroids**
- **Anisidine, ortho-**
- **Antimony trioxide**
- **Aramite**
- **Areca nut**
- **Aristolochia genus herbal remedies**
- **Arsenic and arsenic compounds**
- **Asbestos**
- **Attapulgate (palygorskite), long fibers › 5mm**
- **Auramine, technical-grade**
- **Azacitidine**
- **Azaserine**
- **Azathioprine**
- **Aziridine**
- **Benz(a)anthracene**
- **Benzene**
- **Benzidine**
- **Benzidine-based dyes(technical grade)**
- **Direct Black 38**
- **Direct Blue 6**
- **Direct Brown 95**
- **Benzo(a)pyrene**
- **Benzo(b)fluoranthene**
- **Benzo(j)fluoranthene**
- **Benzo(k)fluoranthene**
- **Benzofuran**
- **Benzotrichloride**
- **Benzyl violet 4B**

- **Beryllium and beryllium compounds**
- **Betel quid with tobacco**
- **Betel quid without tobacco**
- **Bis(2-chloroethyl)-2-napthylamine(Chlornaphazine),N,N-Bis(chloromethyl) ether**
- **Bis(bromomethyl)propane-1,3-diol,2,2-**
- **Bischloroethyl nitrosourea (BCNU)**
- **Bis(chloromethyl) ether**
- **Bitumens, extract of steam-refined and air-refined**
- **Bleomycins**
- **Bracken fern**
- **Bromodichloromethane**
- **Butadiene, 1,3-**
- **Butanediol dimethanesulphonate (myleran), 1,4-**
- **Butanediol dimethanesulfonate (myleran), 1,4-**
- **Butylated hydroxyanisole (BHA)**
- **Butyrolactone, beta-**
- **C.I. Basic Red 9 monohydrochloride**
- **Cadmium and certain cadmium compounds**
- **Caffeic acid**
- **Captafol**
- **Carbon black extract**
- **Carbon tetrachloride**
- **Carrageenan, degraded**
- **Catechol**
- **Ceramic fibers (respirable size)**
- **Chlorambucil**
- **Chloramphenicol**
- **Chlordane**
- **Chlordecone (kepone)**
- **Chlorendic acid**
- **Chloro-4-(dichloromethyl) 5-hydroxy-2(5H)-furanone, 3-**
- **Chloroaniline, para**
- **Chloroethyl-3-cyclohexyl-1-nitrosourea (CCNU), 1-(2-**
- **Chloromethyl-3-4-methylcyclohexyl-1-1nitrosourea, 1-(2-**

- **Chloronated paraffins (C12, 60% Chlorine)**
- **Chlorinated toluenes, alpha- (not necessarily all in froup)**
- **Chlomaphazine**
- **Chloro-2-methylpropene, 1-**
- **Chloro-2-methylpropene, 3-**
- **Chloro-o-phenylenediamine, 4-**
- **Chloro-ortho-toluidine, para-**
- **Chloroform**
- **Chloromethyl ether**
- **Chloromethyl methyl ether (technical grade)**
- **Chlrophenols and their sodium salts**
- **Chlorophenoxy herbicides**
- **Chloroprene**
- **Chlorothalonil**
- **Chlorozotoxin**
- **Chromium compounds, hexavalent**
- **Cl Acid red 114**
- **Cl Basic Red 9**
- **Cl Direct Blue 15**
- **Cisplatin**
- **Citrus Red No. 2**
- **Clonorchis sinensis (Oriental liver fluke)**
- **Coal tar pitches**
- **Coal tars**
- **Cobalt and cobalt compounds**
- **Cobalt metal with tungsten carbide**
- **Cobalt metal without tungsten carbide**
- **Cobalt (II) sulfate and other soluble cobalt (II) salts**
- **Coffee (bladder)**
- **Conjugated estrogens**
- **Creosotes**
- **Cresidue, para-**
- **Cupferron**
- **Cycasin**
- **Cyclophospamide**
- **Cyclosporin A**
- **Dacarbazine**
- **Danthron (1,8-dihydroxyanthraquinone)**
- **Daunomycin**
- **DDT**
- **Diacetylbenzidine, N,N'-**
- **Diaminoanisole, 2,4-**
- **Diaminoanisole sulfate, 2,4-**

- **Diaminodiphenyl ether, 4,4'-**
- **Diaaminotoluene, 2,4-**
- **Diazoaminobenzene**
- **Dibenz(a,h)acridine**
- **Dibenz(a,h)anthracene**
- **Dibenz(a,j)acridine**
- **Dibenzo(a,e)pyrene**
- **Dibenzo(a,h)pyrene**
- **Dibenzo(a,i)pyrene**
- **Dibenzo(a,l)pyrene**
- **Dibenzo(c,g)carbazole, 7H-**
- **Dibromo-3-chloropropane, 1,2-**
- **Dibromoethane (EDB), 1,2-**
- **Dibromopropan-1-ol, 2,3-**
- **Dichloroacetic acid**
- **Dichlorobenzene, para-**
- **Dichlorobenzene, 1,4-**
- **Dichlorobenzidine, 3,3'-**
- **Dichloroethane, 1,2-**
- **Dichloromethane (methylene chloride)**
- **Dichloropropene (technical grade), 1,3-**
- **Dichlorvos**
- **Diepoxybutane**
- **Diesel engine exhaust**
- **Diesel fuel (marine)**
- **Di-2-ethylhexyl) phthalate**
- **Diethyl sulphate**
- **Diethylhydrazine, 1,2-**
- **Diethylstilbestrol**
- **Diglycidyl resorcinol ether**
- **Dihydrosafrole**
- **Diisopropyl sulfate**
- **Dimethoxybenzidine, 3,3'-**
- **Dimethoxybenzidine (ortho-dianisidine), 3,3'-**
- **Dimethyl sulphate**
- **Dimethylaminoazobenzene, para-**
- **[(Dimethylamino) methylamino]-5-[2-(5nitro-2-, trans-2-**
- **Dimethylaniline, 2,6- (2,6-xylidene)**
- **Dimethylbenzidine, 3,3'-**
- **Dimethylbenzidine (ortho-toluidine), 3,3'**
- **Dimethylcarbamoyl chloride**
- **Dimethylhydrazine, 1,1-**

- Dimethylhydrazine, 1,2-
- Dimethylvinylchloride
- Dinitrofluoroanthrene, 3,7-
- Dinitrofluoroanthrene, 3,9-
- Dintropyrene, 1,6-
- Dinitropyrene, 1,8-
- Dinitrotoluene, 2,4-
- Dinitrotoluene, 2,6-
- Dioctyl Phthalate [Di(2-ethylhexyl)phthalate]
- Dioxane, 1,4-
- Direct Black 38
- Direct Blue 6
- Direct Brown 95
- Disperse Blue 1
- Epichlorohydrin
- Epoxybutane, 1,2-
- Epstein-Barr virus
- Erionite
- Estrogens (not conjugated): estradiol-17
- Estrogens (not conjugated): estrone
- Estrogens (not conjugated): mestranol
- Estrogens (not conjugated): ethinylestradiol
- Ethylbenzene
- Ethyl acrylate
- Ethyl methanesulphonate
- Ethyl-N-nitrosurea, N-
- Ethylene oxide
- Ethylene thiourea
- Ethylene dibromide
- Ethyleneimine
- Etoposide
- Etoposide in combination with cisplatin and bleomycin
- Formaldehyde
- Formylhydrazino-4-(5-nitro-2-furyl)thiazole, 2-(2-
- Fuel oils (residual, heavy)
- Furan
- Furyl-3-(5-nitro-2-furyl)acrylamide], AF-2[2-
- Fusarium moniliform (toxins derived from)
- Gallium arsenide
- Gamma radiation (ionizing radiation)
- Gasoline

- **Gasoline engine exhaust**
- **Glasswool (respirable size)**
- **Glu-P-1(2-amino-6-methyldipyridol[1,2-a:3',2'-d]imidazole)**
- **Glu-P-2(2-aminodipyridol[1,2-a:3',2'-d]imidazole)**
- **Glycidaldehyde**
- **Glycidol**
- **Griseofulvin**
- **HC Blue No 1**
- **Helicobacter pylori (infection with)**
- **Hepatitis B virus (chronic infection with)**
- **Hepatitis C virus (chronic infection with)**
- **Heptachlor**
- **Hexachlorobenzene**
- **Hexachlorocyclohexanes**
- **Hexachloroethane**
- **Hexamethylphosporamide**
- **Human immunodeficiency virus type 1 (infection with)**
- **Human immunodeficiency virus type 2 (infection with)**
- **Human papilloma virus type 16**
- **Human papilloma virus type 18**
- **Human papilloma virus type 31**
- **Human papilloma virus type 33**
- **Human papilloma virus: some types other than 16, 18, 31 and 33**
- **Human T-cell lymphotropic virus type I**
- **Hydrazine and hydrazine sulfate**
- **Hydrazobenzene**
- **Hydroxyanthroquinone, 1-**
- **Indenol(1,2,3-cd)pyrene**
- **Indium phosphide**
- **IQ (2-amino-3-methyllimidazo[4,5-f]quinoline**
- **Iron-dextran complex**
- **Isoprene**
- **Kaposi's sarcoma herpesvirus/ human herpesvirus 8**
- **Kepone (chlordecone)**

- Lasiocarpine
- Lead
- Lead acetate and lead phosphate
- Lead compounds, inorganic
- Lindane and other hexachlorocyclohexane isomers
- Magenta (containing CI Basic Red9)
- Man-made mineral fibers (glasswool, rockwool, slagwool, and ceramic fibers), respirable size
- MeA-alpha-C(2-amino-3-methyl-9H-pyridol[2,3-b]indole)
- MeIQx(2-amino-3,8-dimethylimidazol[4,5-f]-quinolone
- MeIQx(2-amino-3,8-dimethylamidazol[4,5-f] quinozaline
- Medroxyprogesterone acetate
- Melphalan
- Merphalam
- Methoxsalen with ultraviolet A therapy (PUVA)
- Methoxypsoralen, 8-plus ultraviolet radiation
- Methoxypsoralen, 5-
- Methyl mercury compounds (methylmercuric chloride)
- Methyl methanesulphonate
- Methyl chloromethyl ether
- Methyl-1-nitroanthraquinone (uncertain purity), 2-
- Methyl-N'-nitro-N-nitrosguanidine, N-(MNNG)
- Methyl-N-nitrosurethane, N-
- Methyl-N-nitrosurea, N-
- Methylaziridine (propyleneimine), 2-
- Methylazoxymethanol and its acetate
- Methyl chrysene, 5-
- Methylene bis(2-methylaniline), 4,4'-
- Methylenebis (N,N-dimethyl)bensenamine, 4,4'

- Methylenebis(2-chloroaniline) (MBOCA), 4,4'
- Methylene hloride (dichloromethane)
- Methylenedianiline, 4,4'- and its dihydrochloride
- Methyleugenol
- Methylthiouracil
- Metronidazole
- Michler's Ketone
- Mineral oils-untreated and mildly treated oils
- Mirex
- Mitoxantrone
- Mitomycin C
- Monocrotaline
- MOPP an dother combied chemotheraphy for cancer
- Morpholinnomethyl -3-[5-nirtofurfurylidene)amino]-2-oxazolidinone,5-
- Mustard gas (sulphur mustard)
- Nafenopin
- Naphthalene
- Naphthalamine, alpha-
- Naphthylamine, beta-
- Neutrons (ionizing radiation)
- Nickel and certain nickel compounds
- Niridazole
- Nitrilotriacetic acid and its salts
- Nitro-2-furyl)-2-thiazolyl]acetamide , N-[4-5-
- Nitroacenaphthene, 5-
- Nitroanisole, 2-
- Nitrobenzene
- Nitrobiphenyl, 4-
- Nitrochrysene, 6-
- Nitrofen
- Nitrofluorene, 2-
- Nitrofurfurylidene)amino]-2-imidazolidinone, 1-[(5-
- Nitro-2-furyl)-2-thiazolyl] acetamide, N-[4-(5-
- Nitrogen mustard N-oxide
- Nitrogen mustard hydrochloride
- Nitrogen mustard
- Nitrolotriacetic acid and its salts
- Nitromethane
- Nitropropane, 2-
- Nitropyrene, 1-
- Nitropyrene, 4-

- **Nitroso-N-ethylurea, N-**
- **Nitroso-N-methylurea, N-**
- **Nitrosodi-n-butylamine, N-**
- **Nitrosodi-n-propylamine, N-**
- **Nitrosodidiethanolamine, N-**
- **Nitrosodiethylamine, N-**
- **Nitrosodimethylamine, N-**
- **Nitrosomethylamino)propionitrile, 3-(N-**
- **Nitrosomethylamino)1-(3-pyridyl)-1-butanone (NNK),4-(N-**
- **Nitrosomethylethylamine, N-**
- **Nitrosomethylvinylamine, N-**
- **Nitrosomorpholine, N-**
- **Nitrosonomicotine, N- (NNN)**
- **Nitrospiperidine, N-**
- **Nitrosopyrrolidine, N-**
- **Nitrososarcosine, N-**
- **Norethisterone**
- **Ocratoxin A**
- **Oil Orange SS**
- **Opisthoschis viverrini (infection with)**
- **Oxazepam**
- **Oxydianiline, 4,4'-**
- **Oxymetholone**
- **Panfuran S (containing dihydroxymethylfuratrizine)**
- **Phenacetin**
- **Phenazopyridine hydrochloride**
- **Phenobarbital**
- **Phenolphthalein**
- **Phenoxybenzamine hydrochloride**
- **Phenyl glycidyl ether**
- **Phenytoin**
- **PhIP (2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine)**
- **Phosphorus-32 (32P), as phosphate**
- **Plutonium-239(239P) and its decay products, as aerosols**
- **Polybrominated biphenyls (PBBs)**
- **Polychlorinated Biphenyls (PCbs)**

- **Polycyclic aromatic hydrocarbons (PAHs)**
- **Ponceau MX**
- **Ponceau 3R**
- **Potassium bromated**
- **Procarbazine hydrochloride**
- **Progesterone**
- **Progestines**
- **Propane sultone-propiolactone, 1,3-**
- **Propane sultone, 1,3-**
- **Propiolactone, beta-**
- **Propylene oxide**
- **Propylthiouracil**
- **Radionuclides, ∞ and β particle emitting, internally deposited**
- **Radium-224 (224Ra) and its decay products**
- **Radium-226 (226Ra) and its decays products**
- **Radium-228 (228Ra) and its decay products**
- **Radon-222 (222Rn) and its decay products**
- **Refractory ceramic products**
- **Reserpine**
- **Riddelliine**
- **Safrole**
- **Schistosoma haematobium (infection with)**
- **Schistosoma japonicium (infection with)**
- **Selenium sulfide**
- **Shale oils**
- **Silica (crystalline)**
- **Sodium ortho-phenylphenate**
- **Sterigmatocystin**
- **Streptozotocin**
- **Styrene**
- **Styrene oxide (styrene-7,8-oxide)**
- **Sulfallate**
- **Sulphuric acid (occupational exposures to strong inorganic acid mists)**
- **Talc containing asbestiform fibers**
- **Tamoxifen**
- **Tenopiside**
- **Tetrachlorodibenzo -p-dioxin (TCDD), 2,3,7,8-**
- **Tetrachloroethylen e (perchloroethylene)**
- **Tetrafluoroethylene**
- **Tetranitromethane**

- **Thioacetamide**
- **Thiodianiline, 4,4'-**
- **Thiotepa[tris(1-aziridinyl)phosphine sulfide]**
- **Thiouracil**
- **Thiourea**
- **Thorium dioxide**
- **Thorium-232 (232Th) and its decay products**
- **Toluene diisocyanates**
- **Toluidine, ortho- (3,3-Dimethylbenzidine)**
- **Toluidine hydrochloride, ortho-**
- **Toxaphene (polychlorinated camphenes)**
- **Trans-2[(Dimethylamino) methylimino]-5[2-(5-nitro-2-furyl)vinyl]-Treosulphan**
- **Treosulphan**
- **Trichloroethylene**
- **Trichlormethine (trimustine hydrochloride)**
- **Trichlorophenol, 2,4,6-**
- **Trichloropropane, 1,2,3-**
- **Tris(2,3-dibromopropyl)phosphate**
- **Trp-P-1(3-Amino-1,4-dimethyl-5H-pyrido[4,3-b]indole)**
- **Trp-P-2(Amino-1-methyl-5H-pyrido[4,4-b]indole)**
- **Trypan blue**
- **Uracil mustard**
- **Urethane**
- **Vanadium pentoxide**
- **Vinyl acetate**
- **Vinyl bromide**
- **Vinyl chloride**
- **Vinyl fluoride**
- **Vinylcyclohexene diepoxide, 4-**
- **Zalcitabine**
- **Zidovudine (AZT, retrovir)**

Appendix B – Reproductive Hazards

This list is provided as a guide and is not all inclusive. Review material safety data sheet.

Name	CAS#	Name	CAS#
Acetaldehyde	75-07-0	Hydrazine(s)	302-01-2
Arsenic	7440-38-2	Hexafluoroacetone	684-16-2
Aniline	62-53-3	Halothane	151-67-7
Aflatoxins	1402-68-2	Karathane	131-72-6
Benzene	71-43-2	Lead (inorganic compounds)	7439-92-1
Benzo(a)pyrene	50-32-8	2-Methoxyethanol	109-86-4
Carbon disulfide	75-15-0	2-Methoxyethyl acetate	110-49-6
Chloroform	67-66-3	Methyl chloride	74-87-3
Chloroprene	126-99-8	N-Methyl-2-pyrrolidone	872-50-4
Dimethyl formamide	68-12-2	Propylene glycol monomethyl ether	107-98-2
Di-sec-octyl-phthalate	117-81-7	Propylene glycol monomethyl ether acetate	108-65-6
Dinitrooctyl phenol	63149-81-5	Propylene oxide	75-56-9
Dithane	111-54-6	Trichloroethylene	79-01-6
2-Ethoxy ethanol	110-80-5	RH-7592	
2-Ethoxyethyl acetate	111-15-9v	Systhane/RH-3866	88671-89-0
Ethylene thiourea	96-45-7	TOK (herbicide)	1836-75-5
2-Ethyhexanol	104-76-7	Toluene	108-88-3
Glycol ethers		Vinyl chloride	75-01-4

Appendix C – List of Highly Toxic Chemicals

Chemical Name	Alternate Name	CAS Number
Abrin	Toxalbumin; Rosary Pea	1393-62-0
Acrolein	2-Propen-1-one	107-02-8
Acrylonitrile	2-Propenenitrile; Cyanoethylene	107-12-1
Actinomycin	Actinomycin C; Oncostatin	1402-38-6
Actinomycin D	Oncostatin K	50-76-0
Activated Factor X	Factor C Activating Enzyme from Russells's Viper Venom	9002-05-5
Aflatoxin B1		1402-68-2
Aldicarb	Propanal, 2-methyl-2-(methylthio)-, O-((methylamino)oxime	116-06-2
Aldrin		309-00-2
Allyl iodide	Iodopropene, 3-	556-56-9
Amanitine, alpha-	Amatoxin, alpha-	23109-05-9
Aminopterin	Aminofolic Acid, 4-	54-62-6
Aminopyridine, 3-	Aminopyridine, m-	462-08-8
Aminopyridine, 4-	Aminopyridine, p-	504-24-5
Amiton		78-53-5
Amiton Oxalate	Tetram Monooxalate	3734-97-2
Amphetamine Sulfate, d-	Benzedrine Sulfate, d-	51-63-8
Amphetamine, d-	Amphetamine,(+)-	51-64-9
Antimony Hydride	Stibine	7803-52-3
Antimycin A	Virosin	1397-94-0
Arsenic Acid	Orthoarsenic Acid	7778-39-4
Arsenic (III) Chloride	Arsenic Trichloride	7784-34-1
Arsenic (III) Fluoride	Arsenic Trifluoride	7784-35-2
Arsenic (III) Oxide	Arsenic Trioxide; Arsenious Oxide	1327-53-3
Arsenic (III) Sulfide	Arsenic Trisulfide	1303-33-9
Arsenic (V) Oxide	Arsenic Pentoxide	1303-28-2
Arsenic (V) Sulfide	Arsenic Pentasulfide	1303-34-0

Chemical Name	Alternate Name	CAS Number
Arsine	Hydrogen Arsenide	7784-42-1
Azinphos-Methyl	Guthion	86-50-0
Beryllium (powdered)		7440-41-7
Beryllium Sulfate Tetrahydrate	Sulfuric acid, beryllium salt (1:1), tetrahydrate	7787-56-6
Bidrin	Dipadrin; Dicrotphos	141-66-2
Bis(2-chloroethyl)-N-nitrosourea, N,N'-	BCNU; Carmustin	154-93-8
Bis(chloromethyl) Ether	BCME	542-88-1
Bis(dimethylamido) fluorophosphates	Dimefox	115-26-4
Boron Trobromide	Boron Bromide	10294-33-4
Boron Trichloride	Boron Chloride	10294-34-5
Boron Trifluoride	Boron Fluoride	7637-07-2
BotulinumToxin B	Botulinum Toxin E	93384-44-2
Bromadiolone	Bromatrol	28772-56-7
Butyronitrile	Cyanopropane, 1-	109-74-0
Calcium Arsenate	Arsenic Acid, Calcium Salt (2:3)	7778-44-1
Calcium Cyanide	Calcid; Cyanogas	592-01-8
Capsaicin	6-Nonenamide, 8-methyl-N-vanillyl-, (E)	404-86-4
Carbachol Chloride	Doryl	51-83-2
Carbofuran	Yaltox	1563-66-2
Carbonyl Cyanide m-Chlorophenylhydrazone	Carbonyl Cyanide 3-Chlorophenyl Hydrazone	555-60-2
Carbophenothion	Acarithion	786-19-6
Chlorfenvinphos	Apachlor	470-90-6
Chlormephos	S-Chloromethyl-o,o-diethylphosphorodithioate	24934-91-6
Chlorophacinone		3691-35-8
Chlorthiophos		21923-23-9
Cholecalciferol	Quintox	67-97-0
Cholera Toxin		9012-63-9
Cisplatin		15663-27-1

Chemical Name	Alternate Name	CAS Number
Colchicine		64-86-8
Copper Acetoarsenite	C.I. Green 21	12002-03-8
Coumaphos		56-72-4
Crimidine	Crimitox	535-89-7
Cyanide		57-12-5
Cyanogen Chloride	Chlorine Cyanide	506-77-4
Cyanuric Fluoride	Trifluorotriazine	675-14-9
Cycloheximide	Actidione	66-81-9
Cytochalasin D	Zygosporin A	22144-77-0
Demecolcine	Colcemid	477-30-5
Dialifor		10311-84-9
Diborane	Boroethane	19287-45-7
Dibutyltin Diacetate		1067-33-0
Dichloroacetylene		7572-29-4
Dichloro-N-methyldiethylamine Hydrochloride, 2,2'-	Nitrogen Mustard Hydrochloride	55-86-7
Dichlorophenylarsine	Phenyl Dichloroarsine	696-28-6
Dichlorvos	DDVP	62-73-7
Dieldrin		60-57-1
Diethyl 4-Nitrophenol Phosphate	Ethyl Paraoxon	311-45-5
Diethyl Chlorophosphate		814-49-3
Digitoxin		71-63-6
Digoxigenim		1672-46-4
Digoxin		20830-75-5
Diisopropyl Fluorophosphate	Isopropyl Phosphorofluoridate	55-91-4
Dimethyl Sulfate	Methyl Sulfate	77-78-1
Dimethylmercury	Methyl Mercury	593-74-8
Dimetilan		644-64-4
Dinitrobutylphenol	DNBP; 2-sec-buty-4,6-Dinitrophenol	88-85-7

Chemical Name	Alternate Name	CAS Number
Dinitro-o-Cresol, 4,6-		534-52-1
Dinitrophenol, 2,4-	Aldifen; DNP,24-	51-28-5
Dioxathion		78-34-2
Disulfoton		298-04-4
Di-tert-butyl Dicarbonate	BOC-Anhydride	24424-99-5
Dithiobiuret, 2,4-	DTB	541-53-7
Doxorubicin (Free Base)	Adriamycin (Free Base)	23214-92-8
Emetine Dihydrochloride		316-42-7
Endosulfan Sulfate		1031-07-8
Endothion		2778-04-3
Endrin	Hexadrin	72-20-8
Ergocalciferol	Vitamin D2	50-14-6
Ergosterol	Provitamin D2	57-87-4
ERL 4221	Chissonox 221 monomer	2386-87-0
Ethion		563-12-2
Ethoprosphos	Ethoprop	13194-48-4
Ethylene Fluorohydrin	Fluoroethanol, 2-	371-62-0
Ethyleneimine	Aziridine	151-56-4
Ethylmercuric Phosphate		2235-25-8
Ethyl-p-nitrophenylbenzenethiophosphate	EPN	2104-64-5
Etorphine	Immobilon	14521-96-1
Fenamiphos		22224-92-6
Fensulfothion	Dasanit	115-90-2
Fluenetil		4301-50-2
Fluoride ion		16984-48-8
Fluorine		7782-41-4
Fluoroacetamide		640-19-7
Fluoroacetic Acid		144-49-0

Chemical Name	Alternate Name	CAS Number
Fonofos		944-22-9
Formaldehyde (gas)	Methyl Aldehyde	50-00-0
Formaldehyde Cyanohydrin	Glycolonitrile	107-16-4
Formetanate Hydrochloride		23422-53-9
Formparanate		17702-57-7
Gitoxin		4562-36-1
Heptachlor		76-44-8
Heptachlor Epoxide		1024-57-3
Hexaethyl Tetraphosphate		757-58-4
Hydrazine		302-01-2
Hydrogen Cyanide	Hydrocyanic Acid	74-90-8
Hydrogen Selenide	Selenium Hydride	7783-07-5
Hygromycin B	Antihelmucin	31282-04-9
Iron Pentacarbonyl		13463-40-6
Isobenzan	Telodrin	297-78-9
Isobutyronitrile	Isopropyl Cyanide	78-82-0
Isocyanatoethyl Methacrylate, 2-		30674-80-7
Isodrin		465-73-6
Lactonitrile		78-97-7
Lannate	Methomyl	16752-77-5
Lepthophos		21609-90-5
Lewesite		541-25-3
Malonitrile	Malononitrile	109-77-3
Mephosfolan		950-10-7
Mercaptofos	Demeton	8065-48-3
Mercury (II) Acetate	Mercuric Acetate	1600-27-7
Mercury (II) Bromide	Mercuric Bromide	7789-47-1
Mercury (II) Chloride	Mercuric Chloride	7487-94-7
Mercury (II) Cyanide	Mercuric Cyanide	592-04-1

Chemical Name	Alternate Name	CAS Number
Mercury (II) Iodide	Mercuric Iodide	7774-29-0
Mercury (II) Nitrate	Mercuric Nitrate	10045-94-0
Mercury (II) Oxide	Mercuric Oxide	21908-52-2
Mercury (II) Thiocyanate	Mercuric Sulfocyanate	592-85-8
Methacrolein Diacetate		10476-95-6
Methamidophos		10265-92-6
Methanesulfonyl Fluoride	Mesyl Fluoride; Fumette	558-25-8
Methidathion	Supracide	950-37-8
Methiocarb	Mecaptodimethur	2032-65-7
Methoxyethylmercuric Acetate		151-38-2
Methoxyethylmercuric Chloride		123-88-6
Methoxyflurane	Metofane; Penthrane	76-38-0
Methyl Chloroformate	Methyl Chlorocarbonate	79-22-1
Methyl Fluoroacetate	Fluoroacetic Aci, Methyl Ester	453-18-9
Methyl Isocyanate		624-83-9
Methyl Lactonitrile, 2-	Acetone Cyanohydrin	75-86-5
Methyl Phosphonic Dichloride		676-97-1
Methylaziridine, 2-	Propyleneimine	75-55-8
Methylhydrazine		60-34-4
Mevinphos	Phosdrin	7786-34-7
Mexacarbate		315-18-4
Mitomycin C	Ametycin	50-07-7
Monensin Sodium	Coban	22373-78-0
Monochrotophos		6923-22-4
Muscimol	Pantherin;Aminomethyl-3-isoxyzole, 5-	2763-96-4
Mustard Gas	Bis(2-Chloroethyl)sulfide	505-60-2
Naphthylthiourea, alpha	ANTU	86-88-4
Nickel Carbonyl	Nickel Tetracarbonyl	13463-39-3
Nickel Cyanide	Dicyanonickel	557-19-7

Chemical Name	Alternate Name	CAS Number
Nicotine		54-11-5
Nicotine Sulfate		65-30-5
Nitric Acid (Red Fuming)		7697-37-2
Nitric Oxide	Nitrogen Monoxide	10102-43-9
Nitrobenzonitrile, p-		619-72-7
Nitrogen Dioxide		10102-44-0
Nitrogen Mustard	Dichloro-N-methyldiethylamine, 2, 2'-	51-75-2
Nitrogen Tetroxide		10544-72-6
Nitrosodimethylamine, N-	Dimethylnitrosamine	62-75-9
Nitrosomethylvinylamine, N-		4549-40-0
Norbormide		991-42-4
Ochratoxin A		303-47-9
Octamethyldiphosphoramide	Octamethylpyrophosphoramide	152-16-9
Osmium Tetroxide		20816-12-0
Ouabain	Acocantherin	630-60-4
Oxamyl		23135-22-0
Oxidiphenoxarsine, 10, 10'-	Vinadine	58-36-6
Oxotremorine		70-22-4
Oxygen Difluoride	Fluorine Oxide; Oxygen Fluoride	7783-41-7
Parathion	Phosphostigmine	56-38-2
Parathion-Methyl	Methyl Parathione; Metaphor	298-00-0
Pentaborane(9)	Nonahydropentaborane	19624-22-7
Pentachlorophenol		87-86-5
Phalloidin	Phalloidon from Amanita Phalloides	17466-45-4
Phenyl Mercaptan	Thiophenol; Benzenethiol	108-98-5
Phenylmercuric Acetate	Phenylmercury Acetate	62-38-4
Phenylmercuric Triethanolamine Lactate		23319-66-6
Phenylphosphine		638-21-1

Chemical Name	Alternate Name	CAS Number
Phenylsilatrane		2097-19-0
Phenylthiocarbamide	Phenyl-2-Thiourea, 1-	103085-5
Phorate		298-02-2
Phosacetim		4104-14-7
Phosfolan		947-02-4
Phosgene	Carbonyl Chloride	75-44-5
Phosphamidon		13171-21-6
Phospine	Hydrogen Phosphide	7803-51-2
Phosphonothioic Acid, Methyl-, o-(4-nitrophenyl)o-phenyl Ester	Colep	2665-30-7
Phosphorous Oxychloride	Phosphoryl Chloride	10025-87-3
Phosphorus Trichloride	Phosphorous Chloride	7719-12-2
Phosphorus, Yellow	Phosphorus White	7723-14-0
Physostigmine	Eserine	57-47-6
Physostigmine Salicylate	Eserine Salicylate	57-64-7
Physostigmine Sulfate	Eserine Sulfate	64-47-1
Picrotoxin	Cocculin	124-87-8
Potassium Arsenite	Arsenenous Acid, Potassium Salt	10124-50-2
Potassium Azide		20762-60-1
Potassium Cyanide		151-50-8
Potassium Silver Cyanide	Silver Potassium Cyanide	506-61-6
Promecarb		2631-37-0
Propanenitrile	Propionitrile; Ethyl Cyanide	107-12-0
Propargyl Alcohol		107-19-7
Propiolactone, beta-	Propiolactone, 1,3-	57-57-8
Puromycin	Achromycin	53-79-2
Ricin		9009-86-3
Sarin	Isopropyl methane flurophosphonate	107-44-8
Selenium Dioxide	Selenium (IV) Dioxide	7446-08-4

Chemical Name	Alternate Name	CAS Number
Sodium Arsenate	Arsenic Acid, Sodium Salt	7631-89-2
Sodium Azide		26628-22-8
Sodium Cyanide		143-33-9
Sodium Dichromate		10588-01-9
Sodium Fluoroacetate	Fluoroacetic Acid, Sodium Salt	62-74-8
Sodium Meta Arsenite		7784-46-5
Sodium Selenate	Selenic Acid, Disodium Salt	13410-01-0
Sodium Selenite	Selenious Acid, Disodium Salt	10102-18-8
Streptonigrin	Bruneomycin	3930-19-6
Strychnine		57-24-9
Strychnine Sulfate	Vampirol	60-41-3
Sulfur Pentafluoride	Sulfur Decafluoride	5714-22-7
Sulfur Tetrafluoride		7783-60-0
Tabun		77-81-6
Tellurium Hexafluoride		7783-80-4
Tetrachlorodibenzo-p-Dioxin, 2,3,7,8-	TCDD, 2,3,7,8-; Dioxine	1746-01-6
Tetraehyl Dithiopyrophosphate	Sulfotep;TEDP	3689-24-5
Tetraethyl Lead	Tetraethyl Plumbane	78-00-2
Tetraethyl Pyrophosphate	Vapatone	107-49-3
Tetraethyltin	Tetraethyl Stannate	597-64-8
Tetrodotoxin	Tetrodotoxin Citrate	4368-28-9
Thallium Malonate	Thallous Malonate	2757-18-8
Thallium Sulfate		10031-59-1
Thallium (I) Acetate	Thallous Acetate	563-68-8
Thallium (I) Carbonate	Thallous Carbonate	6533-73-9
Thallium (I) Chloride	Thallous Chloride	7791-12-0
Thallium (I) Nitrate	Thallous Nitrate	10102-45-1
Thallium (I) Sulfate	Thallous Sulfate	7446-18-6

Chemical Name	Alternate Name	CAS Number
Thallium (III) Oxide	Thallic Oxide	1314-32-5
Thiocarbazide	Thiocarbohydrazide –TCH	2231-57-4
Thiodan	Endosulfan	115-29-7
Thiofanox	Dacamox	39196-18-4
Thionazin		39196-18-4
Thiosemicarbazide	Thiocarbamylhydrazine	79-19-6
Tirpate	2,4-Dimethyl-1,3-dithiolane-2-carboxaldehyde, O-(methylcarbamoyl)oxime	26419-73-8
Toluene Diisocyanate	Methyl-m-phenylene Diisocyanate	26471-62-5
Toluene-2,4-Diisocyanate		584-84-9
Toxaphene	Camphechlor	8001-35-2
Triamiphos		1031-46-6
Tricarbonylmethylcyclopentadienyl Manganese		12108-13-3
Trichloronate	Agrisil; Phytosol	327-98-0
Trimethylpropane Phosphite		824-11-3
Trimethyltin Chloride	Chlorotrimethylstannate	1066-45-1
Triphenyltin Hydroxide		76-87-9
Tris(1-aziridinyl)phosphine Sulfide	Thiotepa	52-24-4
Tris(2-chloroethyl)amine		555-77-1
Tubocurarine	Tubocurarine Hydrochloride	57-94-3
Tungsten Hexafluoride	Tungsten(IV) Fluoride	7783-82-6
Uracil Mustard	5-(Bis-(2-chloroethyl)-amino)-uracil	66-75-1
Valinomycin, (+)-	Valinomicin	2001-95-8
Vanadium(V) Oxide	Vanadium Pentoxide	1314-62-1
Warfarin		81-81-2
Warfarin Sodium	Sodium Coumadin	129-06-6
Yohimbine Hydrochloride		65-19-0
Zinc Phosphite		1314-84-7
Zinc Silicofluoride		16871-71-9

Health & Safety Technical Guidelines

TG - 02

Biological Safety

Produced by

Health & Safety – Facilities & GS Department

Table of Contents

Appendices

Appendix A – Toxins Table

1 Purpose

1.1.1 The purpose of this document is to protect the health and well-being of all Qatar University (**QU**) staff, students, and visitors, and to prevent damage to property, equipment, facilities, and the environment associated with the usage of biohazardous agents as part of the university's activities.

1.1.2 This document provides guidelines on the application of the requirements and principles of the QU Health & Safety Management System (**HSMS**) to activities associated with these QU workplaces.

2 Scope

2.1.1 This HS Technical Guideline applies to all operations and activities associated with QU activities where biohazardous agents are involved, to enable the effective management of HS risks within these workplaces.

2.1.2 Biohazardous agents are infectious microorganisms, or their toxins, which cause or may cause human disease. Although the OSHA "Occupational Exposures to Hazardous Chemicals in Laboratories" (referred to as the "Laboratory Standard") does not apply to biological agents, the University shall apply the same basic requirements responsibilities, training, laboratory safety plan, reporting of accidents/exposures, etc.

3 Responsibilities

3.1 Top Management

3.1.1 QU top management shall allocate sufficient resources for the effective implementation of the HSMS, including the application of this HS Technical Guideline, and ensure that QU employees, students, contractors and visitors are aware of their responsibilities through appropriate regulation, delegation and communication.

3.1.2 The QU Top Management is also accountable for monitoring and reporting HS performance and appropriate programs and actions to ensure compliance with the QU HS Policy.

3.2 Other Accountabilities

3.2.1 The QU HSS and the HS Committee are accountable to the QU Top Management for the implementation of this HS Technical Guideline.

3.2.2 (VPs), , Deans, Directors, Managers, Head Sections are accountable to the QU Top Management for the application of this HS Technical Guideline in areas under their supervision.

3.2.3 All QU staff are responsible for performing their duties by complying with the requirements of this HS Technical Guideline as it applies to their activities and workplaces, observing and obeying safety postings and rules, and promptly reporting all incidents and accidents to their supervisors.

4 Guidelines

4.1 Principles of Biological Safety

The term “containment” is used in describing safe methods for managing infectious agents in the laboratory environment where they are being handled or maintained. The purpose of containment is to reduce or eliminate exposure of laboratory workers, other persons, and the outside environment to potentially hazardous agents.

Both good microbiological technique and the use of appropriate safety equipment provide primary containment, the protection of personnel and the immediate laboratory environment from exposure to infectious agents. The use of vaccines may provide an increased level of personal protection. Secondary containment is the protection of the environment external to the laboratory from exposure to infectious materials, through a combination of facility design and operational practices. Therefore, the three elements of containment include laboratory practice, technique, safety equipment, and facility design. The risk assessment of the work to be done with a specific agent will determine the appropriate combination of these elements.

4.1.1 Laboratory Practice and Technique

The most important element of containment is strict adherence to standard microbiological practices and techniques. Persons working with infectious agents or potentially infectious materials must be aware of potential hazards, and must be trained and proficient in the practices and techniques required for handling such material safely.

Each laboratory shall adopt this laboratory biosafety policy to identify the hazard that will or may be encountered, and which specifies practices and procedures designed to minimize or eliminate risks. Personnel should be advised of special hazards and should be required to read and to follow the required practices and procedures. A person trained and knowledgeable in appropriate laboratory techniques, safety procedures, and hazards associated with handling infectious agents must direct the laboratory activities.

When standard laboratory practices are not sufficient to control the hazard associated with a particular agent or laboratory procedure, additional measures may be needed. The laboratory in-charge and HS are responsible for selecting additional safety practices, which must be in keeping with the hazard associated with the agent or procedure.

Laboratory personnel, safety practices, and techniques must be supplemented by appropriate facility design and engineering features, safety equipment, and management practices.

4.1.2 Safety Equipment (Primary Barrier)

Safety equipment includes biological safety cabinets (BSCs), enclosed containers, and other engineering controls designed to remove or minimize exposures to hazardous biological materials. The biological safety cabinet (BSC) is the principal device used to provide containment of the infectious splashes or aerosols generated by many microbiological procedures. Open-fronted Class I and Class II biological safety cabinets are primary barriers which provide significant levels of protection to laboratory personnel and to the environment when used with good microbiological techniques. The Class II biological safety cabinet also provides protection from external contamination of the materials (e.g., cell cultures, microbiological stocks) being manipulated inside the cabinet. The gas-tight Class III biological safety cabinet provides the highest attainable level of protection to personnel and the environment.

An example of another primary barrier is the safety centrifuge cup; an enclosed container designed to prevent aerosols from being released during centrifugation. To minimize this

hazard, containment controls such as BSCs or centrifuge cups must be used for handling infectious agents that can be transmitted through the aerosol route of exposure.

Safety equipment also may include items for personal protection such as gloves, coats, gowns, shoe covers, boots, respirators, face shields, safety glasses, or goggles. Personal protective equipment is often used in combination with the biological safety cabinets and other devices that contain the agents, animals, or materials being worked with. In some situations in which it is impractical to work in biological safety cabinets, personal protective equipment may form the primary barrier between the personnel and the infectious materials. Examples include certain animal studies, animal necropsy, agent production activities, and activities relating to maintenance, service, or support of the laboratory facility.

4.1.3 Facility Design (Secondary Barrier)

The design of facility is important in providing a barrier to protect persons working inside and outside the laboratory within the facility, and to protect persons or animals in the community from infectious agents that may be accidentally released from the laboratory. The Laboratory supervisor in-charge in cooperation with the HS shall be responsible for providing the facilities commensurate with the laboratory's function and the recommended biosafety level for the agents being manipulated.

The recommended secondary barrier(s) will depend on the risk of transmission of specific agents. For example, the exposure risks for most laboratory work in Biosafety Level 1 and 2 facilities will be in direct contact with the agents, or inadvertent contact exposures through contaminated work environments. Secondary barriers in these laboratories may include separation of the laboratory work area from public access, availability of a decontamination facility (e.g., autoclave), and hand washing facilities.

As the risk for aerosol transmission increases, higher levels of primary containment and multiple secondary barriers may be necessary to prevent infectious agents from escaping into the environment. Such design features could include specialized ventilation systems to assure directional air flow, air treatment systems to decontaminate or remove agents from exhaust air, controlled access zones, airlocks such as laboratory entrances, or separate buildings or modules for isolation of the laboratory.

4.2 Biological Safety Levels (BSLs)

4.2.1 Biosafety Level 1 (BSL-1)

Biosafety Level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to laboratory personnel and the environment. The laboratory is not necessarily separated from the general traffic patterns in the building. Work is generally conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is neither required nor generally used. Laboratory personnel have specific training in the procedures conducted in the laboratory and are supervised by a scientist with general training in microbiology or a related science.

The following standard and special practices, safety equipment and facilities apply to agents assigned to **Biosafety Level 1**:

4.2.1.1 Standard Microbiological Practices

- Access to the laboratory is limited or restricted at the discretion of the laboratory in-charge when experiments or work with cultures and specimens are in progress.
- Persons wash their hands after they handle viable materials, after removing gloves, and before leaving the laboratory.
- Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human use are not permitted in the work areas. Persons who wear contact lenses in laboratories should also wear goggles or face shields. Food is stored outside the work area in cabinets or refrigerators designated and used for this purpose only.
- Mouth pipetting is prohibited; yet, mechanical pipetting devices are used.
- Policies for the safe handling of sharps are instituted.
- All procedures are performed carefully to minimize the creation of splashes or aerosols.
- Work surfaces are decontaminated at least once a day and after any spill of viable material.
- All cultures, stocks, and other regulated wastes are decontaminated before disposal by an approved decontamination method such as autoclaving.
- A biohazard sign shall be posted at the entrance to the laboratory whenever infectious agents are present.

4.2.1.2 Safety Equipment (Primary Barriers)

- Special containment devices or equipment such as biological safety cabinet are generally not required for manipulations of agents assigned to Biosafety Level 1.
- It is recommended that laboratory coats, gowns, or uniforms be worn to prevent contamination or soiling of street clothes.
- Gloves should be worn if the skin on the hands is broken or if a rash is present.
- Alternatives to powdered latex gloves should be available.
- Protective eyewear should be worn for conduct of procedures in which splashes of microorganisms or other hazardous materials is anticipated.

4.2.1.3 Laboratory Facilities (Secondary Barriers)

- Laboratories should have doors for access control.
- Each laboratory contains a sink for hand washing.
- The laboratory is designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.
- Bench tops are water resistant and are resistant to moderate heat and the organic solvents, acids, alkalis, and chemicals used to decontaminate the work surface and equipment.
- Laboratory furniture shall be capable of supporting anticipated loading and uses. Spaces between benches, cabinets, and equipment are accessible for cleaning.

4.2.2 Biosafety Level 2 (BSL-2)

Biosafety Level 2 is similar to Biosafety Level 1 and is suitable for work involving agents of moderate potential hazard to personnel and the environment. It differs from BSL-1 in that: (1) laboratory personnel have specific training in handling pathogenic agents and are directed by competent scientists. (2) Access to the laboratory is limited when work is being conducted; (3) extreme precautions are taken with contaminated sharp items. (4) Certain procedures in which infectious aerosols or splashes may be created and conducted in biological safety cabinets or other physical containment equipment.

The following standard and special practices, safety equipment, and facilities apply to agents assigned to **Biosafety Level 2**.

4.2.2.1 Standard Microbiological Practices

- Access to the laboratory is limited or restricted at the discretion of the laboratory in-charge when experiments are in progress.
- Persons should wash their hands after handling hazardous materials, after removing gloves, and before leaving the laboratory.
- Eating, drinking, smoking, handling contact lenses, and applying cosmetics are not permitted in the work areas. Food is stored outside the work area in cabinets or refrigerators designated for this purpose only.
- Mouth pipetting is prohibited; mechanical pipetting devices should be used.
- Policies for the safe handling of sharps are instituted.
- All procedures are performed carefully to minimize the creation of splashes or aerosols.
- Work surfaces are decontaminated on completion of work or at the end of the day and after any spill or splash of viable material with disinfectants that are effective against the agents of concern.
- All cultures, stocks, and other regulated wastes are decontaminated before disposal by an approved decontamination method such as autoclaving.

4.2.2.2 Special Practices

- Access to the laboratory is limited or restricted by the laboratory in-charge when work with infectious agents is in progress. In general, persons who are at increased risk of acquiring infection, or for whom infection may have serious consequences, which are not allowed in the laboratory or animal rooms. The laboratory in-charge has the final responsibility for assessing each circumstance and for determining who may enter or work in the laboratory or animal room.
- The laboratory supervisor in-charge establishes policies and procedures whereby only persons who have been advised of the potential hazards and meet specific entry requirements (e.g. immunization) may enter the laboratory.
- A biohazard sign must be posted on the entrance to the laboratory. Appropriate information to be posted includes the agent(s) in use, the biosafety level, the required immunizations, the laboratory in-charge name and telephone number, any personal protective equipment that must be worn in the laboratory, and any procedures required for exiting the laboratory.
- Laboratory personnel receive appropriate immunizations or tests for the agents handled or potentially present in the laboratory (e.g., hepatitis B vaccine or TB skin testing).
- When appropriate, consider the agent(s) handled baseline serum samples for laboratory and other at-risk personnel are collected and stored. Additional serum specimens may be collected periodically, depending on the agents handled or the function of the facility.
- Biosafety procedures are incorporated into standard operating procedures or in a biosafety manual adopted or prepared specifically for the laboratory by the laboratory supervisor in-charge. The personnel are advised of special hazards and are required to read and follow instructions on all practices and procedures.
- The laboratory in-charge ensures that laboratory and support personnel receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. Personnel receive annual updates or additional training as necessary for procedural or policy changes.

- A high degree of precaution must always be taken with any contaminated sharp items, including needles and syringes, slides, pipettes, capillary tubes, and scalpels.
- Needles and syringes or other sharp instruments should be restricted in the laboratory for use only when there is no alternative. Plastic ware should be substituted for glassware whenever possible.
- Only needle- locking syringes or disposable syringe-needle units (i.e., needle is integral to the syringe) are used for injection or aspiration of infectious materials. Used disposable needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal; rather, they must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal. Non-disposable sharps must be placed in a hard-walled container for transport to a processing area for decontamination, preferably by autoclaving.
- Syringes which re-sheathe the needle, needleless systems, and other safety devices are used when appropriate.
- Broken glassware must not be handled directly by hand, but must be removed by mechanical means such as a brush and dustpan, tongs, or forceps. Containers of contaminated needles, sharp equipment, and broken glass are decontaminated before disposal.
- Cultures, tissues, specimens of body fluids, or potentially infectious wastes are placed in a container with a cover that prevents leakage during collection, handling, processing, storage, transport, or shipping.
- Laboratory equipment and work surfaces should be decontaminated with an effective disinfectant on a routine basis, after work with infectious materials is finished, and especially after overt spills, splashes, or other contamination by infectious materials. Contaminated equipment must be decontaminated according to state, or international regulations before it is sent for repair or maintenance or to be packaged for transport in accordance with applicable state, or international regulations, before removal from the facility.
- Spills and accidents that result in overt exposures to infectious materials must be immediately reported to the laboratory supervisor in-charge. Medical evaluation, surveillance, and treatment are provided as appropriate and written records are maintained.
- Animals not involved in the work being performed are not permitted in the lab.

4.2.2.3 Safety Equipment (Primary Barriers)

- Properly maintained biological safety cabinets, preferably Class II, or other appropriate personal protective equipment or physical containment devices are used whenever:
- Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include centrifuging, grinding, blending, vigorous shaking or mixing, sonic disruption, opening containers of infectious materials whose internal pressures may be different from ambient pressures, inoculating animals intranasally, and harvesting infected tissues from animals or embryonate eggs.
- High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory if sealed rotor heads or centrifuge safety cups are used, and if these rotors or safety cups are opened only in a biological safety cabinet.
- Face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials to the face when the microorganisms must be manipulated outside the BSC.
- Protective laboratory coats, gowns, smocks, or uniforms designated for lab use are worn while in the laboratory. This protective clothing is removed and left in the

laboratory before leaving for non-laboratory areas (e.g., cafeteria, library, administrative offices). All protective clothing is either disposed of in the laboratory or laundered by the institution; it should never be taken home by any of the personnel.

- Gloves are worn when hands may contact potentially infectious materials, contaminated surfaces or equipment. Wearing two pairs of gloves may be appropriate. Gloves are disposed of when overtly contaminated, and removed when work with infectious materials is completed or when the integrity of the glove is compromised. Disposable gloves are not washed, reused, or used for touching "clean" surfaces (keyboards, telephones, etc.), and they should not be worn outside the lab. Alternatives to powdered latex gloves should be available. Hands are washed following removal of gloves.

4.2.2.4 Laboratory Facilities (Secondary Barriers)

- Provide lockable doors for facilities that house restricted agents.
- Consider locating new laboratories away from public areas.
- Each laboratory contains a sink for hand washing.
- The laboratory is designed so that it can be easily cleaned. Carpets and rugs in the laboratories are inappropriate.
- Bench tops are water resistant and are resistant to moderate heat and the organic solvents, acids, alkalis, and chemicals used to decontaminate the work surfaces and equipment.
- The laboratory furniture is capable of supporting anticipated loading and uses. Spaces between the benches, cabinets, and equipment are accessible for cleaning. Chairs and other furniture used in the laboratory work should be covered with a non-fabric material that can be easily decontaminated.
- Install biological safety cabinets in such a manner that fluctuations of the room supply and exhaust air do not cause the biological safety cabinets to operate outside their parameters for containment. Locate biological safety cabinets away from doors, from windows that can be opened, from heavily traveled laboratory areas, and from other potentially disruptive equipment so as to maintain the biological safety cabinets' air flow parameters for containment.
- An eyewash station is readily available.
- Illumination is adequate for all activities, avoiding reflections and glare that could impede vision.
- There are no specific ventilation requirements. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without recirculation to spaces outside of the laboratory. If the laboratory has windows that open to the exterior, they shall be fitted with fly screens.

4.2.3 Biosafety Level 3 (BSL-3)

Biosafety Level 3 is applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents which may cause serious or potentially lethal disease as a result of exposure by the inhalation route. Laboratory personnel have specific training in handling pathogenic and potentially lethal agents, and are supervised by competent scientists who are experienced in working with these agents.

All procedures involving the manipulation of infectious materials are conducted within the biological safety cabinets or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment. The laboratory has special engineering and design features.

It is recognized, however, that some existing facilities may not have all the facility features recommended for Biosafety Level 3 (i.e., double-door access zone and sealed penetrations). Under this circumstance, an acceptable level of safety for the conduct of routine procedures, (e.g., diagnostic procedures involving the propagation of an agent for identification, typing, susceptibility testing, etc.), may be achieved in a Biosafety Level 2 facility, providing 1) , the exhaust air from the laboratory room is discharged through the outdoors, 2) the ventilation to the laboratory is balanced to provide directional airflow into the room, 3), Access to the laboratory is restricted when work is in progress, and 4) the recommended Standard Microbiological Practices, Special Practices, and Safety Equipment for Biosafety Level 3 are rigorously followed. The decision to implement this modification of Biosafety Level 3 recommendations should be made only by the laboratory in-charge.

4.2.3.1 Standard Microbiological Practices

- Access to the laboratory is limited or restricted at the discretion of the laboratory in-charge when experiments are in progress.
- Persons wash their hands after handling infectious materials, after removing gloves, and when they leave the laboratory.
- Eating, drinking, smoking, handling contact lenses, and applying cosmetics are not permitted in the laboratory. Persons who wear contact lenses in laboratories should also wear goggles or a face shield. Food is stored outside the work area in cabinets or refrigerators designated for this purpose only.
- Mouth pipetting is prohibited; mechanical pipetting devices should be used.
- Policies for the safe handling of sharps are instituted.
- All procedures are performed carefully to minimize the creation of aerosols.
- Work surfaces are decontaminated at least once a day and after any spill of viable material.
- All cultures, stocks, and other regulated wastes are decontaminated before disposal by an approved decontamination method, such as autoclaving. Materials to be decontaminated outside of the immediate laboratory are placed in a durable, leak-proof container and closed for transport from the laboratory. Infectious waste from BSL-3 laboratories should be decontaminated before removal for off-site disposal.

4.2.3.2 Special Practices

- The laboratory doors should be kept closed when experiments are in progress.
- The laboratory director controls access to the laboratory and restricts access to persons whose presence is required for program or support purposes. Persons who are at increased risk of acquiring infection or for whom infection may have serious consequences are not allowed in the laboratory or animal rooms. The Laboratory in-charge has the final responsibility for assessing each circumstance and determining who may enter or work in the laboratory. No minors should be allowed in the laboratory.
- The laboratory supervisor in-charge shall ensure only persons who have been advised of the potential biohazard, who meet any specific entry requirements (e.g., immunization), and who comply with all entry and exit procedures, enter the laboratory or animal rooms.
- When infectious materials or infected animals are around in the laboratory or containment module, a hazard warning sign, incorporating the universal biohazard symbol, is posted on all the laboratory and animal room access doors. The hazard warning sign identifies the agent, lists the name and telephone number of the laboratory supervisor in-charge or other responsible person(s), and indicates any special

requirements for entering the laboratory, such as the need for immunizations, respirators, or other personal protective measures.

- The laboratory personnel receive the appropriate immunizations or tests for the agents handled or potentially present in the laboratory (e.g., hepatitis B vaccine or TB skin testing), and periodic testing as recommended for the agent being handled.
- The baseline serum samples are collected as appropriate and stored for all laboratory and other at-risk personnel. Additional serum specimens may be periodically collected, depending on the agents handled or the function of the laboratory.
- A biosafety manual specific to the laboratory is prepared or adopted by the laboratory in-charge and biosafety precautions are incorporated into standard operating procedures. Personnel are advised of special hazards and are required to read and follow instructions on practices and procedures.
- The laboratory and support personnel receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. Personnel receive annual updates or additional training as necessary for procedural changes.
- The laboratory supervisor in-charge is responsible for ensuring that, before working with organisms at Biosafety Level 3, all personnel demonstrate proficiency in standard microbiological practices and techniques; and in the practices and operations specific to the laboratory facility. This might include prior experience in handling human pathogens or cell cultures, or a specific training program provided by the laboratory director or other competent scientist proficient in safe microbiological practices and techniques.
- A high degree of precaution must always be taken with any contaminated sharp items, including needles and syringes, slides, pipettes, capillary tubes, and scalpels.
- Needles and syringes or other sharp instruments should be restricted in the laboratory for use only when there is no alternative, such as parenteral injection, phlebotomy, or aspiration of fluids from laboratory animals and diaphragm bottles. Plastic ware should be substituted for glassware whenever possible.
- Only needle- locking syringes or disposable syringe-needle units (i.e., needle is integral to the syringe) are used for injection or aspiration of infectious materials. Used disposable needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal. Rather, they must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal. Non-disposable sharps must be placed in a hard-walled container for transport to a processing area for decontamination, preferably by autoclaving.
- Syringes which re-sheathe the needle, needleless systems, and other safe devices are used when appropriate.
- Broken glassware must not be handled directly by hand, but must be removed by mechanical means such as a brush and dustpan, tongs, or forceps. Containers of contaminated needles, sharp equipment, and broken glass should be decontaminated before disposal, and disposed of according to state regulations.
- All open manipulations involving infectious materials are conducted in biological safety cabinets or other physical containment devices within the containment module. No work in open vessels is conducted on the open bench. Clean-up is facilitated by using plastic-backed paper toweling on non-perforated work surfaces within biological safety cabinets.
- Laboratory equipment and work surfaces should be decontaminated routinely with an effective disinfectant, after work with infectious materials is finished, and especially after overt spills, splashes, or other contamination with infectious materials.
- Spills of infectious materials are decontaminated, contained and cleaned up by appropriate professional staff, or others properly trained and equipped to work with concentrated infectious material. Spill procedures are developed and posted.

- Contaminated equipment must be decontaminated before removal from the facility for repair or maintenance or packaging for transport, in accordance with applicable local, state, or federal regulations.
- Cultures, tissues, specimens of body fluids, or wastes are placed in a container that prevents leakage during collection, handling, processing, storage, transport, or shipping.
- All potentially contaminated waste materials (e.g., gloves, lab coats, etc.) from laboratories are decontaminated before disposal or reuse.
- Spills and accidents that result in overt or potential exposures to infectious materials are immediately reported to the laboratory director. Appropriate medical evaluation, surveillance, and treatment are provided and written records are maintained.
- Animals and plants not related to the work being conducted are not permitted in the laboratory.

4.2.3.3 Safety Equipment (Primary Barriers)

- Protective laboratory clothing such as solid- front or wrap-around gowns, scrub suits, or coveralls are worn by workers when in the laboratory. Protective clothing is not worn outside the laboratory. Reusable clothing is decontaminated before being laundered. Clothing is changed when overtly contaminated.
- Gloves must be worn when handling infectious materials, infected animals, and when handling contaminated equipment.
- Frequent changing of gloves should be accompanied by hand washing as recommended. Disposable gloves should not be reused.
- All manipulations of infectious materials, necropsy of infected animals, harvesting of tissues or fluids from infected animals or embryonate eggs, etc., are conducted in a Class II or Class III biological safety cabinet.
- When a procedure or process cannot be conducted within a biological safety cabinet, then the appropriate combinations of personal protective equipment (e.g., respirators, face shields) and physical containment devices (e.g., centrifuge safety cups or sealed rotors) are to be used.
- Respiratory and face protection are used when in rooms containing infected animals.

4.2.3.4 Laboratory Facilities (Secondary Barriers)

- The laboratory must be separate from areas that are open to unrestricted traffic flow within the building, and access to the laboratory is restricted. Passage through a series of two self-closing doors is the basic requirement for entry into the laboratory from access corridors. Doors are lockable. A clothes change room may be located in the passageway.
- Each laboratory room contains a sink for hand washing. The sink is hands- free or automatically operated and is located near the room exit door.
- The interior surfaces of walls, floors, and ceilings of areas where BSL-3 agents are handled are constructed for easy cleaning and decontamination. Seams, if present, must be sealed. Walls, ceilings, and floors should be smooth, impermeable to liquids and resistant to the chemicals and disinfectants normally used in the laboratory. Floors should be monolithic and slip-resistant. Consideration should be given to the use the floor coverings. Penetrations in floors, walls, and ceiling surfaces are sealed. Openings such as around ducts and the spaces between doors and frames are capable of being sealed to facilitate decontamination.
- Bench tops are water resistant and are resistant to moderate heat and to the organic solvents, acids, alkalis, and those chemicals used to decontaminate the work surfaces and equipment.
- The laboratory furniture is capable of supporting anticipated loading and uses. Spaces between benches, cabinets, and equipment are accessible for cleaning. Chairs and

other furniture used in laboratory work should be covered with a non-fabric material that can be easily decontaminated.

- All windows in the laboratory should be closed and sealed.
- A method for decontaminating all laboratory wastes is available in the facility and utilized, preferably within the laboratory (i.e., autoclave, chemical disinfection, incineration, or other approved decontamination method). Consideration should be given to means of decontaminating equipment. If waste is transported out of the laboratory, it should be properly sealed and not transported in public corridors.
- Biological safety cabinets are required and are located away from doors, from room supply louvers, and from heavily-traveled laboratory areas.
- A ducted exhaust air ventilation system is provided. This system creates directional airflow which pumps air into the laboratory from the "clean" areas and toward "contaminated" areas. The exhaust air is not recirculated to any other area of the building. Filtration and other treatments of the exhaust air are not required, but may be considered based on site requirements, and specific agent manipulations and use conditions. The outside exhaust must be dispersed away from occupied areas and air intakes, or the exhaust must be HEPA- filtered. Laboratory personnel must verify that the direction of the airflow (into the laboratory) is proper. It is recommended that a visual monitoring device that indicates and confirms directional inward airflow should be provided at the laboratory entry. Consideration should be given to installing an HVAC control system to prevent sustained positive pressurization of the laboratory. Audible alarms should be considered to notify personnel of HVAC system failure.
- HEPA-filtered exhaust air from a Class II biological safety cabinet can be recirculated into the laboratory if the cabinet is tested and certified at least annually. When exhaust air from Class II safety cabinets is to be discharged to the outside through the building exhaust air system, the cabinets must be connected in a manner that avoids any interference with the air balance of the cabinets or the building exhaust system (e.g., an air gap between the cabinet exhaust and the exhaust duct). When Class III biological safety cabinets are used they should be directly connected to the exhaust system. If the Class III cabinets are connected to the supply system, it is done in a manner that prevents positive pressurization of the cabinets.
- Continuous flow centrifuges or other equipment that may produce aerosols are contained in devices that exhaust air through HEPA filters before discharge into the laboratory. These HEPA systems are tested annually at least. Alternatively, the exhaust from such equipment may be vented to the outside if it is dispersed away from occupied areas and air intakes.
- Vacuum lines are protected with liquid disinfectant traps and HEPA filters, or their equivalent. Filters must be replaced as needed. An alternative is to use portable vacuum pumps (also properly protected with traps and filters).
- An eyewash station is readily available inside the laboratory.
- Illumination must be adequate for all activities, avoiding reflections and glare that could impede vision.
- The Biosafety Level 3 facility design and operational procedures must be documented. The facility must be tested for verification that the design and operational parameters have been met prior to operation. Facilities should be re- verified, at least annually, against these procedures as modified by operational experience.
- Additional environmental protection (e.g., personnel showers, HEPA filtration of exhaust air, containment of other piped services and the provision of effluent decontamination) should be considered if recommended by the agent summary statement, as determined by the risk assessment, the site conditions, or other applicable state regulations.

4.2.4 Biosafety Level 4 (BSL-4)

Biosafety Level 4 is required for work with dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections and life-threatening diseases. Agents with a close or identical antigenic relationship to Biosafety Level 4 agents are handled at this level until sufficient data are obtained either to confirm continued work at this level, or to work with them at a lower level. Members of the laboratory staff have specific and thorough training in handling extremely hazardous infectious agents and they understand the primary and secondary containment functions of the standard and special practices, the containment equipment, and the laboratory design characteristics. They are supervised by competent scientists who are trained and experienced in working with such agents. Access to the laboratory is strictly controlled by the laboratory director. The facility is either in a separate building or in a controlled area within a building, which is completely isolated from all other areas of the building. A specific facility operations manual is prepared or adopted. Within work areas of the facility, all activities are confined to Class III biological safety cabinets, or Class II biological safety cabinets used with one-piece positive pressure personnel suits ventilated by a life support system. The Biosafety Level 4 laboratory has special engineering and design features to prevent microorganisms from being disseminated into the environment.

4.2.4.1 Standard Microbiological Practices

- Access to the laboratory is limited by the laboratory director when experiments are in progress.
- Policies for safe handling of sharps are instituted.
- All procedures are performed carefully to minimize the creation of aerosols.
- Work surfaces are decontaminated at least once a day and after any spill of viable material.
- All waste is decontaminated before disposal by an approved method such as autoclaving.

4.2.4.2 Special Practices

- Only persons whose presence in the facility or individual laboratory rooms is required for program or support purposes are authorized to enter. Persons who are immunocompromised or immunosuppressed may be at risk of acquiring infections. Therefore, persons who may be at increased risk of acquiring infection or for whom infection may be unusually hazardous, such as children or pregnant women are not allowed in the laboratory or animal rooms.
- The laboratory supervis*or* has the final responsibility for assessing each circumstance and determining who may enter or work in the laboratory. Access to the facility is limited by means of secure, locked doors. Accessibility is managed by the laboratory supervisor, HS, or other person responsible for the physical security of the facility. Before entering, people are advised of the potential biohazards and instructed as to appropriate safeguards for ensuring their safety. Authorized persons comply with the instructions and all other applicable entry and exit procedures. A logbook, signed by all personnel, indicates the date and time of each entry and exit. Practical and effective protocols for emergency situations are established.
- When infectious materials or infected animals are present in the laboratory or animal rooms, hazard warning signs, incorporating the universal biohazard symbol, are posted on all access doors. The sign identifies the agent, lists the name of the laboratory director or other responsible person(s), and indicates any special requirements for entering the area (e.g., the need for immunizations or respirators).
- The laboratory supervisor is responsible for ensuring that, before working with organisms at Biosafety Level 4, all personnel demonstrate a high proficiency in standard microbiological practices and techniques; and in the special practices and operations

specific to the laboratory facility. This might include prior experience in handling human pathogens or cell cultures, or a specific training program provided by the laboratory director or other competent scientist proficient in these unique safe microbiological practices and techniques.

- The laboratory personnel receive available immunizations for the agents handed or potentially present in the laboratory.
- Baseline serum samples for all laboratory and other at-risk personnel are collected and stored. Additional serum specimens may be periodically collected, depending on the agents handled or the function of the laboratory. The decision to establish a serologic surveillance program takes into account the availability of methods for the assessment of antibody to the agent(s) of concern. The program provides for the testing of serum samples at each collection interval and the communication of results to the participants.
- A biosafety manual is prepared and adopted. The personnel are advised of special hazards and are required to read and follow instructions on practices and procedures.
- Laboratory and support personnel receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. The personnel receive annual updates or additional training as necessary for procedural changes. Personnel enter and leave the laboratory only through the clothing change and shower rooms. They take a decontaminating shower each time they leave the laboratory. The personnel use the airlocks to enter or leave the laboratory only in an emergency.
- Personal clothing is removed in the outer clothing change room and kept there. Complete laboratory clothing, including undergarments, pants and shirts or jumpsuits, shoes, and gloves, is provided and used by all personnel entering the laboratory. When leaving the laboratory and before proceeding into the shower area, personnel remove their laboratory clothing in the inner change room. Soiled clothing is autoclaved before laundering.
- Supplies and materials needed in the facility are brought in by way of the double-door autoclave, fumigation chamber, or airlock, which is appropriately decontaminated between each use. After securing the outer doors, personnel within the facility retrieve the materials by opening the interior doors of the autoclave, fumigation chamber, or airlock. These doors are secured after materials are brought into the facility.
- A high degree of precaution must always be taken with any contaminated sharp items, including needles and syringes, slides, pipettes, capillary tubes, and scalpels.
- Needles and syringes or other sharp instruments are restricted in the laboratory for use only when there is no alternative, such as for parenteral injection, phlebotomy, or aspiration of fluids from laboratory animals and diaphragm bottles. Plastic ware should be substituted for glassware whenever possible. PS: This page is repeated already
- Only needle- locking syringes or disposable syringe-needle units (i.e., needle is integral to the syringe) are used for injection or aspiration of infectious materials. Used disposable needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal; rather, they must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal. Non-disposable sharps must be placed in a hard-walled container for transport to a processing area for decontamination, preferably by autoclaving.
- Syringes that re-sheath the needle, needleless systems, and other safety devices are used when appropriate.
- Broken glassware must not be handled directly by hand, but must be removed by mechanical means such as a brush and dustpan, tongs, or forceps. Containers of contaminated needles, sharp equipment, and broken glass must be decontaminated before disposal, according to any local, state, or federal regulations.
- Biological materials to be removed from the Class III cabinet or from the Biosafety Level 4 laboratory in a viable or intact state are transferred to a non-breakable, sealed primary

container and then enclosed in a non-breakable, sealed secondary container. This is removed from the facility through a disinfectant dunk tank, fumigation chamber, or an airlock designed for this purpose.

- No materials, except biological materials that are to remain in a viable or intact state, are removed from the Biosafety Level 4 laboratory unless they have been autoclaved or decontaminated before they leave the laboratory. Equipment or material that might be damaged by high temperatures or steam may be decontaminated by gaseous or vapor methods in an airlock or chamber designed for this purpose.
- Laboratory equipment is decontaminated routinely after work with infectious materials is completed, and especially after overt spills, splashes, or other contamination with infectious materials. Equipment is decontaminated before it is sent for repair or maintenance.
- Spills of infectious materials are contained and cleaned up by appropriate professional staff or others properly trained and equipped to work with concentrated infectious material. A spill procedure is developed and posted within the laboratory.
- A system is established for reporting laboratory accidents and exposures and staff absenteeism, and for the medical surveillance of potential laboratory-associated illnesses. Written records are prepared and maintained. An essential adjunct to such a reporting-surveillance system is the availability of a facility for the quarantine, isolation, and medical care of personnel inflicted with potential or known laboratory-associated illnesses.
- Materials not related to the experiment being conducted (e.g., plants, animals, and clothing) are not permitted in the facility.

4.2.4.3 Safety Equipment (Primary Barriers)

All procedures within the facility are conducted in the Class III biological safety cabinet or in Class II biological safety cabinets used in conjunction with one-piece positive pressure personnel suits ventilated by a life support system.

4.2.4.4 Laboratory Facility (Secondary Barriers)

There are two models for Biosafety Level 4 laboratories: the Cabinet Laboratory where all handling of the agent is performed in a Class III Biological Safety Cabinet, and the Suit Laboratory where personnel wear a protective suit. Biosafety Level-4 laboratories may be based on either a model or a combination of both models in the same facility. If a combination is used, each type must meet all the requirements identified for that type.

Cabinet Laboratory

- The Biosafety Level 4 facility consists of either a separate building or a clearly demarcated and isolated zone within a building. The rooms in the facility are arranged to ensure passage through a minimum of two doors prior to entering the room(s) containing the Class III biological safety cabinet (cabinet room). Outer and inner change rooms separated by a shower are provided for personnel entering and leaving the cabinet room. A double-door autoclave, dunk tank, fumigation chamber, or ventilated anteroom for decontamination is provided at the containment barrier for passage of those materials, supplies, or equipment that are not brought into the cabinet room through the change room.
- Daily inspections of all containment parameters (e.g., directional airflow) and life support systems are completed before laboratory work is initiated to ensure that the laboratory is operating according to its operating parameters.
- Walls, floors, and ceilings of the cabinet room and inner change room are constructed to form a sealed internal shell which facilitates fumigation and is resistant to entry and exit of animals and insects. Floors are integrally sealed and covered. The internal surfaces of this shell are resistant to liquids and chemicals to facilitate cleaning and

decontamination of the area. All penetrations in these structures and surfaces are sealed. Openings around doors into the cabinet room and inner change room are minimized and are capable of being sealed to facilitate decontamination. Any drains in the cabinet room floor are connected directly to the liquid waste decontamination system. Sewer vents and other service lines contain HEPA filters and protection against vermin.

- Bench tops have seamless or sealed surfaces which are water resistant and are resistant to moderate heat and the organic solvents, acids, alkalis, and chemicals used to decontaminate the work surfaces and equipment.
- Laboratory furniture is of simple open construction, capable of supporting anticipated loading and uses. Spaces between benches, cabinets, and equipment are accessible for cleaning and decontamination. Chairs and other furniture used in laboratory work should be covered with a non- fabric material that can be easily decontaminated. 6. A hands- free or automatically operated hand washing sink is provided near the door of the cabinet room(s) and the outer and inner change rooms.
- If there is a central vacuum system, it does not serve areas outside the cabinet room. Inline HEPA filters are placed as near as practicable to each use point or service cock. Filters are installed to permit in-place decontamination and replacement. Other liquid and gas services to the cabinet room are protected by devices that prevent backflow.
- If water fountains are provided, they are automatically or foot-operated and are located in the facility corridors outside the laboratory. The water service to the fountain is isolated from the distribution system supplying water to the laboratory areas and is equipped with a backflow preventer.
- Access doors to the laboratory are self-closing and lockable.
- Any windows are breakage-resistant and sealed.
- Double-door autoclaves are provided for decontaminating materials passing out of both the Class III biological safety cabinet(s) and the cabinet room(s). Autoclaves that open outside of the containment barrier must be sealed to the wall of the containment barrier. The autoclave doors are automatically controlled so that the outside door can only be opened after the autoclave "sterilization" cycle has been completed. 12. Pass-through dunk tanks, fumigation chambers, or equivalent decontamination methods are provided so that materials and equipment that cannot be decontaminated in the autoclave can be safely removed from both the Class III biological safety cabinet(s) and the cabinet room(s).
- Liquid effluents from the dirty-side inner change room (including toilets) and cabinet room sinks, floor drains (if used), autoclave chambers, and other sources within the cabinet room are decontaminated by a proven method, preferably heat treatment, before being discharged to the sanitary sewer. Effluents from showers and clean-side toilets may be discharged to the sanitary sewer without treatment. The process used for decontamination of liquid wastes must be validated physically and biologically.
- A dedicated non-recirculating ventilation system is provided. The supply and exhaust components of the system are balanced to ensure directional airflow from the area of least hazard to the area(s) of greatest potential hazard. The differential pressure/directional airflow between adjacent areas is monitored and alarmed to indicate any system malfunction. An appropriate visual pressure monitoring device that indicates and confirms the pressure differential of the cabinet room is provided and located at the entry to the clean change room. The airflow in the supply and exhaust components is monitored and the HVAC control system is designed to prevent sustained positive pressurization of the laboratory. The Class III cabinet should be directly connected to the exhaust system. If the Class III cabinet is connected to the supply system, it is done in a manner that prevents positive pressurization of the cabinet.

- The supply air to and exhaust air from the cabinet room, inner change room, and anteroom pass through HEPA filter(s). The air is discharged away from occupied spaces and air intakes. The HEPA filter(s) are located as near as practicable to the source in order to minimize the length of potentially contaminated ductwork. All HEPA filters need to be tested and certified annually. The HEPA filter housings are designed to allow for *in situ* decontamination of the filter prior to removal, or removal of the filter in a sealed, gas-tight primary container for subsequent decontamination and/or destruction by incineration. The design of the HEPA filter housing should facilitate validation of the filter installation. The use of pre-certified HEPA filters can be an advantage. The service life of the exhaust HEPA filters can be extended through adequate pre-filtration of the supply air.
- The Biosafety Level 4 facility design and operational procedures must be documented. The facility must be tested for verification that the design and operational parameters have been met prior to operation. Facilities should be re- verified annually against these procedures as modified by operational experience.
- Appropriate communication systems are provided between the laboratory and the outside (e.g. voice, fax, computer, etc.).

Suit Laboratory

- The Biosafety Level 4 facility consists of either a separate building or a clearly demarcated and isolated zone within a building. The rooms in the facility are arranged to ensure passage through the changing and decontamination areas prior to entering the room(s) where work is done with BSL-4 agents (suit area). Outer and inner change rooms separated by a shower are provided for personnel entering and leaving the suit area. A specially designed suit area is maintained in the facility to provide personnel protection equivalent to that provided by Class III biological safety cabinets. Personnel who enter this area wear a one-piece positive pressure suit that is well ventilated by a life-support system protected by HEPA filtration. The life support system includes redundant breathing air compressors, alarms and emergency backup breathing air tanks. Entry to this area is through an airlock fitted with airtight doors. A chemical shower is provided to decontaminate the surface of the suit before the worker leaves the area. An automatically starting emergency power source is provided at a minimum for the exhaust system, life support systems, alarms, lighting, entry and exit controls, and BSCs. The air pressure within the suit is positive to the surrounding laboratory. The air pressure within the suit area is lower than that of any adjacent area. Emergency lighting and communication systems are provided. All penetrations into the internal shell of the suit area, chemical shower, and airlocks, are sealed.
- A daily inspection of all containment parameters (e.g., directional airflow, chemical showers) and life support systems should be completed before laboratory work is initiated to ensure that the laboratory is operating according to its operating parameters.
- A double-door autoclave is provided at the containment barrier for decontaminating waste materials to be removed from the suit area. The autoclave door, which opens to the area external to the suit area, is sealed to the outer wall of the suit area and is automatically controlled so that the outside door can be opened only after the autoclave "sterilization" cycle. A dunk tank, fumigation chamber, or ventilated airlock for decontamination is provided for passage of materials, supplies, or equipment that are not brought into the suit area through the change room. These devices can be also used for the safe removal of materials, supplies, or equipment from the laboratory that cannot be decontaminated in the autoclave.
- Walls, floors, and ceilings of the suit area are constructed to form a sealed internal shell, which facilitates fumigation and is animal and insect repellent. The internal surfaces of this shell are resistant to liquids and chemicals, facilitating cleaning and

decontamination of the area. All penetrations in these structures and surfaces are sealed. Any drains in the floor of the suit area contain traps filled with a chemical disinfectant of demonstrated efficacy against the target agent, and they are connected directly to the liquid waste decontamination system. Sewer vents and other service lines contain HEPA filters.

- Internal facility appurtenances in the suit area, such as light fixtures, air ducts, and utility pipes, are arranged to minimize the horizontal surface area.
- Bench tops have seamless surfaces which are water proof and are resistant to moderate heat and the organic solvents, acids, alkalis, and chemicals used to decontaminate the work surfaces and equipment.
- Laboratory furniture is of simple open construction capable of supporting anticipated loading and uses. Non-porous materials are preferable. Spaces between benches, cabinets, and equipment are accessible for cleaning and decontamination. Chairs and other furniture used in the laboratory work should be covered with a non- fabric material that can be easily decontaminated.
- A hands- free or automatically operated hand washing sink is provided in the suit area(s); hand washing sinks in the outer and inner change rooms should be considered based on the risk assessment.
- If there is a central vacuum system, it does not serve areas outside the suit area. In-line HEPA filters are placed as near as practicable to each use point or service cock. Filters are installed to permit in-place decontamination and replacement. Other liquid and gas services to the suit area are protected by devices that prevent backflow. 10. Access doors to the laboratory are self-closing and lockable. Inner and outer doors to the chemical shower and inner and outer doors to airlocks are interlocked to prevent both doors from being opened simultaneously.
- Any windows are breakage-resistants' are sealed.
- Liquid effluents from sinks, floor drains (if used), autoclave chambers and other sources within the containment barrier are decontaminated by a proven method, preferably heat treatment, before being discharged into the sanitary sewer. Effluents from showers and toilets may be discharged to the sanitary sewer without treatment. The process used for decontamination of liquid wastes must be validated physically and biologically.
- A dedicated non-recirculating ventilation system is provided. The supply and exhaust components of the system are balanced to ensure directional airflow from the area of least hazard to the area(s) of greatest potential hazard. Redundant supply fans are recommended. Redundant exhaust fans are required. The differential pressure/directional airflow between adjacent areas is monitored and alarmed to indicate malfunction of the system. An appropriate visual pressure monitoring device that indicates and confirms the pressure differential of the suit area must be provided and located at the entry to the clean change room. The airflow in the supply and exhaust components is monitored and an HVAC control system is installed to prevent positive pressurization of the laboratory.
- The supply air to the suit area, decontamination shower, and decontamination airlock are protected by passage through a HEPA filter. The general room exhausts air from the suit area, decontamination shower and decontamination airlock is treated by a passage through two HEPA filters in series prior to discharge to the outside. The air is discharged away from occupied spaces and air intakes. The HEPA filters are located as near as practicable to the source in order to minimize the length of potentially contaminated ductwork. All HEPA filters need to be tested and certified annually. The HEPA filter housings are designed to allow for *in situ* decontamination of the filter prior to removal. Alternatively, the filter can be removed in a sealed, gas-tight primary container for subsequent decontamination and/or destruction by incineration. The design of the HEPA filter housing should facilitate validation of the filter installation. The

use of pre-certified HEPA filters can be an advantage. The service life of the exhaust HEPA filters can be extended through adequate pre-filtration of the supply air.

- The positioning of the supply and exhaust points should be such that dead air space in the suit room should be minimized.
- The treated exhaust air from Class II biological safety cabinets, located in a facility where workers wear an anti-pressure suit, may be discharged into the room environment or to the outside through the facility air exhaust system. If the treated exhaust is discharged to the outside through the facility exhaust system, it is connected to this system in a manner that avoids any interference with the air balance of the cabinets or the facility exhaust system.
- The Biosafety Level 4 facility design and operational procedures must be documented. The facility must be tested for verification that the design and operational parameters have been met prior to the operation. Facilities should be re- verified annually against these procedures as modified by operational experience.
- Appropriate communication systems should be provided between the laboratory and the outside.

4.3 Animal Biosafety Levels

4.3.1 Animal Biosafety Level 1 (ABSL-1)

Animal Biosafety Level 1 (ABSL-1) is suitable for work involving well characterized agents that are not known to cause disease in healthy adult humans and all that is of minimal potential hazard to laboratory personnel and the environment.

4.3.1.1 Standard Practices

- Only those persons required for the program or the support purposes are authorized to enter the facility. Before entering, persons shall be advised of the potential biohazards and are instructed on the appropriate safeguards.
- An appropriate medical surveillance program shall be provided.
- Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human use shall only be done in the designated areas and are not permitted in the animal or procedure rooms.
- All procedures shall be carefully performed to minimize the creation of aerosols or splatters.
- Work surfaces shall be decontaminated after use or after any spill of viable materials.
- All wastes from the animal room (including animal tissues, carcasses, and contaminated bedding) shall be transported from the animal room in leak-proof, covered containers for appropriate disposal in compliance with applicable institutional or local requirements. Incineration is recommended.
- Policies for the safe handling of sharps shall be followed.
- The personnel shall wash their hands after handling cultures and animals, after removing gloves, and before leaving the animal facility.
- A biohazard sign must be posted on the entrance to the animal room whenever infectious agents are present. The hazard warning sign identifies the infectious agent(s) in use, lists the name and telephone number of the responsible person(s), and indicates the special requirements for entering the animal room (e.g., the need for immunizations and respirators).
- An insect and rodent control program shall be implemented.

4.3.1.2 Safety Equipment (Primary Barriers)

- Wearing of laboratory coats, gowns, and/or uniforms in the facility shall be strictly applied. The laboratory coats remain in the animal room. Gowns and uniforms shall not be worn outside the facility.

- Persons having contact with non-human primates shall assess their risk of mucous membrane exposure and wear appropriate eye and face protection.

4.3.1.3 Facilities (Secondary Barriers)

- The animal facility shall be separated from areas that are open to unrestricted personnel traffic within the building.
- External facility doors shall be self-closing and self-locking. Doors to the animal rooms open inward, shall be self-closing, and shall be kept closed when experimental animals are present. Cubicle room inner doors may open outward or be horizontal or vertical sliding.
- The animal facility shall be designed, constructed, and maintained to facilitate cleaning and housekeeping. The interior surfaces (walls, floors, and ceilings) shall be water resistant.
- Internal facility appurtenances, such as light fixtures, air ducts, and utility pipes, shall be arranged to minimize horizontal surface areas.
- Windows are not recommended. Any windows must be resistant to breakage. Where possible, windows shall be sealed. If the animal facility has windows that are open, they shall be fitted with fly screens.
- If floor drains are provided, the traps shall always be filled with water and/or an appropriate disinfectant.
- Ventilation shall be provided. No recirculation of exhaust air should occur. It is recommended that animal rooms maintain negative pressure compared to adjoining hallways.
- The facility shall be provided with a hand washing sink.
- Cages shall be washed manually or in a cage washer. The mechanical cage washer shall have a final rinse temperature of at least 180F.
- Illumination shall be adequate for all activities, avoiding reflections and glare that could impede vision.

4.3.2 Animal Biosafety Level 2 (ABSL-2)

Animal Biosafety Level 2 involves practices for work with those agents associated with human disease. It addresses hazards from ingestion as well as from percutaneous and mucous membrane exposure. ABSL-2 builds upon the practices, procedures, containment equipment, and facility requirements of ABSL-1.

4.3.2.1 Standard Practices

- Access to the animal room shall be limited to the fewest number of individuals possible. Personnel who must enter the room for program or service purposes when work is in progress are advised of the potential hazard.
- An appropriate medical surveillance program shall be provided. All personnel shall receive appropriate immunizations or tests for the agents handled or potentially present (e.g., hepatitis B vaccine, TB skin testing). When appropriate, a serum surveillance system shall be implemented.
- The personnel shall be advised of special hazards, and shall be required to read and follow instructions on the practices and procedures.
- Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human use shall only be done in designated areas and are not permitted in animal or procedure rooms.
- All procedures shall be carefully performed to minimize the creation of aerosols or splatters.

- Equipment and work surfaces in the room shall be routinely decontaminated with an effective disinfectant after work with the infectious agent and especially after overt spills, splashes, or other contamination by infectious materials.
- All infectious samples shall be collected, labeled, transported, and processed in a manner that contains and prevents transmission of the agent(s). All wastes from the animal room (including animal tissues, carcasses, contaminated bedding, unused feed, sharps, and other refuse) shall be transported from the animal room in leak-proof, covered containers for appropriate disposal in compliance with applicable institutional or local requirements. The outer surface of the containers shall be disinfected prior to moving the material. Autoclaving of the contents prior to disposal is recommended.
- Needles and syringes or other sharp instruments shall be restricted for use in the animal facility only when there is no alternative, such as for parenteral injection, blood collection, or aspiration of fluids from laboratory animals and diaphragm bottles.
- Syringes that re-sheathe the needle, needle-less systems, and other safe devices shall be used when appropriate.
- Plastic ware shall be substituted for glassware whenever possible.
- Personnel shall wash their hands after handling cultures and animals, after removing gloves, and before leaving the animal facility.
- A biohazard sign must be posted on the entrance to the animal room whenever infectious agents are present. The hazard warning sign identifies the infectious agent(s) in use, lists the name and telephone number of the responsible person(s), and indicates the special requirements (e.g., the need for immunizations and respirators) for entering the animal room.
- An insect and rodent control program shall be implemented.

4.3.2.2 Special Practices

- Animal care laboratory and support personnel shall receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures.
- The personnel shall receive annual updates, or additional training as necessary for procedural or policy changes. Records of all training provided are maintained. In general, persons who may be at increased risk of acquiring infection, or for whom infection might be unusually hazardous, shall not be allowed in the animal facility unless special procedures can eliminate the extra risk.
- Only animals used for the experiment(s) shall be allowed in the room.
- All equipment must be appropriately decontaminated prior to removal from the room.
- Spills and accidents which result in overt exposures to infectious materials must be immediately reported to the facility in-charge and HS. Medical evaluation, surveillance, and treatment shall be provided as appropriate and written records shall be maintained.

4.3.2.3 Safety Equipment (Primary Barriers):

- Gowns, uniforms, or laboratory coats shall be worn while in the animal room. The laboratory coat shall be removed and left in the animal room. Gowns, uniforms, and laboratory coats are removed before leaving the animal facility. Gloves shall be worn when handling infected animals and when skin contact with infectious materials is unavoidable.
- Personal protective equipment shall be used based on risk assessment determinations. Appropriate face/eye and respiratory protection shall be worn by all personnel entering animal rooms that house nonhuman primates.
- Biological safety cabinets, other physical containment devices, and/or personal protective equipment (e.g., respirators, face shields) shall be used whenever conducting procedures with a high potential for creating aerosols. These include

necropsy of infected animals, harvesting of tissues or fluids from infected animals or eggs, or intranasal inoculation of animals.

- When needed, animals shall be housed in primary biosafety containment equipment appropriate for the animal species. Filter top cages shall always be handled in properly designed and operating animal bio-containment cabinets recommended for rodents.

4.3.2.4 Facilities (Secondary Barriers)

- The animal facility shall be separated from areas that are open to unrestricted personnel traffic within the building.
- Access to the facility shall be limited by secure locked doors. External doors are self-closing and self-locking. Doors to animal rooms open inward, shall be self-closing, and shall be kept closed when experimental animals are present. Cubicle room inner doors may open outward or be horizontal or vertical sliding.
- The animal facility shall be designed, constructed, and maintained to facilitate cleaning and housekeeping. The interior surfaces (walls, floors, and ceilings) shall be water resistant.
- Internal facility appurtenances, such as light fixtures, air ducts, and utility pipes, shall be arranged to minimize horizontal surface areas.
- Any windows must be resistant to breakage where possible, windows shall be sealed. If the animal facility has windows that are open, they shall be fitted with fly screens.
- If the floor drains are provided, the traps shall always be filled with an appropriate disinfectant.
- The exhaust air shall be discharged to the outside without being recirculated to the other rooms. Ventilation shall be. The direction of airflow in the animal facility shall open inwardly; animal rooms shall maintain negative pressure compared to the adjoining hallways.
- Cages shall be washed manually or in an appropriate cage washer. The mechanical cage washer shall have a final rinse temperature of at least 180F.
- An autoclave shall be available in the animal facility to decontaminate infectious waste.
- A hand washing sink shall be provided in the animal room where infected animals are housed, as well as elsewhere in the facility.
- Illumination shall be adequate for all activities, avoiding reflections and glare that could impede vision.

4.3.3 Animal Biosafety Level 3 (ABSL-3)

Animal Biosafety Level 3 involves practices suitable for work with animals infected with indigenous or exotic agents that present the potential of aerosol transmission and of causing serious or potentially lethal disease. ABSL-3 builds upon the standard practices, procedures, containment equipment, and facility requirements of ABSL-2.

4.3.3.1 Standard Practices

- The laboratory or animal facility in-charge limits access to the animal room to the fewest number of individuals possible. The personnel who must enter the room for program or service purposes when work is in progress shall be advised of the potential hazard.
- An appropriate medical surveillance program shall be provided. All personnel shall receive appropriate immunizations or tests for the agents handled or potentially present (e.g., hepatitis B vaccine, TB skin testing). When appropriate, a serum surveillance system shall be implemented. In general, persons who may be at increased risk of acquiring infection, or for whom infection might have serious consequences, are not allowed in the animal facility unless special procedures can eliminate the extra risk.

- The personnel shall be advised against special hazards, and shall be required to read and follow instructions on practices and procedures.
- Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human use shall be done only in designated areas and shall not be permitted in animal or procedure rooms.
- All procedures shall be carefully performed to minimize the creation of aerosols or splatters.
- Equipment and work surfaces in the room shall be routinely decontaminated with an effective disinfectant after work with the infectious agent and especially after overt spills, splashes, or other contamination by infectious materials.
- All wastes from the animal room (including animal tissues, carcasses, contaminated bedding, unused feed, sharps, and other refuse animal tissues) shall be transported from the animal room in leak-proof, covered containers for appropriate disposal in compliance with the University and State of Qatar requirements.
- Needles and syringes or other sharp instruments shall be restricted in the animal facility for use only when there is no alternative, such as for parenteral injection, blood collection, or aspiration of fluids from laboratory animals and diaphragm bottles.
- Syringes that re-sheathe the needle, needle-less systems, and other safety devices shall be used when appropriate.
- Plastic ware shall be substituted for glassware whenever possible.
- Personnel shall wash their hands after handling cultures and animals, after removing gloves, and before leaving the animal facility.
- A biohazard sign must be posted on the entrance to the animal room whenever infectious agents are present. The hazard warning sign identifies the infectious agent(s) in use, lists the name and telephone number of the responsible person(s), and indicates the special requirements for entering the animal room (e.g., the need for immunizations and respirators).
- All infectious samples shall be collected, labeled, transported, and processed in a manner that contains and prevents transmission of the agent(s).
- The laboratory and support personnel shall receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. As necessary, personnel receive updates and/or additional training on procedural or policy changes. Records of all training provided shall be maintained.
- An insect and rodent control program shall be implemented.

4.3.3.2 Special Practices

- Cages shall be autoclaved or thoroughly decontaminated before bedding is removed and before they are cleaned and washed. The equipment must be decontaminated according to any University and State of Qatar regulations before being packaged for transport or removal from the facility for repair or maintenance.
- A spill procedure shall be posted. Only the personnel properly trained and equipped to work with infectious materials shall clean up the spills. Spills and accidents that result in overt exposures to infectious materials must be immediately reported to the facility in-charge and HS. Medical evaluation, surveillance, and treatment shall be provided as appropriate and written records are maintained.
- All wastes from the animal room must be autoclaved prior to disposal.
- Materials not related to the experiment (e.g., plants, animals**)** shall not be permitted in the animal room.

4.3.3.3 Safety Equipment (Primary Barriers)

- Uniforms or scrub suits shall be worn by personnel entering the animal room. Wrap-around or solid-front gowns shall be worn over this clothing. Front-button laboratory coats are unsuitable. The gown must be removed and left in the animal room. Before leaving the animal facility, scrub suits and uniforms shall be removed and appropriately contained and decontaminated prior to laundering or disposal.
- Personal protective equipment used is based on risk assessment determinations.
- Personal protective equipment shall be used for all activities involving manipulations of infectious material or infected animals.
- Personnel shall wear gloves when handling infected animals. Gloves shall be removed aseptically and autoclaved with other animal room wastes before disposal.
- Appropriate face/eye and respiratory protection (e.g., respirators and face shields) shall be worn by all personnel entering animal rooms.
- Boots, shoe covers, or other protective footwear, and disinfectant foot baths shall be available and used where indicated.
- The risk of infectious aerosols from infected animals or their bedding also can be reduced if animals are housed in containment caging systems such as open cages placed in inward flow ventilated enclosures (e.g., laminar flow cabinets), solid wall and bottom cages covered with filter bonnets, or other equivalent primary containment systems.
- Biological safety cabinets and other physical containment devices shall be used whenever conducting procedures with a potential for creating aerosols.
- These include necropsy of infected animals, harvesting of tissues or fluids from infected animals or eggs, or intranasal inoculation of animals. At BSL-3, all work shall be done in a primary barrier; otherwise respirators shall be worn by the personnel in the room.

4.3.3.4 Facilities (Secondary Barriers)

- The animal facility shall be separate from areas that are open to the unrestricted personnel traffic within the building.
- Access to the facility shall be limited by a self-closing and self-locking door. This exterior entry door may be controlled by a key lock, card key, or proximity reader. Entry into the animal room is via a double-door entry which includes the change room and shower(s). An additional double-door access (air-lock) or double-doored autoclave may be provided for movement of supplies and wastes into and out of the facility, respectively. Doors to animal rooms open inward and shall be self-closing. Doors to cubicles inside an animal room may open outward or slide horizontally or vertically.
- The animal facility shall be designed, constructed, and maintained to facilitate cleaning and housekeeping. The interior surfaces (walls, floors, and ceilings) shall be water resistant. Penetrations in floors, walls and ceiling surfaces shall be sealed and openings around ducts and the spaces between doors and frames shall be capable of being sealed to facilitate decontamination.
- A hands-free or automatically operated hand washing sink shall be provided in each animal room near the exit door. The sink trap shall be filled with an appropriate disinfectant after each use.
- Internal facility appurtenances, such as light fixtures, air ducts, and utility pipes, shall be arranged to minimize horizontal surface areas.
- Windows are not recommended. Any windows must be resistant to breakage and must be sealed.
- If floor drains are provided, they shall always be filled with an appropriate disinfectant.
- A ducted exhaust air ventilation system shall be provided. This system creates directional airflow which pumps air into the laboratory from "clean" areas and toward "contaminated" areas. The exhaust air is not recirculated to any other area of the building. Filtration and other treatments of the exhaust air may not be required, but

shall be considered based on site requirements, and specific agent manipulations and use conditions. The exhaust must be dispersed away from occupied areas and air intakes, or the exhaust must be HEPA-filtered. Personnel must verify that the direction of the airflow (into the animal areas) is proper. A visual monitoring device that indicates and confirms directional inward airflow shall be provided at the animal room entry. Consideration should be given to installing an HVAC control system to prevent sustained positive pressurization of the animal spaces. Audible alarms shall be installed to notify personnel of HVAC system failure.

- HEPA-filtered exhaust air from a Class II biological safety cabinet can be recirculated into the animal room if the cabinet is tested and certified at least annually. When exhaust air from Class II safety cabinets is to be discharged to the outside through the building exhaust air system, the cabinets must be connected in a manner that avoids any interference with the air balance of the cabinets or the building exhaust system (e.g., an air gap between the cabinet exhaust and the exhaust duct). When Class III biological safety cabinets are used, they shall be directly connected to the exhaust system. If the Class III cabinets are connected to the supply system, it is done in a manner that prevents positive cabinet pressurization.
- Cages shall be washed in a cage washer. The mechanical cage washer has a final rinse temperature of at least 180°F.
- An autoclave shall be available which is convenient to the animal rooms where the biohazard is contained. The autoclave is utilized to decontaminate infectious waste before moving it to other areas of the facility.
- If vacuum service (i.e., central or local) is provided, each service connection shall be fitted with liquid disinfectant traps and an in-line HEPA filter, placed as near as practicable to each use point or service cock. Filters shall be installed to permit in-place decontamination and replacement.
- Illumination must be adequate for all activities, avoiding reflections and glares that could impede vision.
- The facility must be tested for verification that the design and operational parameters have been met prior to operation. Facilities should be re-verified at least annually against these procedures as modified by operational experience.
- Additional environmental protection (e.g., personnel showers, HEPA filtration of exhaust air, containment of other piped services, and the provision of effluent decontamination) shall be considered if recommended by the agent summary statement, as determined by risk assessment of the site conditions.

4.3.4 Animal Biosafety Level 4 (ABSL-4)

Animal Biosafety Level 4 involves practices suitable for addressing dangerous or exotic agents that pose high risk of life threatening diseases, aerosol transmission, or related agents with unknown risk of transmission. ABSL-4 builds upon the standard practices, procedures, containment equipment, and facility requirements of ABSL-3. Procedures must be developed locally to address specific operations of the Class III cabinet line or the suit laboratory.

4.3.4.1 Standard Microbiological Practices

- The laboratory or animal facility in-charge shall limit the access to the animal room to the fewest individuals possible. The personnel who must enter the room for program or service purposes when work is in progress are warned against the potential hazard.
- A medical surveillance program must be instituted for all the persons entering an ABSL-4 facility. This program must include appropriate immunizations, serum collection, and availability of post-exposure counseling and potential prophylaxis. In general, persons who may be at increased risk of acquiring infection, or for whom infection might have serious

consequences, are not allowed in the animal facility unless special procedures can eliminate the extra risk.

- The personnel shall be warned of special hazards, and are required to read and to follow instructions on practices and procedures.
- Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human use shall be done only in designated areas and are not permitted in animal or procedure rooms.
- All procedures are carefully performed to minimize the creation of aerosols or splatters.
- The equipment and work surfaces in the room shall be routinely decontaminated with an appropriate disinfectant after work with the infectious agent, and especially after overt spills, splashes, or other contaminations by infectious materials.
- Only the personnel properly trained and equipped to work with infectious materials are to clean up spills. Spills and accidents that result in overt exposures to infectious materials must be immediately reported to the facility in-charge and HS. Medical evaluation, surveillance, and treatment are provided as appropriate and written records are maintained.
- All wastes (including animal tissues, carcasses, and contaminated bedding), and other materials for disposal, and clothing to be laundered, shall be sterilized in a double-door autoclave located in the secondary barrier wall of the facility.
- Needles and syringes or other sharp instruments shall be restricted in the animal facility for use only when there is no alternative, such as for parenteral injection, blood collection, or aspiration of fluids from the laboratory animals and diaphragm bottles.
- Syringes that re-sheathe the needle, needle- less systems, and other safe devices shall be used when appropriate.
- Plastic ware shall substitute glassware whenever possible.
- A biohazard sign must be posted on the entrance to the animal room whenever infectious agents are present. The hazard warning sign identifies the infectious agent(s) in use, lists the name and telephone number of the responsible person(s), and indicates the special requirements for entering the animal room (e.g., the need for immunizations and respirators).
- Laboratory personnel shall receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. Personnel receive annual updates, or additional training as necessary for procedural or policy changes. Records are maintained on all training provided.
- Cages shall be autoclaved or thoroughly decontaminated before bedding is removed and before they are cleaned and washed. The equipment and work surfaces are routinely decontaminated with appropriate disinfectants after work with infectious materials, and especially after spills, splashes, or other contamination by infectious materials. Equipment must be decontaminated before removal from the facility for repair or maintenance.
- The personnel assigned to work with infected animals shall work in pairs. Use of squeeze cages, working only with anesthetized animals, or other appropriate procedures to reduce possible worker exposure must be implemented.
- Materials not related to the experiment (e.g., plants, animals) shall not be permitted in the facility.

4.3.4.2 Special Practices

- Additional measures shall be implemented to control access (e.g., 24-hour guard and check in/out system). The personnel enter and leave the facility only through the clothing change and shower rooms. The personnel shower each time they leave the facility. The personnel shall not enter or leave the facility through the air locks, except in an emergency.

- In a Class III cabinet operation, personal clothing shall be removed in the outer clothing change room and kept there. Complete laboratory clothing, including undergarments, pants and shirts or jump suits, shoes, and gloves, shall be provided and used by the personnel entering the facility. When exiting, the personnel should remove laboratory clothing in the inner change room before entering the shower area. Soiled clothing is sterilized in an autoclave.
- In an ABSL-4 suit operation, a complete clothing change is required. A personal shower shall be required following removal of the decontaminated suit. Soiled lab clothing shall be autoclaved before laundering.
- Supplies and materials shall be introduced into the facility via a double-door autoclave or fumigation chamber. After the outer door is secure, the personnel inside the facility open the inner door to retrieve the materials. The doors of the autoclave and fumigation chamber shall be interlocked in a manner that prevents opening of the outer door unless the autoclave has been operated through a "sterilization cycle" or the fumigation chamber has been decontaminated.

4.3.4.3 Safety Equipment (Primary Barriers)

- The laboratory animals infected with Biosafety Level 4 agents must be housed within a Class III biological safety cabinet in a BSL-4 Cabinet Laboratory. In a BSL-4 Suit Laboratory, all personnel shall be required to wear one-piece anti-pressure suits ventilated with a life support system. Infected animals shall be housed in a partial containment system (such as open cages placed in ventilated enclosures, solid wall and bottom cages covered with filter bonnets and opened in laminar flow hoods, or other equivalent primary containment systems).
- The use of disposable material that does not require cleaning, including animal caging, should be considered. Disposable materials must be autoclaved on exit from the facility before disposal.

4.3.4.4 Facilities (Secondary Barriers)

BSL-4 animal areas may be included as an integral part of BSL-4 Cabinet Laboratories or Suit Laboratories as described in Section 3.3.4.4.4 Laboratory Facility (Secondary Barriers). The facility requirements described in the BSL-4 Laboratory section should be utilized in conjunction with the caging described in the equipment section above.

4.4 Biological Safety Cabinet

Laboratory techniques may produce aerosols, which can contain hazardous research materials, such as infectious agents or chemical carcinogens that can be inhaled by laboratory workers. Biological safety cabinets (BSC) are used as primary barriers to contain hazardous research materials in order to prevent exposure of laboratory personnel and contamination of the general environment. Some biological safety cabinets are designed also to provide a clean work environment to protect cell cultures or sterile apparatus.

4.4.1 Principles of Containment

Containment of hazardous aerosols in biological safety cabinets is achieved by the use of air barriers, physical barriers, and HEPA filtration. Air barriers provide containment by use of directional airflow from the laboratory past the researcher into the cabinet via the work opening. Hazardous aerosols generated during the experimental procedures inside the cabinet are captured and carried by the flow of air and then trapped in HEPA filters. Some biological safety cabinets provide protection of experimental procedures using uniform, unidirectional HEPA filtered air, referred to as laminar air flow that continuously flows over the work area. Turbulence inside the cabinet is minimized by the laminar air flow allowing for immediate removal of contaminants generated by the procedures. The integrity of the containment provided by air barriers can be compromised by the disruption of the air flow patterns in the cabinet. Air barriers are therefore believed to provide only partial containment and should not be used with highly toxic or infectious materials requiring Biosafety Level 4 containment.

Physical barriers are impervious surfaces such as metal sides, glass panels, rubber gloves and gaskets, which physically separate the experimental procedures from the researcher. Biological safety cabinets incorporating all of these physical barriers (class III BSC), and not relying on air barriers, can be used for higher risk agents since compromising containment is less likely than with air barriers.

High efficiency particulate air (HEPA) filters are defined as filters with a filtration efficiency of 99.97% for thermally generated monodisperse dioctylphthalate (DOP) 0.3 mm diameter particles. Because of their high efficiency, HEPA filters are used in biological safety cabinets to remove virtually all particulates, including hazardous microbiological and chemical aerosols, in the air stream passing through the filter. All biological safety cabinets have exhaust filters that remove contaminants as air is discharged from the cabinet. Some types of biological safety cabinets also have supply HEPA filters which provide clean air to the work area. HEPA filters are not effective in capturing chemical vapors.

4.4.2 Classification of Biological Safety Cabinets

There are three classes of biological safety cabinets, designated as Class I, Class II, and Class III. Class I and II cabinets have a protective air barrier across the work opening that separates the laboratory researcher from the work area. Class II cabinets have an additional feature of providing a HEPA filtered, clean work area to protect the experiment from room contamination. There are several variations of Class II cabinets which are described below. Class III biological safety cabinets have a physical barrier between the operator and the work area. Arm length rubber gloves are sealed to glove ports on the cabinet to provide the operator with access to the work area.

4.4.2.1 Class I (Figure 1)

- The Class I cabinet is ventilated for personnel and environmental protection with an inward airflow away from the operator. It is similar in air movement to a chemical laboratory hood.
- The minimum air flow through the work opening is 75 feet per minute (fpm).
- The cabinet exhaust air is HEPA filtered to protect the environment before it is discharged to the outside atmosphere.
- This cabinet is suitable for work with low and moderate risk biological agents, where no product protection is required.

- Provide good operator protection but do not protect the material within the cabinet (the product) from contamination

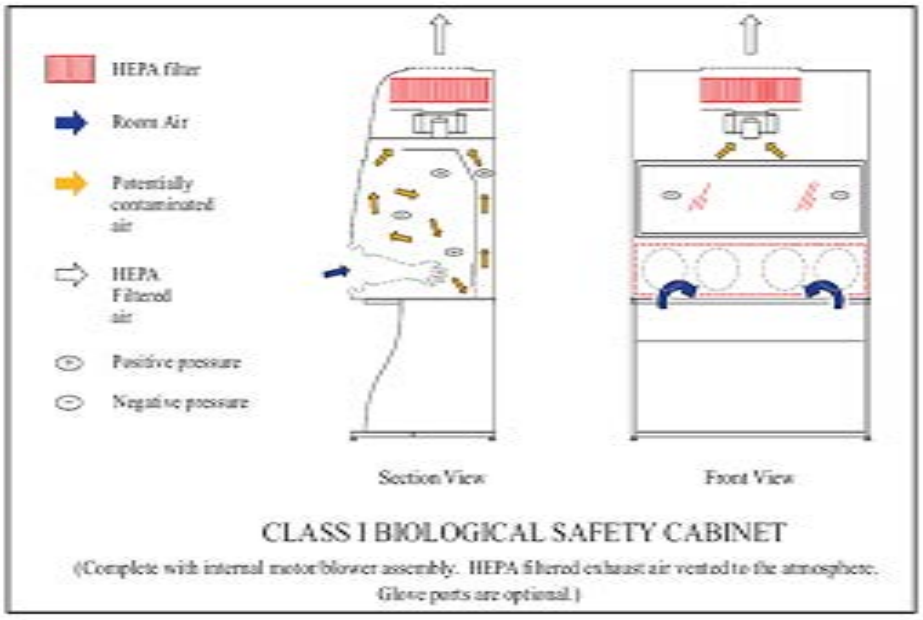

Figure 1a. Class I BSC

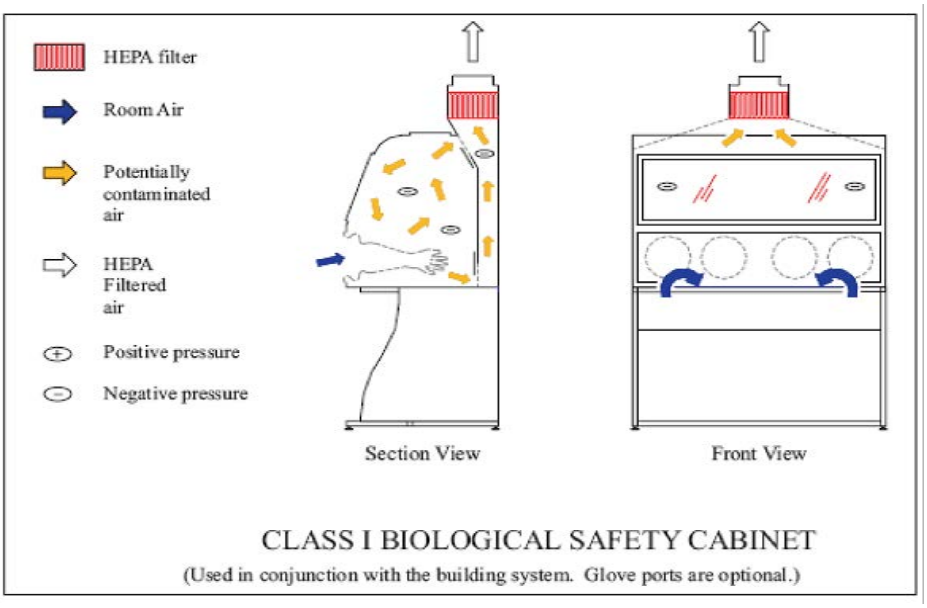

Figure 1b. Class I BSC

4.4.2.2 Class II

- The class II cabinet is ventilated for the personnel, product, and environmental protection having an open front and inward airflow for personnel protection.
- Product protection is provided by HEPA filtered laminar airflow from a diffuser located above the work area. The down flow air splits at the work surface, and exits the work area through grilles located at both the rear and front of the work surface, respectively.
- The cabinet has HEPA filtered exhausted air for environmental protection.
- Designed for work involving microorganisms in containment levels 2, 3 and 4 laboratories and are divided into two types (A and B) on the basis of construction type, airflow velocities and patterns, and exhaust systems(4).
- Within type (A), there are two subtypes, A1 (formerly designated type A) and A2 (formerly designated type B3).
- Within type (B), there are two subtypes, B1 and B2. Class II cabinets are most commonly used in biomedical research laboratories because of their characteristics.

4.4.2.3 Class II, Type A1 Cabinets (Figure 2)

- The cabinet air may be recirculated back into the laboratory or ducted out of the building by means of a "thimble" connection (i.e., a small opening around the cabinet exhaust filter housing) whereby the balance of the cabinet is not disturbed by fluctuations in the building exhaust system. The thimble must be designed to allow for proper certification of the cabinet (i.e., provide access to permit scan testing of the HEPA filter).
- Maintain a minimum average face velocity of 0.38 m/s (75ft/min).
- May have positive pressure contaminated ducts and plenums.
- Are not suitable for work with low levels of volatile toxic chemicals and volatile radionuclides

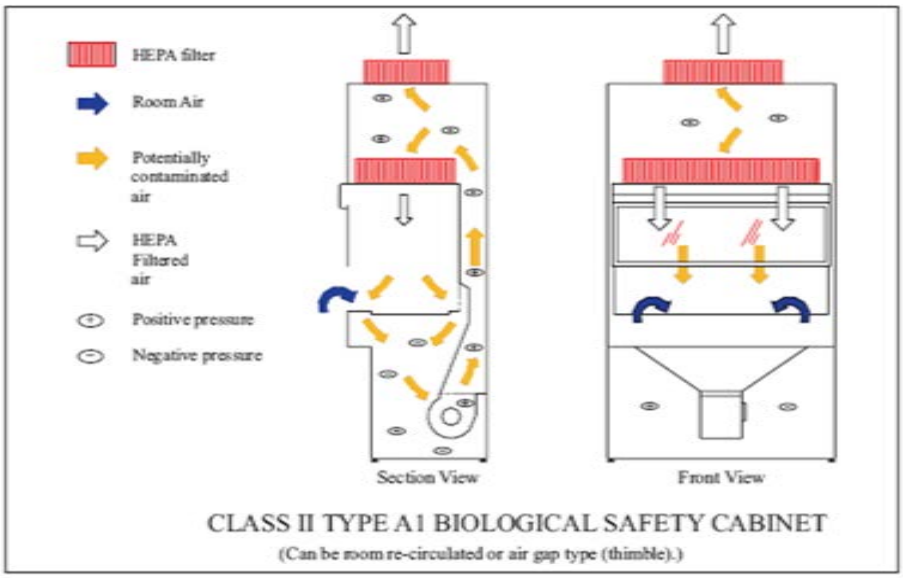

Figure 2. Class II Type A1 BSC

4.4.2.4 Class II, Type A2 Cabinets (Figure 3)

- Cabinet air may be recirculated back into the laboratory or ducted out of the building by means of a "thimble" connection (i.e., a small opening around the cabinet exhaust filter housing) whereby the balance of the cabinet is not disturbed by fluctuations in the building exhaust system. The thimble must be designed to allow for proper certification of the cabinet (i.e., provide access to permit scan testing of the HEPA filter).
- Maintain a minimum average face velocity of 0.5 m/s (100ft/min).
- Have ducts and plenums under negative pressure.
- Is suitable for work with minute quantities of volatile toxic chemicals and trace amounts of radionuclides.

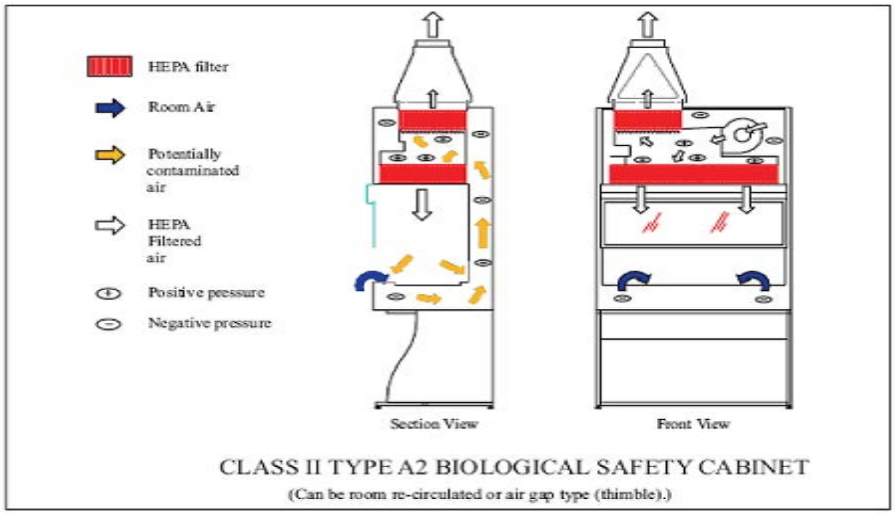

Figure 3. Class II Type A2 BSC

4.4.2.5 Class II, Type B1 Cabinets (Figure 4)

- Hard-ducted through a dedicated duct exhausted to the atmosphere after passage through a HEPA filter; containing negative pressure plena.
- Maintain a minimum average face velocity of 0.5 m/s (100 ft/min).
- Recirculate 30% of the air within the cabinet.
- Suitable for work with low levels of volatile toxic chemicals and trace amounts of radionuclides.

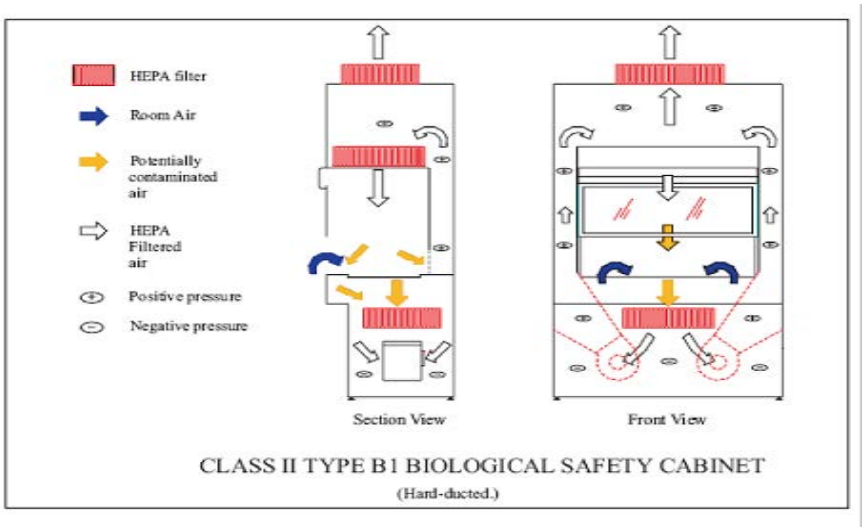

Figure 4. Class II Type B1

4.4.2.6 Class II, Type B2 Cabinets (Figure 5)

- Does not recirculate air within the cabinet.
- Maintain a minimum average face velocity of 0.5 m/s (100 ft/min).
- Hard-ducted through a dedicated duct exhausted into the atmosphere, 100% of cabinet air, after passage through a HEPA filter; contain negative pressure plena.
- Suitable for work with volatile toxic chemicals and radionuclides.
- The exhaust canopy must allow for proper BSC certification. An alarm should be provided that is audible at the cabinet to indicate loss of exhaust flow from the building exhaust system. The cabinet internal fan should also be interlocked to shut down when the building exhaust system fan fails to prevent pressurization of the cabinet.

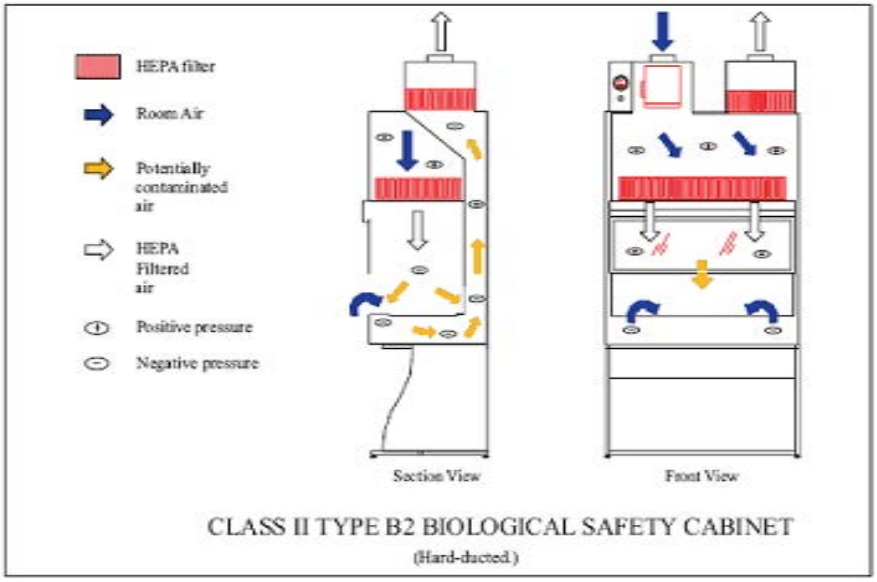

Figure 5. Class II Type B2

4.4.2.7 Class III Cabinets

- The cabinets are totally enclosed and gas-tight with HEPA filtered supply and exhaust air.
- Work is performed with attached long-sleeve- gloves.
- The cabinet is kept under negative pressure of at least 120 Pa, and airflow is maintained by a dedicated exterior exhaust system.
- Cabinets protect the worker and the product.
- Designed for work with level 4 pathogens and provide an alternative to the positive-pressure suit made for the maximum containment laboratories.
- Cabinet lines consisting of several Class III cabinets (e.g., for centrifuges, animal cages, incubators, refrigerators) and transfer devices joined together are traditionally custom built.
- The exhaust air is double HEPA filtered or treated by HEPA filter and incineration. Removal of materials from the cabinet must be through a dunk tank, double door autoclave or air-lock pass-through for decontamination. Interlock or protocols must be used for the autoclave and pass-through doors to prevent both doors from being opened at the same time.

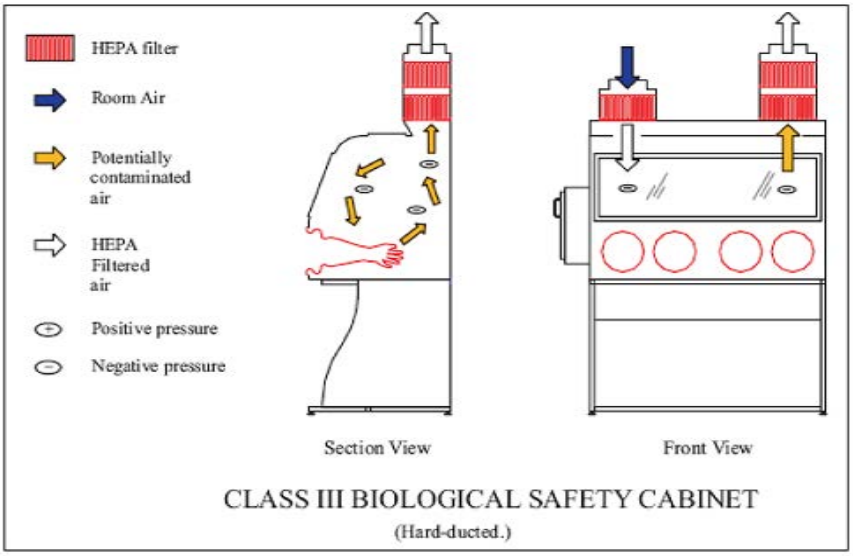

Figure 6. Class III BSC

4.4.3 Installation & Certification of Biological Safety Cabinets

The air curtain at the front of the cabinet is fragile and can easily be disrupted by people walking parallel to it, by the open windows, the air supply registers the laboratory equipment that creates air movement (e.g., vacuum pumps, centrifuges). BSCs should be installed in accordance with the requirements outlined in the NSF Standard 49. They should be located away from high traffic areas, doors and air supply/exhaust grilles that may interrupt airflow patterns. A minimum unobstructed distance of 40 cm should be provided between the exhaust outlet on top of the cabinet and any overhead obstructions. Whenever possible, a 30 cm clearance should be provided on each side of the cabinet to allow for maintenance access. For ducted cabinets, blowers on the exhaust system should be located at the terminal end of the ductwork; failure of exhaust flow should signal an alarm to the user. To prevent pressurization of the cabinet, an interlock system should be installed to prevent the cabinet blower from operating whenever the exhaust flow is insufficient; an anti-backflow device to prevent reverse airflow through the HEPA filter may be required.

Continuous operation of BSCs helps to control dust levels and other airborne particulates in the laboratory. If BSCs are operated only when needed in order to conserve energy, the balancing of laboratory room air must be considered. In some cases, room exhaust is

balanced to include the air exhausted through ducted BSCs, and these cabinets must not be turned off.

The provision of natural gas to BSCs is not recommended. Open flames in the BSC would create turbulence, disrupt airflow patterns and can damage the HEPA filter. When suitable alternatives (e.g., disposable sterile loops, micro-incinerators) are not possible, touch-plate microburners that have a pilot light to provide a flame on demand may be used.
The correct operation of BSCs must be verified before they are used and annually then, and after any repairs or relocation, in accordance with the field tests outlined in annex F of NSF Standard 49. Moving a cabinet can cause damage to the HEPA filter and its seals. These tests include the downward velocity profile, the work access face velocity, the HEPA is the filter leak test and the airflow smoke patterns. Measuring and testing equipment must be calibrated and maintained in accordance with the NSF Standard 49 standard. A copy of the certification report must be provided to the user and kept on file. A label indicating the date of certification, the date of the next certification, to what standard the tests were performed and the name of the certifier should be affixed to the exterior of the cabinet. On-site field testing must be performed by experienced qualified individuals. The NSF accreditation program for BSC certifiers provides a list of individuals who have demonstrated their competence by means of written and practical examinations administered by the NSF. Whenever possible, it is recommended that NSF-accredited field certifiers be used.

4.4.4 Use of the Cabinet

Follow these **start-up procedures** when preparing for work in the BSC:

- Turn off UV lights if in use and ensure that the sash is in the appropriate position.
- Turn on fluorescent light and cabinet blower, if off.
- Check the air intake and exhaust grilles for obstructions.
- If the cabinet is equipped with an alarm, test the alarm and switch it to the "on" position.
- Confirm inward airflow by holding a tissue at the middle of the edge of the viewing panel and ensuring that it is drawn in.
- Disinfect the interior surfaces with a suitable, noncorrosive disinfectant.
- Assemble all materials required for the procedure and load them into the cabinet; do not obstruct the air grilles; the working surface may be lined with absorbent paper with plastic backing; segregate "clean" items from “contaminated" items.
- Wait 5 minutes to purge airborne contaminants from the work area.

Follow these procedures for **working in the cabinet**:

- Don protective clothing and gloves as appropriate.
- Perform operations as far to the rear of the work area as possible.
- Avoid movement of materials or excessive movement of hands and arms through the front access opening during use; when you do enter or exit the cabinet, do so from straight on; allow the cabinet to stabilize before resuming work.

4.5 Biohazards and Potentially Infectious Materials

4.5.1 Biological Risk Assessment

It is the responsibility of the principal investigator or laboratory supervisor in-charge to conduct a risk assessment to determine the proper work practices and containment requirements for work with biohazardous materials. The risk assessment process (*refer to QU HSEMS Section 6.0 Risk Management*) should identify features of microorganisms as well as host and environmental factors that influence the potential for workers to meet with a biohazard incident. This responsibility cannot be shifted to inexperienced or untrained personnel.

The principal investigator or laboratory supervisor in-charge should consult with HS to ensure that the laboratory complies with the established guidelines and regulations. When performing a risk assessment, it is advisable to take a conservative approach if there is incomplete information available. Factors to consider when evaluating a risk include the following:

- Pathogenicity: The more severe the potentially of the acquired disease, the higher the risk.
- Route of transmission: Agents that can be transmitted by the aerosol route which have been known to cause the most laboratory-acquired infections. The greater the aerosol potential, the higher the risk of the infection. Work with *Mycobacterium tuberculosis* is performed at Biosafety Level 3 because disease is acquired via the aerosol route.
- Agent stability: The greater the potential for an agent to survive in the environment, the higher the risk can be. Consider factors such as a desiccation, exposure to sunlight or ultraviolet light, or exposure to chemical disinfections when looking at the stability of an agent.
- Infectious dose: Consider the amount of an infectious agent needed to cause infection in a normal person. An infectious dose can vary from one to hundreds of thousands of organisms or infectious units. An individual's immune status can also influence the infectious dose.
- Concentration: Consider whether the organisms are in solid tissue, viscous blood, sputum, etc., the volume of the material and the laboratory work planned (amplification of the material, sonication, centrifugation, etc.). In most instances, the risk increases as the concentration of microorganisms increases.
- Origin: This may refer to the geographic location (domestic or foreign), host (infected or uninfected human or animal), or nature of the source (potential zoonotic or associated with a disease outbreak).
- Availability of data from animal studies: If the human data is not available, information on the pathogenicity, infectivity, and route of exposure from animal studies may be valuable. Use caution when translating infectivity data from one species to another.
- Availability of an effective prophylaxis or therapeutic intervention: Effective vaccines, if available, should be offered to the laboratory personnel in advance of their handling of infectious material. However, immunization does not replace engineering controls, proper practices and procedures and the use of personal protective equipment (PPE). The availability of post-exposure prophylaxis should also be considered.
- Medical surveillance: Medical surveillance programs may include monitoring the staff health status, participating in post-exposure management, staff counseling prior to offering vaccination, and annual physicals.
- Experience and skill level of at-risk personnel: Laboratory workers must become proficient in specific tasks prior to working with microorganisms. Laboratory workers may have to work with non-infectious materials to ensure they have the appropriate skill level prior to

working with biohazardous materials. Laboratory workers may have to go through additional training (e.g., HIV training, BSL-3 training, etc.) before they are allowed to work with materials or in a designated facility.

- Infectious agents may be classified into risk groups based on their relative hazard. The table below, presents the "Basis for the Classification of Biohazardous Agents by Risk Group."

Risk Group 1	Agents that are not associated with diseases in healthy adult humans
Risk Group 2	Agents that are associated with human diseases which are rarely serious and for which preventive or therapeutic interventions are often available
Risk Group 3	Agents that are associated with serious or lethal human diseases for which preventive or therapeutic interventions may be available (high individual risk but low community risk)
Risk Group 4	Agents that are likely to cause serious or lethal human diseases for which preventive or therapeutic interventions are not usually available (high individual risk and high community risk)

4.5.2 Agent List

The following agents have been listed according to the most appropriate Biological Safety Level to be used. The list presented below is based upon the risk groups given in the March 1996 *Guidelines for Research Involving Recombinant DNA Molecules* (National Institute for Health, NIH Guidelines), Appendix B, the agent summary statements in the Center for Disease Control and Prevention, CDC/NIH publication, *Biosafety in Microbiological and Biomedical Laboratories (BMBL)*, 5th edition (2007), guidance from state and local regulatory agencies, and recommendations of the CDC.

Please note that the Biological Safety Levels are not inherent to an agent but are performance recommendations and should be chosen after a risk assessment is completed. A proper risk assessment takes into account the characteristics of the agent involved, the activities to be performed, and the environment in which the work will be completed. Therefore, certain agents may be used at different Biological Safety Levels depending upon the circumstances. For instance, human clinical samples from HIV-positive patients may be safely handled at BSL-2. Growth of HIV in culture should be performed under BSL-3 containment. Biological Safety Levels may be higher or lower than what is given below for a particular agent depending upon the circumstances of its use.

The Laboratory Safety Subcommittee reviews all the projects involving recombinant DNA, infectious disease agents, and agents of concern to livestock and agriculture and will assist you in the risk assessment process. Once the Laboratory Safety Subcommittee assigns a Biological Safety Level, it must be adhered to unless new information to warrant a change, in most cases from peer-reviewed literature, is provided. The Laboratory Safety Subcommittee will review the literature and make an adjustment, if warranted.

4.5.2.1 Agents - Biological Safety Level 1 (BSL-1)

Agents that are not associated with diseases in healthy adult humans, are of minimal potential hazard to the laboratory personnel, and of minimal potential hazard to the environment may be used at BSL-1. Agents that may be used at BSL-1 include *Lactobacillus* spp., asporogenic

Bacillus subtilis or *Bacillus licheniformis*, *Escherichia coli*-K12 (cloning strains), Baculoviruses, and adeno-associated virus types 1 through 4 in low concentrations (<109 IP/ml).

Those agents not listed under the Biological Safety Levels 2, 3 and 4 are not automatically or implicitly classified as BSL-1; a risk assessment must be conducted based on the known and potential properties of the agents and their relationship to agents that are listed.

4.5.2.2 Agents - Biological Safety Level 2 (BSL-2)

Agents to be used at BSL-2 are associated with human diseases which are rarely serious and for which preventive or therapeutic interventions are often available. They are of moderate potential hazard to the laboratory personnel and/or the environment

BSL-2 - Bacterial Agents Including Chlamydia:

- *Acinetobacter baumannii (formerly Acinetobacter calcoaceticus)*
- *Actinobacillus*
- *Actinomyces pyogenes (formerly Corynebacterium pyogenes)*
- *Aeromonas hydrophila*
- *Amycolata autotrophica*
- *Archanobacterium haemolyticum (formerly Corynebacterium haemolyticum)*
- *Arizona hinshawii - all serotypes*
- *Bacillus anthracis*
- *Bartonella henselae, B. quintana, B. vinsonii*
- *Bordetella including B. pertussis*
- *Borrelia recurrentis, B. burgdorferi*
- *Burkholderia (formerly Pseudomonas species) except those listed under BSL-3*
- *Campylobacter coli, C. fetus, C. jejuni*
- *Chlamydia psittaci, C. trachomatis, C. pneumoniae*
- *Clostridium botulinum, Cl. chauvoei, Cl. haemolyticum, Cl. histolyticum, Cl. novyi, Cl. septicum, Cl. tetani*
- *Corynebacterium diphtheriae, C. pseudotuberculosis, C. renale*
- *Dermatophilus congolensis*
- *Edwardsiella tarda*
- *Erysipelothrix rhusiopathiae*
- *Escherichia coli - all enteropathogenic, enterotoxigenic, enteroinvasive and strains bearing K1 antigen, including E. coli O157:H7*
- *Haemophilus ducreyi, H. influenzae*
- *Helicobacter pylori*
- *Klebsiella - all species except K. oxytoca (BSL-1)*
- *Legionella including L. pneumophila*
- *Leptospira interrogans - all serotypes*
- *Listeria*
- *Moraxella*
- *Mycobacterium (except those listed under BSL-3) including M. avium complex, M. asiaticum, M. bovis BCG vaccine strain, M. chelonei, M. fortuitum, M. kansasii, M. leprae, M. malmoense, M. marinum, M. paratuberculosis, M. scrofulaceum, M. simiae, M. szulgai, M. ulcerans, M. xenopi*
- *Mycoplasma, except M. mycoides and M. agalactiae which are restricted animal pathogens*
- *Neisseria gonorrhoeae, N. meningitidis*
- *Nocardia asteroides, N. brasiliensis, N. otitidiscaviarum, N. transvalensis*

- *Rhodococcus equi*
- *Salmonella including S. arizonae, S. cholerasuis, S. enteritidis, S. gallinarum-pullorum, S. meleagridis, S. paratyphi, A, B, C, S. typhi, S. typhimurium*
- *Shigella including S. boydii, S. dysenteriae, type 1, S. flexneri, S. sonnei*
- *Sphaerophorus necrophorus*
- *Staphylococcus aureus*
- *Streptobacillus moniliformis*
- *Streptococcus including S. pneumoniae, S. pyogenes*
- *Treponema pallidum, T. carateum*
- *Vibrio cholerae, V. parahemolyticus, V. vulnificus*
- *Yersinia enterocolitica*

BSL-2 - Fungal Agents:

- *Blastomyces dermatitidis*
- *Cladosporium bantianum, C. (Xylohypha) trichoides*
- *Cryptococcus neoformans*
- *Dactylaria galopava (Ochroconis gallopavum)*
- *Epidermophyton*
- *Exophiala (Wangiella) dermatitidis*
- *Fonsecaea pedrosoi*
- *Microsporum*
- *Paracoccidioides braziliensis*
- *Penicillium marneffei*
- *Sporothrix schenckii*
- *Trichophyton*

BSL-2 - Parasitic Agents:

- *Ancylostoma human hookworms including A. duodenal, A. ceylanicum*
- *Ascaris including Ascaris lumbricoides suum*
- *Babesia including B. divergens, B. microti*
- *Brugia filaria worms including B. malayi, B. timori*
- *Coccidia*
- *Cryptosporidium including C. parvum*
- *Cysticercus cellulosae (hydatid cyst, larva of T. solium)*
- *Echinococcus including E. granulosis, E. multilocularis, E. vogeli*
- *Entamoeba histolytica*
- *Enterobius*
- *Fasciola including F. gigantica, F. hepatica*
- *Giardia including G. lamblia*
- *Heterophyes*
- *Hymenolepis including H. diminuta, H. nana*
- *Isospora*
- *Leishmania including L. braziliensis, L. donovani, L. ethiopia, L. major, L. mexicana, L. peruvania, L. tropica*
- *Loa loa filaria worms*
- *Microsporidium*
- *Naegleria fowleri*
- *Necator human hookworms including N. americanus*
- *Onchoerca filaria worms including, O. volvulus*

- *Plasmodium including simian species, P. cynomologi, P. falciparum, P. malariae, P. ovale, P. vivax*
- *Sarcocystis including S. sui hominis*
- *Schistosoma including S. haematobium, S. intercalatum, S. japonicum, S. mansoni, S. mekongi*
- *Strongyloides including S. stercoralis*
- *Taenia solium*
- *Toxocara including T. canis*
- *Toxoplasma including T. gondii*
- *Trichinella spiralis*
- *Trypanosoma including T. brucei brucei, T. brucei gambiense, T. brucei rhodesiense, T. cruzi*
- *Wuchereria bancrofti filaria worms*

BSL-2 – Viruses:

- *Adenoviruses, human - all types*
- *Alphaviruses (Togaviruses) - Group A Arboviruses*
- *Eastern equine encephalomyelitis virus*
- *Venezuelan equine encephalomyelitis vaccine strain TC-83*
- *Western equine encephalomyelitis virus*
-
- *Arenaviruses*
- *Lymphocytic choriomeningitis virus (non-neurotropic strains)*
- *Tacaribe virus complex*
- *Other viruses as listed in the BMBL*
-
- *Bunyaviruses*
- *Bunyamwera virus*
- *Rift Valley fever virus vaccine strain MP-12*
- *Other viruses as listed in the BMBL*
- *Calciviruses*
- *Coronaviruses*
- *Flaviviruses (Togaviruses) - Group B Arboviruses*
- *Dengue virus serotypes 1, 2, 3, and 4*
- *Yellow fever virus vaccine strain 17D*
- *Other viruses as listed in the Biosafety in Microbiological and Biomedical Laboratories (BMML)*
- *Hepatitis A, B, C, D, and E viruses*
- *Herpesviruses - except Herpesvirus simiae (Monkey B virus), BSL-4*
- *Cytomegalovirus*
- *Epstein Barr virus*
- *Herpesvirus ateles*
- *Herpesvirus saimiri*
- *Herpes simplex types 1 and 2*
- *Herpes zosterHuman herpesvirus types 6 and 7*
- *Marek's disease virus*
- *Murine cytomegalovirus*
- *Pseudorabies virus*
- *Orthomyxoviruses*
- *Influenza viruses types A, B, and C*

- *Other tick-borne orthomyxoviruses as listed in the BMBL*
- *Papovaviruses*
- *All human papilloma viruses*
- *Bovine papilloma virus*
- *Polyoma virus*
- *Shope papilloma virus*
- *Simian virus 40 (SV40)*
- *Paramyxoviruses*
- *Newcastle disease virus*
- *Measles virus*
- *Mumps virus*
- *Parainfluenza viruses types 1, 2, 3, and 4*
- *Respiratory syncytial virus*
- *Parvoviruses*
- *Human parvovirus (B19)*
- *Picornaviruses*
- *Coxsackie viruses types A and B*
- *Echoviruses - all types*
- *Polioviruses - all types, wild and attenuated*
- *Rhinoviruses - all types*
- *Poxviruses*
- *Vaccinia - all types except Monkeypox virus (BSL-3) and restricted poxviruses including Alastrim, Smallpox, and Whitepox (restricted to the CDC, Atlanta, GA)*
- *Reoviruses - all types including Coltivirus, human Rotavirus, and Orbivirus (Colorado tick fever virus)*
- *Retroviruses*
- *Avian leukosis virus*
- *Avian sarcoma virus*
- *Bovine leukemia virus*
- *Clinical samples from HIV-positive patients*
- *Feline immunodeficiency virus*
- *Feline leukemia virus*
- *Feline sarcoma virus*
- *Gibbon leukemia virus*
- *Mason-Pfizer monkey virus*
- *Mouse mammary tumor virus*
- *Murine leukemia virus*
- *Murine sarcoma virus*
- *Rat leukemia virus*

NOTE: *Murine Retroviral Vectors*
Murine retroviral vectors to be used for human transfer experiments (less than 10 liters) that contain less than 50% of their respective parental viral genome and that have been demonstrated to be free of detectable replication competent retrovirus can be maintained, handled, and administered, under BL1 containment.

- *Rhabdoviruses*
- *Rabies virus - all strains*
- *Vesicular stomatitis virus - laboratory adapted strains ONLY including VSV-Indiana, San Juan, and Glasgow*
- *Togaviruses (see Alphaviruses and Flaviviruses)*
- *Rubivirus (rubella)*

4.5.2.3 Agents - Biological Safety Level 3 (BSL-3)

Agents to be used at BSL-3 are associated with serious or lethal human disease for which preventive or therapeutic interventions may be available.

BSL-3 - Bacterial Agents Including Rickettsia:

- *Bartonella*
- *Brucella including B. abortus, B. canis, B. suis*
- *Burkholderia (Pseudomonas) mallei, B. pseudomallei*
- *Coxiella burnetii*
- *Francisella tularensis*
- *Mycobacterium bovis (except BCG strain, BSL-2), M. tuberculosis*
- *Pasteurella multocida type B -"buffalo" and other virulent strains*
- *Rickettsia akari, R. australis, R. canada, R. conorii, R. prowazekii, R. rickettsii, R, siberica, R. tsutsugamushi, R. typhi (R. mooseri)*
- *Yersinia pestis*

BSL-3 - Fungal Agents:

- *Coccidioides immitis* (sporulating cultures; contaminated soil)
- *Histoplasma capsulatum*, *H. capsulatum* var.. *duboisii*

BSL-3 - Parasitic Agents:

None

BSL-3 - Viruses and Prions:

- *Alphaviruses (Togaviruses) - Group A Arboviruses*
  - *Semliki Forest virus*
  - *St. Louis encephalitis virus*
  - *Venezuelan equine encephalomyelitis virus (except the vaccine strain TC-83 is BSL-2)*
- *Arenaviruses*
  - *Lymphocytic choriomeningitis virus (LCM) (neurotropic strains)*
  - *Flexal*
- *Bunyaviruses*
  - *Hantaviruses including Hantaan virus*
  - *Rift Valley fever virus*
- *Flaviviruses (Togaviruses) - Group B Arboviruses*
  - *Japanese encephalitis virus*
  - *Yellow fever virus*
- *Poxviruses*
  - *Monkeypox virus*
- *Prions*
  - *Transmissible spongiform encephalopathies (TME) agents, Creutzfeldt-Jacob disease and kuru agents (see BMBL for specific containment instruction)*
- *Retroviruses*

- *Human immunodeficiency virus (HIV) types 1 and 2*
- *Human T cell lymphotropic virus (HTLV) types 1 and 2*
- *Simian immunodeficiency virus (SIV)*

- *Rhabdoviruses*
  - *Vesicular stomatitis virus*

4.5.2.4 Agents - Biological Safety Level 4 (BSL-4)

Agents to be used at BSL-4 are likely to cause serious or lethal human diseases for which preventive or therapeutic interventions are not usually available.

BSL-4 - Bacterial Agents:

None

BSL-4 - Fungal Agents:

None

BSL-4 - Parasitic Agents:

None

BSL-4 - Viral Agents:

- *Arenaviruses (Togaviruses) - Group A Arboviruses*
  - *Guanarito virus*
  - *Lassa virus*
  - *Junin virus*
  - *Machupo virus*
  - *Sabia virus*

- *Bunyaviruses (Nairovirus)*
  - *Crimean-Congo hemorrhagic fever virus*

- *Filoviruses*
  - *Ebola virus*
  - *Marburg virus*
- *Filoviruses (Toga viruses) - Group B Arboviruses*
  - *Tick-borne encephalitis virus complex including Absetterov, Central European encephalitis, Hanzalova, Hypr, Kumlinge, Kyasanur Forest disease, Omsk hemorrhagic fever, and Russian spring-summer encephalitis viruses*

- *Herpesviruses (alpha)*
  - *Herpesvirus simiae (Herpes B or Monkey B virus)*

- *Paramyxiviruses*
  - *Equine morbillivirus*

- *Hemorrhagic fever agents*

4.6 Project Registration

Some research projects involve work with potentially hazardous biological agents, known infectious disease agents, or biological materials regulated by the state government. Many granting agencies require that the university monitor the use of biological hazards, infectious disease agents, and recombinant DNA in order for them to raise funds to investigators. Therefore, we have developed a registration system to ensure that all biological materials are handled properly and disposed of appropriately. The Laboratory Safety Subcommittee administers four registration programs for research projects.

4.6.1 Bio-Agent (BA) Registration

Use of the following materials requires that the principal investigator completes and submits the bio-agent registration document for approval by the Laboratory Safety Subcommittee.

Agents to be used at Biosafety Level 2 (BSL-2) or Biosafety Level 3 (BSL-3):

- All human, animal, or plant pathogens that require BSL-2 or BSL-3 containment and handling (see previous section: "Agents List") must be registered. Please note that BSL-4 agents may not be used at Qatar University.
- Unknown human and animal pathogens must be registered. These are considered BSL-2 until identified.
- Cell lines or cultures that:
  - have been immortalized with a virus (such as EBV or a retrovirus),
  - are known to be tumorigenic in primates (including humans), or
  - are primary human tumor cells. These are considered BSL-2 (or higher in many cases).
- Human blood or other tissues that are known to be HIV positive (or positive for any human disease-causing virus or other agent), when used in research, must be registered.

4.6.2 Recombinant DNA (R-DNA) Registration

All R-DNA projects that involve a living recombinant organism require registration. A subset of R-DNA projects requires review and approval from the Laboratory Safety Subcommittee. The committee oversees all research projects and issues involving R-DNA. Use of the following requires that the principal investigator completes and submits an R-DNA registration document.

- All R-DNA projects, including the growth of recombinant bacteria for probe isolation (plasmid or phage preparations) require registration. Projects must be registered regardless of where the material came from or who originally constructed it.
- The development of transgenic animals and plants requires registration.

R-DNA projects are performed at BSL-1, BSL-2, and BSL-3. The Laboratory Safety Subcommittee will make the final determination.

4.6.3 Acute Toxins (AT) Registration

The use and storage of chemicals with a mammalian LD_{50} of $\leq$ 100 µg/kg must be registered with the Laboratory Safety Subcommittee. For a partial list, see the Toxins Table in Appendix A. If a toxin is not on the list, it still may require registration, depending upon the LD_{50}.

4.6.4 Select Agents

Lists of agents, toxins, and pathogens in Appendix B are classified as Select Agents. Any possession, use, transfer or shipment of these materials is strictly controlled by regulation.

Researchers considering work with any of these materials must first contact the HS for the approvals, permits, clearances and other necessary paperwork.

4.7 Safe Handling of Laboratory Animals

The personnel involved in the care and use of research animals work in an environment that presents a number of unique hazards from several sources:

- Hazards related to the equipment, materials and practices used in performing routine animal husbandry.
- Hazards related directly or indirectly to animal contact.
- Hazards related to the techniques or materials (e.g., biohazardous substances) that may be used during the course of animal experimentation.

Regardless of the source of hazard, several basic measures should be taken to reduce the risk of personal exposure. These include understanding the hazards likely to be encountered during animal care and use, using properly designed and maintained facilities and equipment to minimize exposures, wearing appropriate personal protective equipment (PPE) and demonstrating the technical proficiency necessary to accomplish experimental manipulations or animal care procedures in safe and humane fashion.

4.7.2 Common Injuries Associated with Animal Husbandry and Care

Possible injuries and accidents associated with working in the laboratory of animal facilities are provided below:

- Burn injuries due to working around cage washers, autoclaves or other sources of hot water or live steam.
- Crush injuries or lacerations from moving caging equipment, operating sanitation equipment or working with intractable large animals.
- Musculoskeletal injuries (strains, sprains or fractures) due to the use of improper technique in lifting or moving heavy equipment or improper restraint and handling of large animals.
- Slip and fall injuries from walking on wet flooring.
- Hearing impairment resulting from working around loud machinery or animals.
- Visual impairment from direct trauma (equipment), splash exposure (detergents, disinfectants, or particulate matter) or exposure to ultraviolet light resulting in corneal damage.
- Skin irritation or contact dermatitis from exposure to chemicals used in cleaning, latex or talc allergy, or in experimental procedures in the animal facility.
- Respiratory exposure to irritating vapors, aerosols or particulates from working with disinfectants and bedding materials.

- Needle stick exposures from attempts to recap hypodermic needles, improper injection technique or delay or improper disposal of used needles.

Personal awareness of hazardous conditions or factors in the environment is critical to avoiding these types of injuries, and individuals shall develop the habit of assessing the environments in which they work. Research staff are encouraged to consult with their supervisors about the hazards which have been identified in particular work areas and the work practices which have proven to be most effective in preventing incidents. Facility supervisors shall also provide a useful orientation about the available resources and use of the facility. MSDS information for all agents used in the animal care operation shall be available for review in each animal facility. Facility supervisor should provide PPE in all of its facilities consisting of masks, gloves, and in many sites, coveralls, booties, bonnets and hearing protection. For most activities conducted in animal rooms or procedure areas involving laboratory animals, research personnel are encouraged to wear a clean lab coat (or equivalent external cover), latex gloves, face (particle) mask and safety glasses. Shoes rather than sandals also should be worn for adequate foot protection.

Refer to *QU HSEMS Section 12.0 Hazard, Near Miss, Incident Reporting and Investigation* for procedures on hazard, near miss and incident reporting and investigation.

4.7.3 Animal Related Hazards

Bites, scratches and other injuries represent a significant portion of the animal-associated hazards encountered by individuals with laboratory animal contact and are readily preventable through proper animal handling technique and the use of proper PPE. Unusual noises, defective equipment, slippery surfaces and conditions conducive to entrapment or distraction of the animal handler shall be eliminated prior to animal handling. Inappropriate animal handling may induce discomfort, pain and distress in the animal provoking a fractious response, introducing undesirable experimental variables and providing the animal the opportunity to inflict injury upon the handler.

The personnel should always wear a long sleeve lab coat or use other sleeve protection when handling rabbits or larger animals to avoid scratch injury, and in some cases special gloves (e.g., stainless steel mesh or heavy leather gauntlets) should be worn to prevent bites. Special attention shall be given to the training of the personnel involved in the handling and restraint of large animals, especially nonhuman primates. In addition to posing a bite and scratch hazard, nonhuman primates can be challenging and difficult to handle safely because of their remarkable strength, dexterity, intelligence and tenacity. Unsuspecting personnel have been injured when nonhuman primates have grabbed and pulled neckties, loose-fitting lab coats or long hair. When it is compatible with the experimental conditions of animal use and/or the clinical condition of the animal, consideration should be given to chemical immobilization of many nonhuman primate species to enable safe animal handling and to reduce the risk of injury for personnel. Specific PPE requirements are in effect for personnel working with monkeys and are posted in the housing areas for these species.

Animal bites continue to be a relatively common occurrence among research personnel and should be regarded seriously even when they have been inflicted by small rodents causing minor tissue damage. The persons who have been bitten should seek prompt medical help with the wound and their tetanus immunization status by their supervisor, and initiate the veterinary evaluation of the animal involved if warranted. Animal bites also prompt a veterinary review of the animal handling circumstances to ensure that proper animal handling techniques were used. A specific, detailed protocol is in effect for bites, scratches or mucous membrane exposures involving some monkey species due the Herpes B virus, an agent which can cause

fatal infection. The list of other specific viral agents that can be involved as wound contaminants includes rabies virus (all mammals), hantavirus (rodents), lymphocytic choriomenigitis virus (rodents) and or virus (sheep and goats). Numerous bacterial agents and at least one fungal agent have also recorded as wound contaminants resulting in serious localized or systemic infections.

4.7.4 Animal Associated Allergy

An estimated 10 to 30 percent of individuals who work with laboratory animals may eventually develop allergy to laboratory animals manifested by reddened, itchy eyes, nasal symptoms and skin rashes. Individuals with pre-existing allergy to other agents have a predisposition to develop an additional sensitivity to animal allergens. Asthma, which is characterized by cough, wheezing, chest tightness and shortness of breath, develops as a further complication in approximately 10 percent of individuals with animal-associated allergy. Also, anaphylaxis, a generalized allergic reaction presenting as diffuse itching, hives and facial and oral swelling can develop and produce life-threatening consequences from laryngeal edema, airway obstruction and shock in certain individuals with massive allergen exposure, often through saliva.

Although rodents, rabbits and cats are most often incriminated in cases of laboratory animal-associated allergy, other mammals and birds also can be involved. Work practices which minimize contact with animal proteins reduce risk for development of allergy. For example, various levels of PPE are available for personnel working with laboratory animals to reduce exposure to allergen.

4.7.5 Zoonoses

Zoonoses are diseases that are transmissible from animals to humans. Laboratory animal species potentially harbor numerous zoonotic agents, including viruses, bacteria, fungi, protozoa and internal and external parasites, but the reported cases of zoonotic transmission to individuals with laboratory animal contact have been infrequent and sporadic. However, because many of the zoonotic disease episodes likely have remained unreported and because those which have been reported involved serious disease and even fatalities, individuals with laboratory animal contact should be aware of these diseases and take appropriate precautionary measures. The likelihood of encountering a zoonoses varies with the species of laboratory animal used, its source and history of veterinary care. Individuals, who become ill and/or feel they have contracted a disease from a laboratory animal, should consult with their supervisor. The major zoonoses are summarized below.

4.7.5.1 Rodents and Rabbits.

The modern conditions of production and care for most laboratory rodents and rabbits have led to the eradication of zoonoses in most of these species. However, these animals can rarely become contaminated through environmental sources, contact with wild rodents or other infected animals or through tumors, cell lines or other biologics used experimentally. In most circumstances, only wild-caught, laboratory maintained rodents would be regarded as a high risk for the transmission of zoonotic diseases. Personnel should be familiar with several zoonoses associated with rodents and rabbits. Two serious systemic viral zoonoses have been associated with the use of laboratory rodents. Lymphocytic choriomeningitis virus causes a flu-like disease with neurological complications, and hantavirus infection produces a disease marked by renal failure and respiratory complications. Other than the bite-associated bacterial

infections from rodents (i.e., rat-bite fever) there are few bacterial zoonoses in these species. The rabbit is a potential source for human bacterial pathogens especially those which cause human diarrheal disease such as salmonellosis. Rodents and rabbits also can be source for human ringworm infection usually recognized as a reddened, annular lesion of the skin of the affected individual. A similar focal dermatitis can be caused by infestation with the rabbit fur mite and, rarely, other mite species of rodents. The dwarf tapeworm infestation of rodents also is capable of infecting man. The complete absence or extremely low incidence of these agents in our laboratory animal populations has obviated our need to adopt intensive health surveillance measures for individuals who work with these species. However, all personnel should use appropriate PPE when working with these species and are encouraged to report unusual illnesses or conditions possibly related to animal contact

4.7.5.2 Dogs and Cats.

Source control and sound programs of veterinary care at the vendors' facilities and at Qatar University ensure that the majority of zoonotic infections are eradicated in these animal species prior to their experimental utilization. In some cases, subclinical infections may go undetected and untreated posing a risk for the personnel who work with these animals. Such infections would include intestinal bacterial infections (salmonellosis, yersiniosis, and campylobacterosis), systemic bacterial infections (brucellosis, cat-scratch fever, leptospirosis and Q-fever) and intestinal parasitic infections (giardiasis and toxoplasmosis). Also, the dog and cat can also harbor the dermatophytes causing human ringworm and other external parasites capable of infesting humans. Proper use of PPE is essential to minimize exposure to these zoonotic hazards. The personnel involved in the use of laboratory cats that have not been specifically bred for research purposes should give consideration to participation in the rabies vaccination program.

4.7.5.3 Non-human Primates

The list of zoonotic diseases in nonhuman primates is long and includes numerous viral (e.g., B virus, hepatitis A and B, measles and SIV), bacterial (e.g., tuberculosis, salmonellosis and shigellosis) and protozoal (e.g., giardiasis and amebiasis) diseases, and there are many documented cases of zoonotic transmission. Consequently, non-human primates must undergo an extensive quarantine period to preclude the presence of many of these zoonoses before experimental work with these animals can be started. Even after release from quarantine, rigorous disease surveillance continues for some agents such as tuberculosis. The personnel also must participate in periodic tuberculin testing if they have any nonhuman primate contact. The persons who work with macaques must undergo special training concerning the prevention and management of potential exposure to B virus, an agent which has caused many fatalities among laboratory personnel. Strict adherence in the use of PPE is expected of all personnel with nonhuman primate contact.

4.7.5.4 Birds and Livestock.

Q fever has proven to be the most important zoonosis associated with livestock in the laboratory animal facility. Although all ruminants and many other animals are potential carriers, infection of laboratory personnel has most often been associated with pregnant sheep that copiously shed the organisms. The disease causes a flu-like illness which can progress to a serious systemic infection with heart involvement. Or, a pox viral disease of sheep and goats, can also infect humans through contaminated wounds producing firm, nodular lesions. Livestock and birds can harbor bacterial zoonoses causing diarrhea in humans. Birds also can shed the agent of psittacosis (*Chlamyia psittaci*), a serious respiratory and systemic disease of

humans. Proper use of PPE is essential to minimize exposure to these potential zoonotic hazards.

4.7.6 Use of Hazardous Agents in Animal Experimentation

Many studies involve the use of hazardous agents in laboratory animals. Often the use of a hazardous substance is incidental to the research, whereas in other circumstances it is an integral component of the study intended to produce a particular experimental effect. Examples of the former include inhalant anesthetic agents (e.g., ether, methoxyflurane, halothane or isoflurane), injectable anesthetic agents (urethane), and adjuvants (particularly Freund's Complete Adjuvant). Examples of the latter include carcinogens, teratogens, mutagens, toxicants, microbial pathogens, radioisotopes, and organisms modified through recombinant DNA techniques. In either case, the use of hazardous agents is noted during the review of the animal protocol and is referred to the HS or the appropriate Qatar University campus committee to verify or establish the conditions under which the hazardous materials can be used safely. In some cases it may be necessary for the institution to engage outside expert consultants and work with the investigator to develop a more elaborate safety protocol and ensure appropriate personnel training before the animal studies can be initiated.

4.7.7 Special Requirements

- Animal facilities shall have a ventilation system of 10 to 20 air changes per hour.
- Animal holding facilities shall have a 30 to 70 % relative humidity and a temperature of 18 to 26 ^{o}C.
- Laboratory workers who work with items possibly contaminated with disease communicable to humans, including tissues, fluids, fecal materials, and equipment which have come into contact with any of these, shall require immunizations.
- Tetanus shots are required for all works with animals, while those who work with wild animals shall require rabies vaccinations.
- A pre-employment medical examination is mandatory and shall include medical and work histories.
- Any worker who comes into contact with human or primate tissue, blood , and fluids must receive training and be offered shots for Hepatitis-B.
- A decontamination process shall be conducted for individual who work with animals which have diseases that are communicable to humans or other animals. Animals shall be kept in isolation areas.

4.8 Decontamination and Disposal

Decontamination and disposal in laboratories which utilize biohazardous materials are closely interrelated acts in which sterilization and disinfection constitute the first phase of disposal. The goals of decontamination are the protection of personnel and the environment from exposure to biological agents. Blood and body fluids in individual containers that contain greater than 20 ml, microbiological waste, and pathological waste, must be treated before any disposal in order to render the waste nonhazardous.

Sterilization is the process of treating an object or material so as to remove or kill all living organisms. Disinfection is the process of the removal or inactivation of all pathogenic microorganisms. It may not remove all microorganisms and therefore, disinfection is not necessarily sterilization. Whether or not sterility is achieved depends on several factors: the number and nature of the contaminating microorganisms, the presence of bacterial spores, the concentration of the germicide, the length of time of contact between the germicide and the material being disinfected, the type and condition of the material, the amount of soil present, and the temperature.

Sterilizing and disinfecting agents may attack microorganisms in several ways. Some disinfectants coagulate the cell protein so that the cell cannot function. They may injure or destroy the cell membrane altering the normal selective permeability allowing toxins to enter metabolically important components to escape, or prevent the entrance of food. Disinfectants may also react with a specific enzyme to prevent it from reacting with its natural substrate.

Microorganisms exhibit a range of resistance to the inactivating agents. In terms of practical decontamination, most vegetative bacteria, fungi and lipid-containing viruses, are relatively susceptible to chemical decontamination. The non-lipid containing viruses and bacteria with a waxy coating such as tubercle bacillus occupy a mid-range of resistance. Spore forms are the most resistant.

4.8.1 Steam Sterilization

Autoclaving, or steam sterilization, is the most dependable procedure for the destruction of all forms of microbial lives. Saturated steam is employed under pressure to achieve a chamber temperature of at least 121 C (250 F) for a minimum of 15 minutes. The time is measured after the temperature of the material being sterilized reaches 121 C. The critical factors in insuring the reliability of this method other than proper temperature and time is the prevention of entrapment of air that is replaced by the steam and adequate exposure time as related to the "soil" load on the contaminated items.
Gravity displacement autoclaves take advantage of the difference in density of the air related to steam. Steam entering the upper-rear of the chamber displaces the air downward and out of the drain line that is located in the lower front of the chamber. A valve in the drain line remains open until a specific pre-set temperature is reached. After this temperature is reached, the valve closes and the steam continues to enter until the pre-set pressure and/or temperature is obtained. The concern with this type of autoclave is that the air in closed or upright containers, or air trapped in closed systems (items with valves, etc.), or densely loaded chamber packages is not readily replaced. If air is not removed from an area, the temperature in that area may remain sub-lethal throughout the decontamination period. Because of this, autoclaves of this type should not be overloaded, densely packed materials should be avoided, systems should be kept open and containers should be turned on their side.

High vacuum autoclaves pump vacuum into the chamber prior to the entrance of the steam. If the vacuum is high (greater than 27 inches Hg.), the air removal concern is alleviated. However, it should be noted that a small load should not be placed in a high-vacuum autoclave because the air remaining in the chamber can be entrained in this load.
Heavily soiled items, especially if the soil is of proteinaceous nature, should be autoclaved for longer periods of time. The reason for this is that soil may protect the microorganism from the lethal effects of the wet heat. Because of this, an exposure time of 60 minutes or greater for soiled items is not unreasonable.

Other practices to improve the effectiveness of autoclave use include removing the plug screen or strainer daily to make sure it is free from dirt, dust, or sediment that may collect in it and cleaning the interior surfaces of residues collected from the steam or materials being sterilized. The use of spore strips (*Bacillus stearothermophilus* spores) placed at locations throughout the autoclave, can serve as a biological indicator of sterility.

Microbiological waste must be steam sterilized in an autoclave, before disposal. Steam under pressure should be provided to maintain a minimum temperature of 250 F for 45 minutes at 15 psi of gauge pressure. The autoclave should be provided with a chart recorder which accurately records time and temperature for each cycle. Monitoring under conditions of full loading for effectiveness should be performed at least once per week through the use of biological indicators. A log of each test should be maintained, which includes the type of indicator used, date, time, and result of the test.

Criteria for autoclaving typical materials

Material	Temperature	Time
Laundry	121 C (250 F)	30 minutes
Trash	121 C (250 F)	1 hour
Glassware	121 C (250 F)	1 hour
Liquids	121 C (250 F, each gallon	1 hour
Animals	121 C (250 F)	8 hours

4.8.2 Dry Heat Sterilization

Dry heat is useful for the sterilization of anhydrous oils, greases, powders, etc., that can be easily permeated by steam. Dry heat sterilization is less efficient than wet heat sterilization and requires longer times and/or higher temperatures. The specific times and temperatures must be determined for each type of material being sterilized. Generous safety factors are usually added to allow for the variables that can influence the efficiency of this method of sterilization. The moisture of the sterilization environment as well as the moisture history of organisms prior to heat exposure begins to affect the efficiency of dry heat sterilization.
Sterilization can usually be accomplished at 160 - 170 C (320 - 338 F) for periods of 2 -4 hours. High temperatures and shorter times may be used for heat resistant materials. The heat transfer properties and the spatial relationships or arrangement of the articles in the load are critical in insuring effective sterilization. If items are heat sensitive then a temperature of 120 C (248 F) must be used, the exposure time necessary for decontamination is usually greater than 24 hours.

The hazards of handling hot solids and liquids are generally well known. The laboratory personnel should be cautioned that steam under pressure can be a source of scalding jets if the equipment for its application is mishandled. Loads of manageable sizes should be used. Fluids treated by steam under pressure may be superheated if removed from the sterilizer too promptly after treatment. This can cause a sudden and violent boiling of the contents from containers that can splash scalding liquids onto personnel handling the containers. Items being handled following dry heat sterilization can cause severe burns if protective gloves are not used.

4.8.3 Gas Sterilization

A variety of gases and vapors possess germicidal properties. The most useful of these are formaldehyde and ethylene oxide. When these are employed in closed systems and under controlled conditions of temperature and humidity, sterilization can be achieved. Vapor and gas disinfectants are primarily useful in sterilizing biological safety cabinets and associated effluent air-handling systems and air filters; bulky or stationary equipment that resist penetration by liquid surface disinfectants; instruments and optics that might be damaged by other methods; and rooms and buildings that are associated with air-handling systems.

Ethylene oxide (ETO) gas is lethal for microorganisms including spores, viruses, molds, pathogenic fungi and highly resistant thermophilic bacteria. Some of the principal variables that determine the rate of destruction includes: temperature, concentration, humidity, and exposure time.

Temperature affects the penetration of ETO into microbial cell walls and the wrapping and/or packaging materials. The activity of ethylene oxide will increase approximately 2.7 times for each 10 C (18 F) rise in temperature (between 5-37 C, concentration 884 mg/l). Normally, ethylene oxide sterilization is conducted at temperatures between 49-60 C (120-140 F).
Sterilization times may be reduced when the concentration is increased. For practical sterilization, gas concentrations of 500-1000 mg/l at approximately 49-60 C are recommended. The effect of moisture appears to be related to the moisture content of the exposed bacterial cell. A relative humidity of 30-60% is frequently employed in ethylene oxide chambers during exposure conditions.

All materials that have been sterilized with ethylene oxide must be aerated at least 24 hours before contact with human skin. Mixtures of 3-10% ethylene oxide in air are explosive. Commercially available mixtures of ethylene oxide in Freon or CO2 are not explosive and can be safely utilized.

Formaldehyde is the chemical of choice for space disinfection of safety cabinets, incubators, refrigerators, laboratory rooms, buildings, or other enclosed spaces. Formaldehyde can be generated by vaporizing aqueous solutions of formalin or heating paraformaldehyde. Generally, the generation of formaldehyde gas from powdered or flake paraformaldehyde by heating to a temperature above 150 F is the preferred method. A concentration of 0.3 g per cubic foot of space to be treated is employed, at a temperature above 20 C and relative humidity of 70% or higher, for an exposure of 8 hours or overnight. Aeration to remove excess formaldehyde should follow, with length of time related to area decontaminated.

Avoid inhalation of vapors of formaldehyde and ethylene oxide. Stock containers of these products should be capable of confining these vapors and should be kept in properly ventilated chemical storage areas in the event of inadvertent leakage. In preparing to use dilutions and during the application, the personnel should control the operations to prevent exposure of others and wear respiratory protection as necessary. Mutagenic potential has been attributed to ethylene oxide and formaldehyde; toxic and hypersensitivity effects are well established for formaldehyde.

4.8.4 Liquid Disinfection

A chemical disinfection is necessary in the laboratory operations because steam under pressure is not feasible for use in large spaces, surfaces, stationary equipment, high temperatures and moistures may damage delicate instruments. There are many disinfectants

available under a wide variety of trade names. In general, these disinfectants can be classified as acids or alkalines, halogens, heavy metal salts, quaternary ammonium compounds, phenolic compounds, aldehydes, and alcohols. Unfortunately, the more active the disinfectant, the more likely it will possess undesirable characteristics.

The relative resistance to the action of chemical decontaminants can be substantially altered by such factors as: concentration of active ingredient, duration of contact, pH, temperature, humidity, and the presence of extrinsic organic matter. Depending upon how these factors are manipulated, the degree of success achieved with chemical decontaminants may range from minimal inactivation of target microorganisms to an indicated sterility within the limits of sensitivity of the assay system employed. Ineffectiveness of a decontaminant may also be due to the failure of the decontaminant to contact the microorganisms rather than the failure of the decontaminant to act. If one places an item in a liquid decontaminant, one can see that the item is covered with tiny bubbles. Of course, the area under the bubbles is dry, and microorganisms in these dry areas will not be affected by the decontaminant. Similarly, if there are spots of grease, rust or dirt on the object, microorganisms under these protective coatings will not be contracted by the decontaminant. Scrubbing an item when immersed in a decontaminant is helpful; a decontaminant should have incorporated surface-active agents and other detergent properties.

4.8.5 Selecting Chemical Decontaminants

No single chemical decontaminant or method will be effective or practical for all the situations in which decontamination is required. Selection of chemical decontaminants and procedures must be preceded by practical consideration of the purposes for the decontamination and the interacting factors that will ultimately determine how that purpose is to be achieved. Selection of any given procedure will be influenced by the information derived from answers to the following questions:

- What is the target microorganism(s)?
- What are the decontaminants, and in what form they are known to, or can be expected to inactivate the target microorganism(s)?
- What degree of inactivation is required?
- In what menstruum is the microorganism suspended; i.e., simple or complex, on solid or porous surfaces, and/or airborne?
- What is the highest concentration of cells anticipated to be encountered?
- Can the decontaminant be either as an aqueous solution, a vapor, or a gas reasonably expected to contact the microorganisms, and can be effective duration of contact to be maintained?
- What restrictions apply with respect to compatibility of materials? Does the anticipated use situation require immediate availability of an effective concentration of the decontaminant or will sufficient time be available for preparation of the working concentration shortly before its anticipated use?

The primary target of decontamination in the infectious disease laboratory is the microorganism under active investigation. Laboratory preparations of infectious agents usually have titers grossly in excess of those normally observed in nature. The decontamination of these high-titer materials involves certain problems. Maintenance systems for bacteria or viruses are specifically selected to preserve viability of the agent. Agar, proteinaceous nutrients, and cellular materials can be extremely effective in physically retarding or chemically binding active moieties of chemical decontaminants. Such interferences with the desired action of decontaminants may require the use of decontaminant concentrations and contact

times in excess of those shown to be effective in the test tube. Similarly, a major portion of the decontaminant contact time required to achieve a given level of agent inactivation may be expended in inactivating a relatively small number of the more resistant members of the population. The current state of the art provides little information on which basis to predict the probable virulence of these survivors. These problems are, however, common to all potentially pathogenic agents and must always be considered in selecting decontaminants and procedures for their use.

An additional area that must be considered and for which there is little definitive information available is the "inactivation" of nucleic acids. Nucleic acids often have better survival characteristics under adverse conditions than do the intact virions and cells from which they were derived. Strong oxidizers, strong acids and bases, and either gaseous or aqueous formaldehyde should react readily with nucleic acids. Their ability to destroy the nucleic acid being studied, however, should be confirmed in the experimenter's laboratory. Owing to the innate differences in the chemistry of RNA and DNA, the effectiveness of a decontaminant for one cannot be extrapolated for the other. For example, RNA molecules are susceptible to mild alkaline hydrolysis by virtue of the free hydroxyl group in the 2' position, whereas DNA molecules are not susceptible to mild alkaline hydrolysis.

4.8.6 Properties of Some Common Decontaminants

4.8.6.1 Alcohol

Ethyl or isopropyl alcohol in a concentration of 70 - 85% by volume is often used. Alcohols rapidly lose their cidal activity when diluted below 50% concentration. The cidal action of ethyl alcohol is very rapid and includes all microorganisms except spores. Isopropanol is not very effective against either spores or non-lipid viruses. They are also not effective when organic soil is present. Alcohols become ineffective as soon as they start to evaporate. This property has the advantage of having no residue on treated surfaces, but it often makes repeated applications desirable in order to get adequate exposure.

4.8.6.2 Formaldehyde

In concentration of 8% formalin, this is an effective liquid disinfectant against vegetative bacteria, spores, and viruses. Considerable activity is lost at refrigeration temperatures. Care must be taken when using solutions in the laboratory because of its irritating odor.

4.8.6.3 Phenol

Phenol itself is not often used as a decontaminant because it is extremely toxic. The odor is somewhat unpleasant and a sticky, gummy residue remains on the treated surfaces. This is especially true during steam sterilization. Although phenol itself may not be in widespread use, phenol homologs and phenolic compounds are basic to a number of popular decontaminants. The phenolic compounds are effective decontaminants against some viruses, rickettsia, fungi and vegetative bacteria. The phenolics are not effective in ordinary usage against bacterial spores.

4.8.6.4 Quaternary Ammonium Compounds or Quats

After 30 years of testing and use, there is still a considerable controversy over the efficacy of the Quats as decontaminants. These cationic detergents are strongly surface-active and are effective against lipid-containing viruses. The Quats will attach to protein so that dilute solutions of Quats will quickly lose effectiveness in the presence of proteins. The Quats tend to clump microorganisms and are neutralized by anionic detergents, such as soap. The

Quats have the advantages of being nontoxic, odorless, no staining, noncorrosive to metals, stable, and inexpensive.

4.8.6.5 Chlorine

This halogen is a universal decontaminant active against all microorganisms, including bacterial spores. Chlorine combines with protein and rapidly decreases in concentration in its presence. Free, available chlorine is an active element. It is a strong oxidizing agent, corrosive to metals. Chlorine solutions will gradually lose strength so that fresh solutions must be prepared frequently. Sodium hypochlorite is usually used as a base for chlorine decontaminants. An excellent decontaminant can be prepared from the household or laundry bleach. These bleaches usually contain 5.25 percent available chlorine or 52,500 ppm. If one dilutes them 1 to 100, the solution will contain 525 ppm of available chlorine, and, if a nonionic detergent such as Naccanol is added in a concentration of about 0.7 percent, a very good decontaminant is created.

4.8.6.6 Iodine

The characteristics of chlorine and iodine are similar. One of the most popular groups of decontaminants used in the laboratory is the iodophors, and Wescodyne is perhaps the most popular. The range of dilution of Wescodyne recommended by the manufacturer is 1 ounce in 5 gallons of water giving 25 ppm, of available iodine to 3 oz. in 5 gallons giving 75 ppm. At 75 ppm, the concentration of free iodine is .0075 percent. This small amount can be rapidly taken up by any extraneous protein present. Clean surfaces or clear water can be effectively treated by 75 ppm available iodine, but difficulties may be experienced if any appreciable amount of protein is present. For bacterial spores, a dilution of 1 to 40 giving 750 ppm is recommended by the manufacturer. For washing the hands, it is recommended that Wescodyne be diluted 1 to 10 with water or 10% ethyl alcohol (a reasonably good decontaminant itself) which will give 1,600 ppm of available iodine, at which concentration relatively rapid inactivation of any and all microorganisms will occur.

Particular care should be taken when handling concentrated stock solutions of disinfectants. The personnel assigned the task of making up use-concentrations from stock solutions must be properly informed of the potential hazards and trained in the safe procedures to follow. The concentrated quaternary and phenolic disinfectants are particularly harmful to the eyes. Protective face shields and goggles should be used for eye protection and long-sleeved garments and chemically resistant gloves, aprons and boots should be worn to protect from corrosive and depigmentation effects to the skin. One of the initial sources for hazard information or any given product will be the label on its container.

4.9 Biological Waste Disposal

Disposal of biohazardous waste shall be disposed according to *QU SOP-04 Hazardous Waste Disposal*.

4.10 Biological Laboratory Closeout Procedures

Whenever a Laboratory Supervisor (or a person under their charge performing work with biological materials in their laboratory) leaves the university or is transferred to a different location, proper disposition of hazardous materials, glassware, benches, laboratory equipment, fume hoods, etc. is required. Laboratory closeout is also required for renovations or constructions taking place in the laboratory. This undertaking shall be properly coordinated with Campus Facilities Department prior to the start of laboratory close out.

If proper management of bi-logical materials at close-out requires removal services from an outside contractor, the responsible department will be charged for this service.

4.10.1 Biological and Hazardous Chemical Disposal in Laboratories and Containment Areas

- Ensure that containers of chemicals and biological materials are labeled.
- All containers must be securely closed. Beakers, flasks, evaporating dishes, etc., should be emptied. Hazardous chemical wastes must not be sewered or trashed; they must be collected for disposal.
- Clean chemicals from glassware and assure proper waste disposal guidelines are followed.
- Never pour chemical residues down the sink unless it is safe.
- Check refrigerators, freezers, fume hoods, storage cabinets and bench tops for chemical containers and thoroughly clean these locations.
- If another room or facility (such as a freezer or refrigerator, stock rooms, etc.) is shared with other researchers, remove, transfer or dispose of items used by the departing researcher.
- Contact the Campus Facilities Department for pick-up of biological and hazardous waste at least one week prior to vacating the laboratory.
- For gas cylinders, remove regulators, replace cap and return to supplier. If cylinders are nonreturnable, arrange for pick up by authorized hazardous waste collector. Gas cylinders used in the containment area must be decontaminated prior to return.
- As an alternative to disposal, if the chemical is still usable, transfer the responsibility of the chemical to another Laboratory in-charge who is willing to take charge of the chemical.
- Follow all guidelines in the University Hazardous Waste Disposal Guide for disposal of unwanted chemicals. The authorized hazardous waste collector will pick up all hazardous waste provided:
  - All chemical containers are properly labeled as "hazardous waste" and are accompanied with a completely filled out hazardous waste tag.
  - All containers are securely closed.
- Notify the concerned laboratory department and Campus Facilities Department when laboratories or containment area/rooms have been cleared.

4.11 Transportation of Biological Materials on Campus

All biological materials that are of potential risk to humans and/or animals must be stored and transported in primary and secondary containers. Primary containers can be culture tubes, flasks, vials etc. All containers must meet the following requirements:

- Rigid
- Puncture resistant
- Leak proof
- Impervious to moisture
- Of sufficient strength to prevent tearing or bursting under normal conditions of use and handling
- Sealed to prevent leakage during transport
- Labeled with a biohazard or infectious substance label

All containers should be accompanied by a list of content, name of the person responsible for this material, a contact person and phone number.
If materials are to be transported in liquid nitrogen or with other protection from ambient or higher temperatures, all containers and packaging should be capable withstanding very low temperatures, and both primary and secondary packaging must be able to withstand a pressure differential of at least 95 kPa and temperatures in the range of - 40°C to + 50°C.
If the material is perishable, warnings should appear on accompanying documents, e.g., "Keep cool, between + 2°C and + 4°C."

4.12 Equipment

If the laboratory equipment is to be left for the next occupant, clean or decontaminate it before departing the laboratory.
If the laboratory equipment is to be discarded, be aware that capacitors, transformers, mercury switches, mercury thermometers, radioactive sources and chemicals must be removed before disposal.
Use the following guide for Biological Safety Cabinets (BSC):
Remove all the contents.

- Disconnect tissue culture media vacuum flask.
- Decontaminate all accessible surfaces with an appropriate disinfectant.
- Decontaminate the BSC by a certified contractor, if a BSC is being relocated to a location outside of the building.
- Re-certify the BSC using a certified contractor when a BSC is relocated.
- If the BSC is not being moved and repair work will not open the contaminated inner space, a surface decontamination with an appropriate disinfectant is sufficient.

5 Document Control

This Technical Guideline is a controlled document. The controlled version of this guideline is located on the QU Electronic Documentation Management System.
Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.
Refer to *QU HSEMS Section 16.0 – Document Control and Record Retention*.

6 Appendices

Appendix A: Toxins Table

Appendix A – Toxins Table

Toxin	Toxicity (LD50 (µg/kg))
Abrin	0.7
Aerolysin	7.0
Botulinin toxin A	0.0012
Botulinin toxin B	0.0012
Botulinin toxin C1	0.0011
Botulinin toxin C2	0.0012
Botulinin toxin D	0.0004
Botulinin toxin E	0.0011
Botulinin toxin F	0.0025
β-bungarotoxin	14.0
Caeruleotoxin	53
Cereolysin	40-80
Cholera toxin	250
***Clostridium difficile* enterotoxin A**	0.5
***Clostridium difficile* cytotoxin B**	220
***Clostridium perfringens* lecithinase**	3
***Clostridium perfringens* kappa toxin**	1500
***Clostridium perfringens* perfringolysin O**	13-16
***Clostridium perfringens* enterotoxin**	81
***Clostridium perfringens* beta toxin**	400
***Clostridium perfringens* delta toxin**	5
***Clostridium perfringens* epsilon toxin**	0.1
Conotoxin	12-30
Crotoxin	82
Diphtheria toxin	0.1
Listeriolysin	3-12
Leucocidin	50
Modeccin	1-10
Nematocyst toxins	33-70
Notexin	25
Pertussis toxin	15
Pneumolysin	1.5
Pseudomonas aeruginosa toxin A	3
Ricin	2.7
Saxitoxin	8
Shiga toxin	0.250
Shigella dysenteriae neurotoxin	1.3
Streptolysin O	8
Staphylococcus enterotoxin B	25
Staphylococcus enterotoxin F	2-10
Streptolysin S	25
Taipoxin	2
Tetanus toxin	0.001
Tetrodotoxin	8
Viscumin	2.4-80
Volkensin	1.4
Yersinia pestis murine toxin	10

جامعة قطر
QATAR UNIVERSITY

Health and Safety

Technical Guidelines

TG - 04
Machinery Safety

Produced by

Health and Safety – Facilities & GS Department

Table of Contents

1 Purpose

1.1.1 The purpose of this document is to protect the health and well-being of all Qatar University (**QU**) staff, students, and visitors, and to prevent damage to property, equipment, facilities, and the environment associated with the usage of machinery as part of the university's activities.

1.1.2 This document provides guidelines on the application of the requirements and principles of the QU Health and Safety Management System (**HSMS**) to activities associated with these QU workplaces.

2 Scope

2.1.1 This HS Technical Guideline applies to all operations and activities associated with QU activities where machinery is involved, to enable the effective management of HS aspects and risks within these workplaces.

2.2 Responsibilities

2.2.1 Top Management

2.2.1.1 QU top management shall allocate sufficient resources for the effective implementation of the HSMS, including the application of this HS Technical Guideline, and ensure that QU employees, students, contractors and visitors are aware of their responsibilities through appropriate regulation, delegation and communication.

2.2.1.2 The QU Top Management is also accountable for monitoring and reporting HS performance and appropriate programs and actions to ensure compliance with the QU HS Policy.

2.2.2 Other Accountabilities

2.2.2.1 The QU HSS and the HS Committee are accountable to the QU Top Management for the implementation of this HS Technical Guideline.

2.2.2.2 Vice President (VPs), , Deans, Directors, Managers, Head Sections accountable to the QU Top Management for the application of this HS Technical Guideline in areas under their supervision.

2.2.2.3 All QU staff is responsible for performing their duties by complying with the requirements of this HS Technical Guideline as it applies to their activities and workplaces, observing and obeying safety postings and rules, and promptly reporting all incidents and accidents to their supervisors.

3 Guidelines

3.1 Machine Hazards and Safety

Machine hazards are a major cause of accidents and must be identified and controlled to avoid injury to staff working on/or near one of the machines. A hazard is an existing or potential condition which has the potential to harm people, property, or the environment. Thus, any machine motion or condition which can cause injury is considered hazardous and must be guarded against. In addition, any protective device supplied by the manufacturer must remain in place on the equipment, except during properly protected repair and maintenance that utilizes energy neutralization procedures, such as Lockout/Tagout (refer to ***QU HSMS SOP01 – Lockout / Tag out***). All the protective devices shall be re-installed before the equipment is returned to service.

There are four major areas of safety which must be considered for every machine:

- Maintenance
- Servicing and adjustment
- Points of operation where the machine works on material
- Protection from moving parts, other than points of operation.

3.1.1 Maintenance, Servicing and Adjustment

All personnel performing servicing and maintenance of machines must be properly trained, qualified, and competent to perform the task.

Only authorized staff are permitted to perform servicing and maintenance on machines.

3.1.2 Points of Operation

Points of operation are areas of machines where material is processed or changed by the machine, and where work is actually being performed on the material, such as a saw blade cutting a board.

Points of the safeguarding operation depend on the nature of the specific machine and the materials being processed. Normally each machine has specific protective device.

3.1.3 Mechanical Motions

Mechanical motions which may be hazardous include:

- Rotating Motion
- Reciprocating Motion
- Transverse Motion

3.1.4 Rotating Motion

Even slow smooth rotating shafts can pull body parts into dangerous positions. The resulting injuries can be severe or even deadly. Such things as collars, couplings, cams clutched flywheels, shaft ends, spindles and horizontal or vertical shafting are examples of the common rotating parts that are dangerous. Those dangers are increased by bolts, nicks, abrasions, projecting keys, or set screws which can serve as a cleat to grab clothing and/or as a protruding cutter head. These projections are difficult to see during rotation and must be made flush with the shaft if possible.

There are three basic in-running nip point hazards that are created by rotating parts.

- If there are parts rotating in opposite directions that are touching or there are rotating parts that are in close proximity, then a hazard exists where workers could be pulled in-between the rotating parts.
- Another nip point is created between rotating and tangential moving parts such as chain and sprocket drives, V belt drives, or a rack and pinions.
- Nip points can also occur between fixed and rotating parts which create shearing, crushing or abrading hazards. They include: spoked wheels, or flywheels, screen conveyors, or an abrasive wheel and the work rest.

3.1.5 Reciprocating Motion

Reciprocating motions create hazards during their back and forth or up and down motion that may strike a worker or cause him to be caught between a moving and a stationary part. This could include a bed of a milling machine.

3.1.6 Transverse Motion

Transverse motion or movement in a straight or continuous line creates a hazard when the worker is pulled into the pinch or shears point or is dragged by the moving parts into other moving parts.

3.1.7 Mechanical Actions

Mechanical actions are machine motions (actions) which include:

- Cutting
- Punching
- Shearing
- Bending

3.1.7.2 Cutting Action

A cutting action may be created in any rotating, reciprocating or transverse motion. The hazards of a cutting action are created in many points of operation activities. Injuries may occur to fingers, hands, head, arms, or where flying chips or scrap material may strike the eyes or face. Many examples include the cutting hazards of band saw, circular saw, boring or drilling machines, turning lathes, or milling machines.

3.1.7.3 Punching Actions

A punching action is created when power is applied to a stud or dies for the purpose of blanking, drawing, or stamping material. A hazard is created at the point where material is inserted, held, or withdrawn by hand. These hazards could be created on power presses, or iron workers.

3.1.7.4 Shearing Action

Shearing action hazards are created when power is applied to a slide or knife in order to shear or trim materials, such as metal or paper shears.

3.1.7.5 Bending Action

A bending action occurs when two dies together contact under power in order to bend, draw, or stamp metal or another material. The hazard is created at the point where hands are used to insert, hold or withdraw material from the point of operation.

3.1.8 Machine Safeguards

One or more methods of machine guarding must be used to protect the operator and others in the machine area from hazards such as:

- Points of operation
- In-going nip point
- Rotating part
- Flying chips and sparks.

3.2 Machine Safety Basic Rules

Before using equipment and machines or attempt practical work in a workshop you must understand the basic safety rules. These rules will help keep you and others safe in the workshop. Read the safety rules carefully.

Follow instructions.

- Do not run in the workshop, you could ‘bump’ into another person which can cause an accident.
- Know where the emergency stop buttons are positioned in the workshop. If you see an accident at the other side of the workshop you can use the emergency stop button to turn off all electrical power to machines.
- Always wear an apron or lab coat as it will protect your clothes and hold lose clothing such as ties in place.
- Wear good strong shoes. Steel-toe shoes are advisable.
- When attempting practical work all stools should be put away.

- Bags should not be brought into a workshop as people can trip over them.
- When learning how to use a machine, listen very carefully to all the instructions given by the teacher. Ask questions, especially if there is something you do not fully understand.
- Do not use a machine if you have not been shown how to operate it safely by the teacher.
- Always be patient, never rush into the workshop.
- Always use a guard when working on a machine.
- Keep hands away from moving/rotating machinery.
- Use hand tools carefully, keeping both hands behind the cutting edge.
- Report any damage to machines/equipment as this could cause an accident.
- Don't wear loose cloths.
- Always wear the proper Personal Protective Equipment (PPE).

3.3 Safety Requirements for Specific Machines

Note: safety information related to operation of additional tools and equipment is presented in **HS Technical Guideline TG-07 – Operations and Maintenance Safety.**

3.3.1 Use of Milling Machine

Milling machine is a machine tool used for shaping metal.

3.3.1.1 Safe Work Practices

- Ensure that the milling machine has a start/stop button within easy reach of the operator.
- Ensure that the work piece and cutter are mounted securely before taking a cut.
- Check that work is mounted squarely.
- Mount work in a vise that is bolted or fixed magnetically to the table. Use proper hand tools to make adjustments.
- Hold milling cutters with a cloth to avoid being cut when handling them.
- Move table as far as possible from the cutter while setting up work to avoid injuring your hands.
- Mill the largest surface first.
- Keep hands, brushes and rags away from the revolving milling cutter.
- Use a vacuum, brush or rake to remove cuttings only after the cutters have stopped moving.
- Change cutting compounds periodically.
- Keep cutters sharpened correctly and in good condition.
- Keep the working surface clear of scraps, tools and materials.
- Keep floor around the milling machine free of oil and grease.

- Use lifting equipment when appropriate to move heavy work to or from the milling machines. Do not wear gloves, rings, watches or loose clothing. Tie back long hair.
- Do not attempt to mount measure or adjust work until the cutter is completely stopped.
- Do not use an excessively heavy cut or feed as it can cause the cutter to break. The flying pieces could cause serious injury.
- Do not reach over or near a revolving cutter. Keep hands at least 30 cm (12 in.) from a revolving cutter.
- Do not lean or rest hands on a moving table.
- Do not make any adjustments while the machine is running.
- Do not use paper shims to check the distance between the cutter and the stock.
- Do not move the operating levers without knowing what they control and what action is going to take place.
- Do not leave machine unattended while it is running.
- Use safety glass and steel toe shoes working with the Milling Machine.

3.3.1.2 Before starting the machine, make sure that:

- All guards are in place.
- Work is properly secured in place.
- Bolts used to hold down work clear the tooling.
- Tooling and supporting pieces are properly tightened in position.
- Table stops are secured properly.
- Handles on all feed screws are in neutral positions.
- Table is free of stock, tools or other loose material.
- The arbor and arbor support are clear of the work.

3.3.2 Use of Lathe Machine

Lathe is a machine tool which spins a block of material to perform various operations such as cutting, sanding, knurling, deformation with tools that are applied to the work piece to create an object that has symmetry about an axis of rotation.

3.3.2.1 Safe Work Practices

- Ensure that the lathe has a start/stop button within easy reach of the operator.
- Follow job specifications for the speed, feed and depth of cut for materials being turned. Make sure all work runs true and centered.
- Center drill work deeply enough to provide support for the piece while it is turning.
- Adjust tool and tool rest so that they are slightly above the center of the work.

- Use a lifting device to handle heavy chucks or work.
- Inspect chucks for wear or damage. Flying pieces can be very dangerous.
- Remove chuck wrench immediately after adjusting chuck.
- Use a barrier guard when operating the lathe in semi-automatic or automatic mode.
- Guard all the power transmission parts.
- Remove all tools, measuring instruments and other objects from saddle or lathe bed before starting the machine.
- Ensure that the chip and coolant shields are in place.
- Shut off the power supply to the motor before mounting or removing accessories.
- Stop the lathe before taking measurements of any kind.
- Use a vacuum, brush or rake to remove cuttings only after the lathe has stopped moving.
- Keep the working surface clean of scraps, tools and materials.
- Keep the floor around the lathe clean and free from oil and grease.
- Do not wear gloves, rings, watches or loose clothing. Confine long hair.
- Don't lean on machine. Stand erect; keep your face & eyes away from flying chips.
- Do not place hands on work turning in the lathe.
- Do not use calipers or gauges on a work piece while machine is moving.
- Do not make heavy cuts on long slender pieces because the work could bend and fly out of the lathe.
- Do not leave the lathe unattended while it is running.
- Use safety glass and steel toe shoes while working with the Lathe Machine.

3.3.2.2 Steps to follow when filing

This procedure is done by hand. Take extra care because it involves reaching over rotating work.

- Cover the lathe bed with paper.
- Set the lathe at twice the speed used for turning.
- Adjust work freely between centers. If available, use a rotating dead center.
- Disengage lead screw by placing the reverse lever in a neutral position.
- Select a suitable long-handled lathe or mill file with a properly fitted handle.
- Grip file handle in the left hand and use the fingers of the right hand to balance and guide the file at the point. This method ensures that arms and hands will be clear of the head stock.
- Move file along work after each stroke so that each cut overlaps approximately one half the width of the file.
- Use long strokes, applying pressure only on forward stroke.
- Use approximately 40 strokes per minute.
- Clean loaded file with file brush and rub file teeth with a little chalk.

3.3.3 Use of Bench Grinder

The Bench Grinder is used for grinding the edges of flat metals, removing burrs from the ends tubing or rods, and minor shaping of some metal tools.

3.3.3.1 Safe Work Practices:

- Do not operate while under the influence of drugs, alcohol, or medication.
- Secure any loose fitting jewelry or clothing, tie back long hair - they can get caught in moving parts.
- Inspect the wheels for cracks or chips before use. A cracked wheel will disintegrate when operated.
- Guard must be used at all times.
- Eye shields must be over work area.
- Grind only on the face of the wheels. Grinding on the side of the wheel weakens the wheel and may cause breakage.
- Always use tool rest when working with this machine.
- Do not force metal into the moving grinding wheel.
- Do not make any adjustments to tool rests or spark arrestors while grinder is "ON".
- Remove any wrenches from the grinder before use if you make adjustments to the tool rest.
- Never grind soft metals (bronze, zinc, copper) on wheels designed for hard metal. The grinder is normally set up for grinding hard metals, i.e. steel. Soft metals can become incorporated within the wheel resin, causing overheating and subsequent wheel disintegration.
- For safe operation, the tool rest must not be in contact with the grinding wheel.
- Adjust angle of tool rest to the desired position and tighten nuts securely. Maintaining 1/16" - 1/8" clearance between tool rest and grinding wheel.
- The spark arrestor should be adjusted for approximately 1/16"- 1/8" clearance between it and the grinding wheel.
- Adjust eye shield to position aliening center of eye shield in line of sight to tool rest. The eye shields can swivel.
- Do not hold material above tool rest while grinding. Doing so can cause you to lose your grip on the material.
- Be aware of the gap between the tool rest and the grinding wheel. If too much gap exists, the material can get pinched or be projected towards the user.
- If you need to grind a small object, use a pair of vise grips to keep your fingers away from the grinding wheel.
- Be aware that this tool takes a long time to come to a rest (stop spinning).
- Never leave the machine on and step away.
- Use a grinding wheel "dressing stone" from time to time in order to tune up the wheel face and prevent wheel break up.
- Recommended Personal Protection Equipment while working with the Bench Grinder:
    - o Clear face shield or safety glass
    - o Leather jacket and long pants
    - o Leather gloves
    - o Leather top shoes or boots
    - o Wear ear plug or ear muffs during all grinding operations as the grinding process may generate high decibels.
    - o Respirator, N95

3.3.4 Use of Mug Welding Machine

The Mug Welder is used for joining two pieces of similar metals

3.3.4.1 Safe Work Practices:

- Do not operate while under the influence of drugs, alcohol, or medication.
- Secure any loose fitting jewelry or clothing, tie back long hair - they can get caught in moving parts.
- Do not wear flammable clothing. Avoid permanent press and nylon clothing because of the difficulty of putting out their fire.
- Do not touch live electrical parts.
- Do not adjust voltage range or voltage switch while operating the welder.
- Do not weld near a flammable source.
- Do not weld on drums, tanks, or any closed container it contained flammable material.
- Do not weld on containers or hollow castings which do not have vents.
- Never weld without adequate ventilation.
- Do not pick up hot objects. Assume that every metal objet around a weld bead or cut line is hot.
- Do not leave the electrode in contact with a metal table top or any grounded surface while the machine is on.
- Do not look at the welding arc without adequate eye protection.
- Do not strike an arc without checking the area to be certain that it is free of bystanders without safety equipment.
- Recommended Personal Protection Equipment while working with the Mug Welding:
    - o Shade 8 Helmet or better
    - o Leather welding jacket and long pants
    - o Leather welding gloves
    - o Leather top shoes or boots
    - o Respirator, N95

3.3.5 Use of Oxygen Acetylene Torch

Depending on the type of attachment, the Oxy/Acetylene torch can be used for heating and bending, welding, or cutting metal.

3.3.5.1 Safe Work Practices:

- There are two sets of regulators and valves: one for oxygen (color code – green) and one for the acetylene (color code – red).

- There are two gauges on each regulator, one on the right, indicating the tank pressure, and one on the left that indicates gas pressure in the line.
- Check all connections before lighting the torch.
- Never stand directly in front of or behind a regulator when opening the cylinder valve.
- Turn both cylinders off immediately when the torch flashes back, or if it is burning on the side. First oxygen and then acetylene
- Never open both fuel (acetylene) and oxygen valves before lighting the preheat flame.
- Always turn the oxygen cylinder valve all the way open.
- Open the acetylene cylinder valve not more than one turn. One-half turn is preferred.
- Always place the welding tip so that it points to the side of the torch to which the acetylene hose is attached.
- Always weld at least 5 feet from the cylinders.
- Do not use any oil or grease on any oxygen or acetylene connections.
- Never hammer on oxygen or acetylene regulators or stuck valves.
- Do not light a torch with a match or open flame. Use a striker.
- Before lighting torch, be positive that hose, tanks, or any inflammable material will not be exposed to heat, flame, or sparks.
- Beware of the high acetylene pressure. Never use acetylene gas when the pressure is greater than 15 pounds per square inch (acetylene gas when compressed to more than 15 pounds per sq. in. becomes a very high explosive.).
- Do not hold welding or cutting tip too close to your work.
- Never use a tip that gets too hot.
- Never use a torch that leaks.
- Never leave torch burning and go away from it.
- Never leave torch valves open.
- Do not adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment.
- Do not lift cylinders by the caps or valves.
- Do not transport the cylinders without the caps in place.
- Cylinders must be stored in upright position and chained to the wall.
- Keep valves closed on empty cylinders.
- Never weld a closed or jacketed vessel without air vent.
- Never weld a vessel that has contained any explosive or flammable material until you are positive that it has been thoroughly emptied and purged, and then use extreme care.
- Recommended Personal Protection Equipment while working with the oxygen acetylene torch:

- Shade 5 goggles
- Leather welding jacket and long pants
- Leather welding gloves
- Leather top shoes or boots
- Respirator, N95

3.3.6 Use of Power Hack Saw

The Power Hack Saw is used for cutting metal; it can cut pipe or flat stock perpendicular to the saw base and is only used to make straight or angled cuts. A masonry cutoff wheel can be used cut masonry on this saw.

3.3.6.1 Safe Work Practices:

- Do not operate while under the influence of drugs, alcohol, or medication.
- Secure any loose fitting jewelry or clothing, tie back long hair.
- Always know what type of metal you are cutting.
- Do not force the saw to cut through material.
- Always use vise. Do not ever attempt to hold a piece of metal and use this saw.
- Inspect the cutting wheel for cracks or flaws before use. If a crack of flaw is evident, the wheel must be discarded.
- Do not cut wood or plastic with this saw.
- Avoid bouncing the wheel or giving it rough treatment when in use. If this occurs during the operation, stop the tool and inspect the wheel for damage.
- Angles are best clamped and cut with both legs resting against the saw base.
- A spacer block slightly narrower than the work space can be used to increase wheel utilization.
- Long work pieces must be supported by a block or material support stand so it will be level with top of base. The cutoff end should be free (not supported).
- The vise has a quick travel feature. To release the vise when it is clamped tightly, turn the crank counterclockwise one or two times to remove clamping pressure.
- For accurate angle cutting, first use a protractor or adjustable angle to set adjustable fence.
- Recommended Personal Protection Equipment while working with the power hack saw:
    - Clear face shield or safety glass
    - Steel toe shoes
    - Respirator, N95

3.3.7 Use of Drill Press

Drill press is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench. Drill press are often used for sanding, honing or polishing, by mounting sanding drums, honing wheels and various other rotating accessories in the chuck.

3.3.7.1 Safe Work Practices:

- Wear appropriate safety glasses.
- Ensure that the drill press has a start/stop button within easy reach of the operator.
- Use a vacuum, brush or rake to remove cuttings.
- Remove burrs and chips from a drilled hole. When making deep holes, clean out the hole frequently.
- Use a clamp or drill vise to prevent work from spinning.
- Lubricate drill bit when drilling metal.
- Reduce the drilling pressure when the drill begins to break through the work piece. This action prevents drill from pulling into the work and breaking.
- Keep drill bits clean and sharp. Dull drills are a common cause of breakage.
- Keep floor around the drill press free of oil and grease.
- Keep the working surface clean of scraps, tools and materials.
- Keep guards in place and in good working order.
- Do not wear any loose clothing or ties. Roll sleeves above the elbow to prevent them from being caught in revolving parts. Confine long hair.
- Do not wear gloves, rings, watches, or bracelets while working with a drill press.
- Do not set speeds, adjust, or measure work until machine is completely stopped.
- Do not leave the chuck key in the drill chuck. Make adjustments and remove key immediately.
- Do not hold work by hand when drilling holes larger than 12 mm (1/2 in.) in diameter.
- Do not place hands under the stock being drilled.
- Do not stop the rotation of chuck and spindle with your hand.
- Do not remove a broken drill with a center punch and hammer.
- Do not leave the drill press running unattended.
- Recommended Personal Protection Equipment while working with the drill press:
    - Clear face shield or safety glass
    - Steel toe shoes

3.3.8 Use of Furnace

Furnaces are used to heat a material at a high temperature. Sometimes these are capable of heating to temperatures over 1000 degrees Celsius. There are no interlock devices to prevent the furnaces from being opened when they are hot and quite often it is necessary to do so. This procedure should be carried out with great care - stand at one side of the furnace as the door is opened.

3.3.8.1 Safe Work Practices:

- Wear protective gloves as well as lab coat (with sleeves rolled down).
- Wear safety glasses.
- Use tongs for loading/ unloading the furnace.
- Do not leave furnaces on overnight.
- Always check the temperature at which the ovens and furnaces are set. They are used at various settings and may not be set at the temperatures you require.

3.3.9 Use of Mechanical Shaper

A Mechanical Shaper is a machine tool used for shaping or surfacing metals and other materials.

3.3.9.1 Safe Work Practices:

- Always keep guards in place and in proper operating condition.
- If you are not properly trained in the use of a shaper do not use it until the proper training has been obtained.
- Read, understand and follow the safety instructions included in this manual. Know the limitations and hazards associated with this machine. Electrical grounding: Make certain that the machine frame is electrically grounded and that a ground lead is included in the incoming electrical service. In cases where a cord and plug are used, make certain that the grounding plug connects to a suitable ground. Follow the grounding procedure indicated in the National Electrical Code.
- Eye safety: Wear an approved safety shield, goggles, or glasses to protect eyes. Common eyeglasses are only impact-resistant, they are not safety glasses.
- Before operating the machine, remove the tie, rings, watch and other jewelry and roll up sleeves above the elbows. Remove all loose outer clothing and confine long hair. Steel Toe shoes should be used. Where the noise exceeds the level of exposure allowed in Section 1910.95 of the OSHA Regulations, use hearing protective devices. Do not wear gloves.
- Keep the machine guards in place for every operation for which they can be used. If any guards are removed for maintenance, do not operate the machine until the guards are reinstalled. Work area: Keep the floor around the machine clean and free of scrap material, saw dust, oil and other liquids to minimize the danger of tripping or slipping. Be sure the table is free of all scrap, foreign material and tools before starting to cut. Make certain the work area is well lit and that a proper exhaust system is used to minimize dust. Use anti-skid floor strips on the floor area where the operator normally stands and mark off the machine work area. Provide adequate work space around the machine.
- Maintain a balanced stance and keep your body under control at all times.
- Before turning on the machine, remove all extra equipment such as keys, wrenches, scraps, and cleaning rags away from the machine.
- Give the work you are doing your undivided attention. Looking around, carrying on a conversation and “horseplay” are careless acts that can result in serious injury. Disconnect all power sources: Before performing any service, maintenance, adjustments or when changing cutters. A machine under repair should be RED TAGGED to show it should not be used until the maintenance is complete.
- Never shape stock less than 12 inches in length without special fixtures. When practical, shape longer stock and cut to size.
- When shaping never allow hands to come closer than 12 inches from the cutters.
- When shaping with collars, the collar must have sufficient bearing surface. The work must also be fairly heavy in proportion to the cut being made. Do not use short, lightweight stock when the opening between the fence plates should only be enough space to clear the cutter.
- Always use the meter gauge and clamping mechanism when edge shaping stock less than 6" wide.
- Feed stock opposite to the direction of the cutter rotation. Never back stock out of the cutter once the cut has been started. Instead, pull the stock straight back away from cutter and begin the cut again.

- Make sure the spindle and the draw bar are tightened on the arbor.
- Never operate the shaper without the safety locking keyed washer located immediately under the spindle nut. This prevents the nut from coming loose when the spindle is running in a counterclockwise direction. Do not substitute any other type washer in place of the safety lock washer.
- If you are not thoroughly familiar with the operation of spindle shapers, seek advice from your supervisor, instructor or other qualified person.
- Maintain cutting tools in top condition: Keep blades sharp and clean for safe and best performance. Dull tools increase noise levels and can cause kickbacks and glazed surfaces. Check the condition and adjustment of the tools before making any cuts. Never use a tool that is not balanced and rated for the selected RPM.
- Do not clear chips and sawdust with hands; use a brush.
- If the operator leaves the machine area for any reason, the shaper should be turned "off" and the cutter should come to a complete stop before their departure. In addition, if the operation is complete, they should clean the shaper and the work area. Never clean the shaper with power "on" and never use hands to clear sawdust and debris; use a brush.

3.3.10 Use of Computer Numerical Control (CNC) Machine

Computer numerical control (CNC) is a computer "controller" that reads G-code and M-code commands and drives a machine tool, a powered mechanical device typically used to fabricate components by the selective removal of material.

3.3.10.1 Safe Work Practices:

- CNC machines are very safe to use as they are designed to be as safe as possible. One of the main advantages of CNC machines is that they are much safer than manually operated machines.
- CNC machines are designed so that the cutting tool will not start unless the guard is in position. Also, CNC machines automatically lock the guard in position even as the cutter is shaping material. The guard can only be opened if the cutter s stopped.
- It is essential that students / machine operators receive ‘quality’ instruction before attempting to use any CNC equipment.
- CNC routers, used for shaping materials such as woods and plastics, have built in extraction. Dust can be very dangerous if inhaled and can also cause eye irritation. Use respirator N95 and safety glass if necessary.
- Most CNC machines work behind a guard or even a closed, transparent safety door. This means that the operator cannot be hurt by 'flying' pieces of sharp/hot material.
- Commonsense applies to the use of all machines including CNC machines. Basic safety training regarding working in a workshop and with other machines applies to CNC machines as well.

4 Document Control

This Technical Guideline is a controlled document. The controlled version of this guideline is located on the QU Documentation Management System.
Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.
Refer to ***QU HSMS – Document Control and Record Retention***.

Health & Safety Technical Guidelines

TG - 07

Construction, Operations and Maintenance Safety

Produced by

Health and Safety – Facilities & GS Department

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Appendices

Appendix A – Work Equipment Assessment Checklist

Appendix B – Confined Space and PRCS Recognition Checklist

1 Purpose

The purpose of this document is to protect the health and well-being of all employees, students, contractors and visitors to Qatar University (QU), for matters associated with operations and maintenance activities, as well as protecting QU properties and the environment by:

- Preventing operations and maintenance-related accidents and injuries;
- Assuring all QU employees, students, contractors and visitors clearly understand operations and maintenance-related risks;
- reducing, controlling, or avoiding personnel exposure to all known or suspected occupational health and safety risks;
- instituting adequate procedures to protect all property and the environment from damage and loss; and
- Requiring all QU employees, students, contractors and visitors to be in compliance with all operations and maintenance-related safety regulations and procedures.

2 Scope

This HS Technical Guideline applies to all operations and maintenance activities that may affect QU employees, students, contractors and visitors.

This HS Technical Guideline presents the minimum level of acceptable HS practices and requirements that are expected from all individuals (faculty, staff, and contractors) involved in the operations and maintenance of QU equipment and facilities.

3 Responsibilities

3.1 Top Management

QU top management shall allocate sufficient resources for the effective implementation of the HSMS, including the application of this HS Technical Guideline, and ensure that QU employees, students, contractors and visitors are aware of their responsibilities through appropriate regulation, delegation and communication.

QU Top Management is also accountable for monitoring and reporting HS performance and appropriate programs and actions to ensure compliance with QU HS Policy.

3.2 Other Accountabilities

QU Health and Safety Section (HS) and the HS Committee are accountable to QU Top Management for the implementation of this HS Technical Guideline.

Vice President (VPs), Deans, Directors, Managers, Head Sections and Project Managers are accountable to QU Top Management for the application of this HS Technical Guideline in areas under their supervision.

All QU staff and students are responsible for performing their duties in compliance with the requirements of this HS Technical Guideline as it applies to their activities, and promptly reporting all hazards, incidents and accidents to their supervisors.

All QU contractors are responsible for performing their duties in compliance with the requirements of this HS Technical Guideline as it applies to their activities, and promptly reporting all hazards, incidents and accidents to their QU supervisors. HS aspects of the selection and management of contractors performing operations and maintenance tasks will be in accordance with QU **HSMS – Contractor Management.**

4 Guidelines

4.1 Hazard Identification and Risk Management

Identification, assessment, control, and monitoring of HS risks will be applied in accordance with QU **HSMS – Risk Management Procedure**.
HS Hazards and Risks related to operations and maintenance-related activities are detailed in the facilities Health and Safety Risk Register, and the Environmental Impacts Register. Any emerging HS hazards will be reported to supervisors and the Environment and Safety Office in accordance with QU **HSMS – Incident Reporting and Investigation**.

4.2 Personal Protective Equipment

All QU staff performing operations or maintenance activities shall wear appropriate Personal Protective Equipment when undertaking such tasks. Guidelines on Personal Protective Equipment requirements and use are presented in the following sections.

Contractors performing operations or maintenance activities are also required to wear appropriate Personal Protective Equipment when undertaking such tasks. Provision for new or additional Personal Protective Equipment shall be the responsibility of the contractor. QU Health and Safety Section (HSS) and QU contract managers have the right to require the contractor/s to issue/ re-issue new Personal Protective Equipment if it is deemed necessary due to work requirements.

4.2.1. Head Protection

- Personnel must wear protective helmets when working in areas where there is a potential for injury to the head from staff initiated impact or impact from falling or other moving objects. These areas include but are not limited to: construction sites, central service unit, energy center, chiller plants (including but not limited to Food court, women's sports center, men & women's activity center), and areas where working requires lifting and/or excavation.
- Protective helmets designed to reduce electrical shock hazards will be worn by each worker when exposed near electrical conductors which could contact the head. Helmets will comply with ANSI Z89.1-1986 or be equally effective.
- Class C head protection shall be used for protection from minor scalp abrasion and minor bump hazards. Class B head protection shall be used for electrical hazard. Class G (known as class A) head protection shall be used for construction.
- Head protection shall be replaced if cranked, chopped, dropped or damaged.
- Personnel shall not paint or deface hard hat or bump cap.
- Personnel shall be issued one head protection according to usage.

4.2.2. Eye and Face Protection.

- Use appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.
- Eye and Face PPE must comply with ANSI Z87.1-1989.
- Contractors/ workers shall wear approved eye protection at work site where protection to the eyes is needed (e.g. welding, grinding, cooling tower monitoring, laboratory analysis, chipping, polishing, lathe turning work).
- Safety glasses shall be furnished by contractor to his/her staff.
- Blurred/damaged Eye and face protection shall be replaced immediately.
- Eye and Face Protection shall comply with Standard 1910.133 and passed ANSI Z87.1-1989 and/or EN-166.

4.2.2.1. Safety Glasses

- Do not use ordinary prescription as they do not provide adequate protection from injury to the eyes.
- Use hardened-glass or plastic spectacles with side shield.
- Safety glasses used must comply with the Standard for Occupational and Educational Eye and Face Protection (Z87.1).
- Wearing of contact lenses is allowable provided only if wearing additional eye protection, unless otherwise restricted by the activity's nature.

4.2.2.2. Goggles

- Wear goggles when there is a hazard from splashing chemicals or flying particles, e. g. when using glassware under reduced or elevated pressure, or using glass apparatus in combustion or other high temperature operations.

4.2.2.3. Face Shields

- Wear face shield when there is a need for greater protection from flying particles and harmful liquids to protect face and neck.
- Consider using a face shield when operating a vacuum system (which may implode), or conducting a reaction with potential for mild explosions.

4.2.3. Hand Protection.

- Use appropriate hand protection when their hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns and harmful temperature extremes.
- Supervisors must base the selection of hand protection on evaluation of the performance characteristics of the hand protection relative to the specific tasks to be performed, conditions present, duration of use and the hazards and potential hazards identified.
- Personnel shall wear hand protection when exposed to potential hand injuries and minimize exposure to hazards such as chemical absorption through the skin, severe lacerations or cut, punctures and chemical or thermal burn.
- Personnel shall use protective leather gloves for cutting and welding work.
- The Material Safety Data Sheet shall be used to determine the appropriate gloves to be used during handling of chemicals.
- Personnel working with rigging wire and chains shall use cotton work gloves.
- Personnel shall maintain (clean, safe keep) the hand protection equipment to maximize useful life.
- Hand Protection shall comply with Occupational Health and Safety Standard 1910.138 and passed European Standard EN-388.

4.2.3.1. Gloves

- Wear proper protective gloves for potential contact with corrosive or toxic material, materials of unknown toxicity, sharp edged object, and very hot or cold materials.
- Select gloves based on material handled, the particular hazard involved and their suitability for the operation conducted.
- Consider double gloving (the wearing of two gloves on each hand) when handling highly toxic or carcinogenic materials.
- Before each use, inspect gloves for discoloration, punctures and tears.
- Before removal, wash gloves if the material is impermeable to water.
- Do not reuse single-use disposable gloves.
- Store gloves properly.

- Dispose gloves if already old; shelf life is stamped on the box.
- Dispose contaminated gloves in the proper waste bin.
- Do not wear gloves outside the working area as this may contaminate surface if touch such as doorknobs, elevator buttons or rest fixtures.
- Do not use gloves containing asbestos
- For high temperature operations, use gloves made of synthetic material such as Kevlar.

4.2.3.2. Electrical Gloves

- Defective insulating gloves shall not be used.
- Insulating gloves with the following defects shall not be worn: holes; tears; punctures or cuts; imbedded foreign objects; texture changes such as swelling, hardening or becoming stick or inflexible.
- Rubber insulating gloves that have been used without protectors shall not be used without protective gloves.
- Protective gloves shall not be used if they have holes, tears or other defects that affect their ability to give mechanical protection to the insulating glove.
- Protective gloves shall not be used if they have holes, tears or other defects that affect their ability to give mechanical protection to the insulating glove.
- Protective gloves that have been used for any other purpose shall not be used to protect insulating gloves.
- Gloves that have been rejected and are not suitable for electrical services shall have the fingers removed and the gloves disposed.
- Rubber gloves and protective gloves which have oil, grease or other damaging substance on them, shall be cleaned properly before use.
- Rubber gloves shall be turned inside out and rinsed as necessary to remove perspiration. Excess water shall be removed by shaking and the gloves shall be air-dried.
- Insulating gloves shall be visually inspected by the wearer for defects. Before using, visually inspect the glove especially around the fingers to detect cracks or deterioration.
- Insulating gloves shall be given an air test by rolling the cuffs tightly toward the palm in such a manner that air is trapped inside the gloves or by using a mechanical inflator. When using the latter care shall be taken to avoid over-inflation.
- Gloves shall be air tested each day before use and time there is cause to suspect damage.
- A periodic inspection of the gloves shall be conducted by the Electrical Engineer to determine that such equipment is being maintained in a satisfactory condition by the user.
- Gloves shall be stored in a designated location (e.g. tool room) as cool, dark and dry as possible with no other material or equipment nearby that could cause damage.
- Gloves when not in use must be inside the protectors and in a bag, box or container designed for and used exclusively for them. These gloves shall be stored in their natural shape.
- The protector gloves shall be sized and shaped so the insulating gloves shall not be deformed from their natural shape.
- Electrical gloves shall comply with Occupational Health and Safety Standard 1910.137.

4.2.4. Protective Apparel / Coverall (Long Sleeve)

- Coverall or protective aprons shall be worn at all times while working.
- Wearing loose clothes (e.g. saris, dangling neckties, oversized or ragged coats) in the working area is prohibited.
- It is strictly prohibited to strap the coverall in the waist line portion of the body as this does not served the purpose of protecting the upper half portion of the body.
- Coveralls shall be worn during operation, maintenance of equipment. Shirt and pants shall be worn for other operational duties and light maintenance.
- Trouser legs shall not be rolled above the ankles and shirttails shall be tacked in one's pants.
- Clothing saturated with oil shall be removed as soon as practical and the affected part of the body shall be washed with soap and water.
- Only clean clothing in good condition (free of tears, frays, rips and patches) shall be worn during work.
- Finger rings, watches, bracelets and other jewelry shall be removed while performing maintenance work.
- Wear coveralls under welding aprons and chaps during welding work. Button coveralls to the neck and button pockets to prevent sparks and slag from burning the skin. Do not use clothing to clean torch tips.
- Coveralls shall be worn by contractors at all times during their work at QU.

4.2.5. Respiratory Protection

- Personnel will wear appropriate respiratory protection when adequate ventilation or substitution with non-toxic chemicals, etc., is not possible or feasible or as deemed necessary by the HS risk assessment. Respirator protection must comply with ANSI Z288.2.
- Respiratory protection is necessary when working with highly toxic chemicals, biological hazards, or dust known to cause asthma or pulmonary fibrosis. However, respirators are a “last line” of defense, and should not be used until all engineering controls (e.g. ventilation) and work practice controls are exhausted.
- Respirators to be used shall comply with Respiratory Protection Standard OSHA 29 CFR 1910.134.
- Do not use dust/comfort masks or surgical masks.
- Respirator shall be used during construction where dust accumulation is very heavy.
- Respiratory protection shall be used in confined spaces as deemed by the activity specific HS risk assessment.
- Refer to Safety Data Sheet (SDS) for proper selection of respirators.
- Respirator fit shall be conducted annually for staff required to wear respirator.
- Staff with facial hair shall not be given mask respirator as gases/fumes will still penetrate the sealing surface of the respirator.
- Contact lenses shall not be used with respirators.
- Respirator shall be inspected before and after use by staff for tightness of connections; condition of face piece; head band; valves and connecting tubes, pliability and signs of deterioration of rubber parts; proper air pressure and proper functioning.
- Clean and disinfect equipment after each use according to manufacturer recommendation.
- Positive pressure respirator shall be serviced only by a qualified person using parts designed for the particular respirator.

- Respirator shall be stored where they are protected from dust, sunlight, heat, extreme cold, excessive moisture and damaging chemicals. Store respirator with the face piece and exhalation valve resting in a normal position to prevent distortion. Do not store respirator in places, such as lockers or toolboxes, unless they are in carrying cases or cartons supplied by the manufacturer.
- Chemical cartridges shall be replaced as necessary to provide complete protection.
- Replacement of cartridge shall be installed by experienced personnel. Change a defective respirator for a new one.
- Respirator located at stations and work areas for emergency use shall be readily accessible at all times. They shall be stored in a specially designed compartment.
- Respirator shall comply with Occupational Safety and Health Standard 1910.134

4.2.6. Fall Protection.

Note: For detailed safety requirements related to any work at heights, refer to **'SOP 06 – Working at height'.**

- Fall protection must be provided when staff are exposed to:
  - A vertical fall of 1.8 meters or more over a lower level; or
  - Any height over dangerous equipment.
- Fall protection will consist of either passive or active fall protection. Fall protection must comply with ANSI A10.14-1991.
- Safety harness shall be worn at all times while working above 1.8 meters or more above ground unless other adequate protection against falling is provided.
- All safety harness shall be regularly inspected for excessive wear or damage that could cause them to fail. Harnesses and lanyards that are worn or damaged to the extent that they could fail shall be discarded and not be used.
- Safety harness or lanyards shall be a minimum of 13 mm nylon or the equivalent, with a maximum length of 1.8 meter. They shall have a minimum breaking strength of 2,700 kg.
- The use of shock absorbing lanyard shall consider the total length of the lanyard in consideration of the height of work.
- The use of double lanyard safety harness is mandatory if there is a necessity for the worker to remove his lanyard in order to move.
- Lifelines shall be a minimum of 20 mm, or equivalent, with a minimum breaking strength of 2,700 kg. Steel cables are recommended for horizontal anchor lines with a minimum breaking strength of 2,700 kg or five times the load.
- Fall protection equipment shall comply with Occupational Health and Safety Standard 1926.104 and passed European Standard EN-361, EN-354, EN-355, EN-353-2 and EN-362.

4.2.7. Foot Protection

- Personnel must wear protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects, or from object piercing the sole, and where staff feet are exposed to electrical hazards. PPE for foot protection must comply with ANSI Z41.1991 or be equally effective.
- Workers shall wear employer issued safety shoes at work site at all times. Exceptions are as follows: offices, meeting rooms, change rooms.
- Personnel shall wear protective footwear when working in areas where there is danger of foot injuries due to falling or rolling piercing the sole, or where the feet are exposed to electrical or chemical hazards.
- If safety shoes are inadvertently destroyed as a result of assigned duties (but not caused by staff negligence) safety shoes shall be replaced at employer expense.

- Contractors working inside QU premises shall wear foot protection.
- Visitors shall wear foot protection at areas that require safety shoes and shall be provided by QU and/ or contractors.
- Safety shoes shall comply with Occupational Health and Safety Standard 1910.136 and passed ANSI Z41-1991 and/or European Standard EN-345.

4.2.8. Electrical Protection

- Electrical protective equipment such as insulating blankets, mating, covers, line hoses, gloves, gloves and sleeves must be provided to who are exposed to electrical hazards.

4.3 Electrical Safety

SOP-02: Electrical Safety provides detailed safety requirements that apply to all operations and maintenance activities at QU. This SOP must be strictly adhered to when conducting all such operations and maintenance activities.

4.3.1. Lock Out / Tag Out

Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, and maintaining and/or servicing machines or equipment could expose workers to the unexpected energization or startup of the equipment or release of hazardous energy unless proper precautions are taken.

'SOP-01: Lockout / Tag out' provides detailed safety procedures pertaining to the lockout / tag out program to control hazardous energy and protect personnel. This SOP must be strictly adhered to in when performing all operations and maintenance activities at QU.

4.4 Hot Work

All hot work activities shall be managed under a Permit to Work (refer to *QU HSMS Section 7.1 PTW procedure*) to protect personnel and property from a fire caused by hot work. The permitting system defines the responsibilities and requirements for performing hot work and establishes controls through the use of a permit.

This system establishes the means to assess the work area and the planned hot work activity to ensure sufficient and necessary controls are in place to prevent a fire.

Hot work will only be performed in areas that are or have been made fire safe. Where fire prevention precautions, such as a fire suppression system or a fire or smoke detection system, are not sufficient a fire watch person shall be assigned to monitor the area for fire, as needed.

4.4.1. Scope

This procedure applies to all hot work performed on QU property, including work performed by QU staff and contractors. Hot work includes any temporary operation, scheduled or emergency, indoor or outdoor, involving open flames or producing heat and/or sparks. Hot work activities includes, but is not limited to:

- Torch cutting,
- Welding, soldering,
- Brazing, and
- Grinding.

Permanent areas which are designated areas for long term or permanent performance of hot work, such as a maintenance shop or a detached outside location are not considered hot work as defined above.

A PTW is **not** required for:

- Operations performed that do not generate sufficient heat or sparks to be considered a significant source of ignition to surrounding combustibles.
- Operations performed in permanent areas, which are designated areas for long term or permanent performance of hot work, such as a maintenance shop or a detached outside location.
- Permanent areas where welding, torching, or cutting will be performed must have the following conditions to be exempt from this procedure:
  - Areas constructed of non-combustible or fire resistive material.
  - Areas essentially free of combustible and flammable content.
  - Areas suitably segregated from adjacent areas.
  - Areas equipped with a suitable exhaust system capable of removing the fumes and spent gases associated with Hot Work.

4.4.2. Precautions and Requirements

- A PTW must be completed and approved prior to initiating hot work and posted at the work area. QU PTW is found in *QU HSMS - PTW procedure*.
- The work process shall include (1) an assessment of the facility condition, (2) preparation of the work area, (3) hot work activity, (4) closeout.
- Hot Work is permitted only in areas that are or have been made fire safe.
- Hot Work equipment shall be in good working condition and fully inspected.
- A hazard assessment of the scheduled hot work in the work area shall be required, where the following conditions exist:
  - Fire suppression system is not operable or does not exist.
  - Fire/smoke detection system is localized only or does not exist.
  - Special potential hazards such as work in a confined area, attic, or crawlspace in which an increased fire risk may exist.
  - The floor around the area where the hot work is to be performed shall be swept clean and clear of debris for a radius of 35 feet.
  - Combustibles shall be adequately protected or shielded, using flameproof materials. For torch cutting or welding, combustibles shall be relocated at least 35 ft. horizontally from the work area. The edges of covers at the floor shall be tight to prevent sparks from going under the covers.
  - Openings or cracks in walls, floors, or ducts within 35 feet of the site shall be tightly covered to prevent the passage of sparks to adjacent areas.
  - When torch cutting or welding is performed near combustible partitions or ceilings, fire resistant guards shall be provided to prevent ignition.
  - Welding shall not be attempted on a metal partition, wall, ceiling, or roof having a combustible covering. Oil based paints and epoxies shall be no closer than three feet in any direction.
  - Fully charged and operable fire extinguishers shall be available in the hot work area. The use of wall mounted fire extinguishers, provided in the facility, is prohibited. Available portable fire extinguishers shall be minimum, one 4 Kg (10 lbs) ABC rated extinguisher within 40 feet of the activity.
  - Special precautions shall be taken to avoid accidental operation of automatic fire detection or suppression systems. Systems shall be isolated as per Civil defence rules and regulations.

4.5 Safe Lifting and Back Safety

Workers shall follow the proper safe lifting methods to prevent back injury.

- Avoid the following:
  - Heavy lifting especially repetitive lifting over a long period of time.
  - Twisting at the waist while lifting or holding a heavy load, this frequently happens when using a shovel.
  - Reaching and lifting over your head, across over your head, across a table, or out the back of a truck.
  - Lifting or carrying objects with awkward or odd shapes.
  - Sitting or standing too long in one position, sitting can be very hard on the lower back.
- Place objects up off the floor to minimize the distance where the load has to travel, and allow the person to have a better grip on the object.
- Raise / lower shelves to a height that is most efficient for the workers.
- Use carts, where appropriate.
- Test the weight of an object before lifting by picking up a corner.
- Wear Back Support if necessary.
- Get help if it is too heavy for you to lift it alone.
- Use the following steps when lifting:
  - Take a balanced stance, feet shoulder-width apart.
  - Squat down to lift, get as close as you can.
  - Get a secure grip; hug the load.
  - Lift gradually using legs, keep load close to you, keep back and neck straight.
  - Once standing, change directions by pointing your feet and turn your whole body. Avoid twisting at your waist.
  - To put load down. Use the above process in reverse.
- Use cranes, hoist, forklift, lift tables and other lift-assist devices for lifting heavy objects (e.g. pump, motor, pipes).
- Exercise regularly.

4.6 Working at height

'SOP-06: Working at Height' provides detailed safety requirements that apply to all QU activities performed at heights, including those associated with operations and maintenance activities. This SOP must be strictly adhered to when performing operations and maintenance activities.

This SOP includes requirements related to scaffolding, ladders, mobile platforms, working on roofs, and working above dangerous equipment.

4.7 Walking / Working Surfaces, Floor Openings

4.7.1. Walking / Working Surfaces

- All shop areas, utility rooms, halls, and storerooms shall be kept clean and orderly.
- All floors shall be kept clean and dry as possible.
- Aisles used by material handling equipment shall be appropriately marked on floor.
- Aisles, passageways and floors shall be kept free of any obstructions such as protruding rails, splinters, holes or loose boards.
- Covers or guardrails shall be provided to protect staff from open holes, ditches, etc.

4.7.2. Guarding Floor Openings, Wall Openings & Holes

- A floor opening is any opening measuring at least 12 inches (30.48 cm) or more in any floor, roof, or platform through which a person may fall.
- Every stairway floor opening shall be guarded by a standard railing. All exposed sides (except entrance) shall be guarded.
- All ladder-way floor openings shall be guarded by a railing with toe boards and a swinging gate.
- Every hatchway and chute floor opening shall be guarded by either a hinged floor opening with standard railing or a removable railing with toe board on two sides and fixed railings opening with standard railing or a removable railing with toe board on two sides and fixed railings with toe boards on all other exposed sides.
- All pit and trap door openings infrequently used when the cover is not in place shall either be constantly attended by a member of staff or protected on all exposed sides by removable railings.
- Every temporary floor opening including manholes, when the cover is not in place, shall be constantly attended by staff until the work requiring the opening has ended or protected by removable railings and warning signs if posting of a staff is ineffective or not feasible.

4.7.3. Wall Openings

- All wall openings where there is a drop of more than 4 feet (1.22 meters) shall be protected by a rail, roller, picket fence, half door or equivalent barrier.
- Every temporary wall opening shall have adequate guards.

4.7.4. Open Sided Floors, Platforms and Runways

- Every open sided floor or platform 4 feet (1.22 meters) or more above the adjacent floor or ground level shall be guarded by standard railings.
- Toe boards shall be provided when staff can pass beneath the open sides or falling materials could cause a hazard.

4.8 Safe Use of Tools and Equipment

Note: further safety information related to machinery operation is presented in **HS Technical Guideline TG-04 – Machine Safety.**

Personnel using hand or power tools shall apply the following safety practices.

- Select the right tool for the job. Examples of unsafe practices are: striking hardened faces of hand tools together (such as using a carpenter's hammer to strike another hammer, hatchet, or metal chisel), using a file for a pry, a wrench for a hammer, and pliers instead of the proper wrench.
- Keep tools in good condition. Wrenches with cracked work jaws, screw drivers with broken points or broken handles, hammers with loose heads, dull saws, and extension cords or electric tools with broken plugs, improper or removed grounding lugs, or split insulation are examples of tools in poor conditions. Tools that have deteriorated in this manner must be taken out of service.
- Use tools in the right way. Screw drivers applied to objects held in the hand, knives pulled toward the body, and failure to ground electrical equipment are common causes of accidents.

- Keep tools in a safe place. Many accidents have been caused by tools falling from overhead and by knives, chisels, and other sharp tools carried in pockets or left in tool boxes with cutting edges exposed.
- Apply the following to prevent tool-related accidents:
  - Supervisors are to ensure that staff are trained to select the right tools for each job.
  - Tools shall be inspected prior to use.
  - Proper storage shall be provided for all tools, in the tool room and/or on the job.
- Personnel shall never carry tools, which in any way may interfere with his/her using both hands freely on a ladder or while climbing on a structure. A strong bag, bucket, or similar container is to be used to hoist tools from the ground to the job. Tools are to be returned in the same manner, not brought down by hand, carried in pockets or dropped to the ground.
- Mislaid and loose tools cause a substantial portion of hand tool injuries. Tools should not be left where personnel are moving or walking.
- Chisels, screwdrivers, and pointed tools shall never be carried in a worker's pocket. They are to be carried in a tool box or cart, in a carrying belt (sharp or pointed end down) like those used by electricians and steel workers, in a pocket tool pouch, or in the hand with points and cutting edges pointing away from the body.
- Personnel carrying tools on their shoulders should pay close attention to clearances when turning around and should handle the tools so that they will not strike other staff.
- Appropriate personal protective equipment, e.g. safety goggles, gloves, etc. should be worn due to hazards that may be encountered while using portable power tools and hand tools.
- Personnel using hand and power tools and exposed to the hazard of falling, flying, abrasive and splashing objects, or exposed to harmful dusts, fumes, vapors, or gases are to be provided with the particular personal protective equipment necessary to protect them from the hazard.
- Practices require to be applied by personnel when using specific tools are detailed in the following sections.

Should an HS risk assessment be required for a new or existing tool or piece of equipment (for example where safety hazards or concerns have been identified), a Work Equipment inspection can be conducted using the checklist in *Appendix A*.

4.8.1. Metal Cutting Hand Tools

Chisels

- Factors determining the selection of cold chisels are the materials to be cut, the size and shape of the tool, and the depth of the cut to be made.
- The chisel should be made heavy enough so that they will not buckle or spring when struck.
- A chisel no larger than the job should be selected so that the blade is used rather than the point or corner. Also, a hammer heavy enough to do the job should be used.
- Personnel shall wear safety goggles when using a chisel and should set up a shield or screen to prevent injury to other workers from flying chips. If a shield does not afford positive protection to all exposed staff, then glasses with side protection should be worn.

Tap and Die Work

- The work should be firmly mounted in the vice. Only a T-handle wrench or adjustable tap wrench should be used. When threads are being cut with a hand die, hands and arms should be kept clear of the sharp threads coming through the die, and metal cuttings should be cleared away with a brush

Hack Saws

- Hacksaws should be adjusted in the frame to prevent buckling and breaking, but should not be tight enough to break off the pins that support the blade. Install blade with teeth pointing forward.
- Pressure should be applied on the forward stroke not on the back stroke. If the blade is twisted or too much pressure is applied, the blade may break and cause injury to the hands or arms of the user.

Files

- Selection of the right kind of file for the job will prevent injuries and lengthen the life of the file. Inasmuch as the extremely hard and brittle steel of the file chips easily, the file should never be cleaned by being struck against a vice or other metal object. A file-cleaning card or brush should be used.
- For the same reason, a file is not to be hammered or used as a pry. Such abuse frequently results in the file's chipping or breaking causing injury to the user. A file should not be made into a center punch, chisel, or any other type of tool because the hardened steel may fracture in use.
- A file is never to be used without a smooth, crack-free handle; if the file should bind, the tang may puncture the palm of the hand, the wrist, or other part of the body. Under some conditions, a clamp-on raised offset handle may be useful to give extra clearance for the hands. Files are not to be used on lathe stock turning at high speed (faster than three turns per file stroke) because the end of the file may strike the chuck, dog, or face plate and throw the file (or metal chip) back at the operator hard enough to inflict serious injury.

Tin Snips

- Tin snips should be heavy enough to cut the material so easily that the worker needs only one hand on the snips and can use the other to hold the material. The material is to be well supported before the last cut is made so that cut edges do not press against the hands.
- Jaws of snips are to be kept tight and well lubricated.
- Staff and contractors shall wear safety goggles when trimming corners or slivers of metal because small particles often fly with considerable force. They shall always wear gloves.

Cutters

- Cutters used on wire, reinforcing rods, or bolts should have ample capacity for the stock; otherwise, the jaws may be sprung or spread. Also, a chip may fly from the cutting edge and injure the user.
- Cutters require frequent lubrication. To keep cutting edges from becoming nicked or chipped, cutters are not to be used as nail pullers or pry bars.
- Cutter jaws should have the hardness specified by the manufacturer for the particular kind of material to be cut. By adjustment of the bumper stop behind the jaws, cutting edges are to be set to have a clearance of 0.003 inch when closed.

4.8.2. Wood Cutting Tools

Note: Edged tools are to be used so that if a slip should occur, the direction of force will be away from the body. For efficient and safe work, edged tools are to be kept sharp and ground to the proper angle. A dull tool does a poor job and may stick or bind.

Chisels

- Inexperienced staff and contractors shall be instructed in the proper method of holding and using chisels. Handles are to be free of splinters.
- The wood handle of a chisel struck by a mallet is to be protected by a metal or leather cap to prevent it from splitting.
- The work to be cut must be free of nails to avoid damage to the blade or cause a chip to fly into the user's face or eye.

Saws

- Saws should be carefully selected for the work they are to do. For crosscut work on green wood, a coarse saw (4 to 5 points per inch) is to be used. A fine saw is better for smooth, accurate cutting in dry wood. Saws are to be kept sharp and well set to prevent binding.

Axes

- An axe person is to make sure that there is a clear circle in which to swing the axe before starting to chop. Also, all vines, brush, and shrubbery within the range should be removed, especially overhead vines that may catch or deflect the axe.
- Axe blades shall be protected with a sheath or metal guard wherever possible. When the blade cannot be guarded, it is safer to carry the axe at one's side. The blade on a single-edged axe shall be pointed down.

Hatchets

- Hatchets shall not be used for striking hard metal surfaces since the tempered head may injure the user or others by flying chips. When using a hatchet in a crowded area, staff shall take special care to prevent injury to themselves and other workers. Using a hatchet to drive nails is prohibited.

4.8.3. Miscellaneous Cutting Tools

Planes, Scrapers, Bits, and Drawknives

- Planes, scrapers, bits, and drawknives are to be used only by experienced staff.
- These tools are to be kept sharp and in good condition.
- The principal hazard in the use of knives is that hands may slip from the handle onto the blade or that the knife may strike the body or the free hand. A handle guard or a finger ring (and swivel) on the handle eliminates these hazards. Adequate guarding is important.
- Personnel who must carry knives with them on the job shall keep them in sheaths or holders. Never carry a sheathe knife on the front part of a belt. Always carry it over the right or left hip, toward the back. This will prevent severing a leg artery or vein in case of a fall.
- Knives must never be left lying on benches or in other places where they may cause hand injuries. Safe placing and storing of knives is important to knife safety.

- Supervisors must make certain that personnel who handle knives have ample room in which to work so they are not in danger of being bumped by other workers.
- Supervisors should be particularly careful about the hazard of personnel leaving knives hidden under a product, under scrap paper or wiping rags, or among other tools in work boxes or drawers. Knives are to be kept separate from other tools to protect the cutting edge of the knife as well as to protect the staff.
- Horseplay shall be prohibited around knife operations. Throwing, "fencing", trying to cut objects into smaller and smaller pieces, and similar practices are not only dangerous but reflect inadequate supervision. .
- Supervisors shall assure that nothing is cut that requires excessive pressure on the knife. Knives shall not be used as a substitute for can openers, screwdrivers, or ice picks.

4.8.4. Torsion Tools

Note: Socket wrenches are safer to use than adjustable or open-end wrenches.

Open-End or Box Wrenches

- Open-end or box wrenches shall be inspected to make sure that they fit properly and are never to be used if jaws are sprung or cracked. When defective they shall be taken out of service until repaired.

Socket Wrenches

- Socket wrenches give great flexibility in hard-to-reach places. The use of special types shall be encouraged where there is danger of injury.

Adjustable Wrenches

- Adjustable wrenches are used for many purposes. They are not intended, however, to take the place of standard open-end, box or socket wrenches. They are used mainly for nuts and bolts that do not fit a standard wrench. Pressure is always applied to the fixed jaw.

Pipe Wrenches

- Pipe wrenches, both straight and chain tong, shall have sharp jaws and be kept clean to prevent slipping.
- The adjusting nut of the wrench is to be inspected frequently. If it is cracked, the wrench shall be taken out of service. A cracked nut may break under strain, causing complete failure of the wrench and possible injury to the user.
- A piece of pipe "cheater" slipped over the handle shall not be used to give added leverage because this can strain a pipe wrench to the breaking point. The handle of every wrench designed to be long enough for the maximum allowable pressure.
- A pipe wrench should never be used on nuts or bolts, the corners of which will break the teeth of the wrench, making it unsafe to use on pipe and fittings. Also, a pipe wrench, when used on nuts and bolts, damages their heads. A pipe wrench shall not be used on valves, struck with a hammer, nor used as a hammer.

Pliers

- Side-cutting pliers sometimes cause injuries when short ends of wires are cut. A guard over the cutting edge and the use of safety glasses will help prevent injuries.
- The handles of electricians' pliers are to be insulated. In addition, staff shall wear the proper electrical rated gloves if they are to work on energized lines.
- Pliers shall not be used as a substitute for a wrench.

Special Cutters

- Special cutters include those for cutting banding wire and strap. Claw hammers and pry bars shall not be used to snap metal banding material.

Pipe Tongs

- Staff and contractors must neither stand nor jump on the tongs nor place extensions on the handles to obtain more leverage. They should use larger tongs.

Screwdrivers

- The practice of using screwdrivers for punches, wedges, pinch bars, or pries shall not be allowed.
- Cross-slot (Phillips-head) screwdrivers are safer than the square bit type, because they have fewer tendencies to slip. The tip must be kept clean and sharp, however, to permit a good grip on the head of the screw.
- The part to be worked upon must never be held in the hands; it should be laid on a bench or flat surface or held in a vise.
- No screwdriver used for electrical work shall have the blade or rivet extending through the handle. Both blade and handle shall be insulated except at the tip.

4.8.5. Shock Tools

Hammers

- A hammer is to have a securely wedged handle suited to the type of head used. The handle shall be smooth, without cracks or splinters, free of oil, shaped to fit the hand, and of the specified size and length. Personnel shall be warned against using a steel hammer on hardened steel surfaces.
- Instead, a soft-head hammer or one with a plastic, wood, or rawhide head should be used.
- Safety goggles or safety glasses shall be worn to protect against flying chips, nails, or scale.

Riveting Hammers

- Riveting hammers, often used by sheet metal workers, must have the same kind of use and care as ball pen hammers and should be watched closely for cracked or chipped faces.

Carpenters or Claw Hammers

- The faces shall be kept well-dressed at all times to reduce the hazard of flying nails while they are being started into a piece of wood. A checker-faced head is sometimes used to reduce this hazard.
- Eye protection is advisable for all operators and all staff working in the same area.

Spark-Resistant Tools

- Around flammable substances, sparks produced by iron and steel hand tools can be a dangerous ignition source. Where this hazard exists, spark-resistant tools made from brass, plastic, aluminum, or wood will provide for safety.

4.8.6. Power Tools

General

Power tools can be hazardous when improperly used. There are several types of power tools, based on the power source they use: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

Staff and contractors should be trained in the use of all tools - not just power tools. They should understand the potential hazards as well as the safety precautions to prevent those hazards from occurring.

The following general precautions should be observed by power tool users:

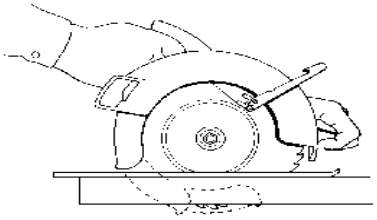
- Never carry a tool by the cord or hose.
- Never yank the cord or the hose to disconnect it from the receptacle.
- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not in use, before servicing, and when changing accessories such as blades, bits and cutters.
- All observers should be kept at a safe distance away from the work area.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. The worker should not hold a finger on the switch button while carrying a plugged-in tool.
- Tools should be maintained with care. They should be kept sharp and clean for the best performance. Follow instructions in the user's manual for lubricating and changing accessories.
- Be sure to keep good footing and maintain good balance.
- The proper apparel should be worn. Loose clothing, ties, or jewelry can become caught in moving parts.
- All portable electric tools that are damaged shall be removed from use and tagged "Do Not Use."

Guards

Hazardous moving parts of a power tool need to be safeguarded. For example, belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating, or moving parts of equipment must be guarded if such parts are exposed to contact by staff.

Guards, as necessary, should be provided to protect the operator and others from the following:

- Point of operation
- In-running nip points
- Rotating parts
- Flying chips and sparks



Safety guards must never be removed when a tool is being used. For example, portable circular saws must be equipped with guards. An upper guard must cover the entire blade of the saw. A retractable lower guard must cover the teeth of the saw, except when it makes contact with the work material. The lower guard must automatically return to the covering position when the tool is withdrawn from the work.

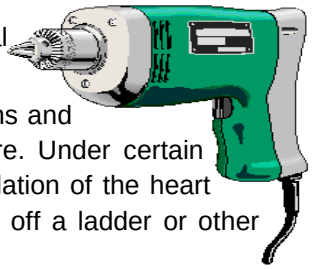
Safety Switches

The following hand-held powered tools must be equipped with a momentary contact "on-off" control switch: drills, tappers, fastener drivers, horizontal, vertical and angle grinders with wheels larger than 2 inches in diameter, disc and belt sanders, reciprocating saws, saber saws, and other similar tools. These tools also may be equipped with a lock-on control provided that turnoff can be accomplished by a single motion of the same finger or fingers that turn it on.

The following hand-held powered tools may be equipped with only a positive "on-off" control switch: platen sanders, disc sanders with discs 2 inches or less in diameter; grinders with wheels 2 inches or less in diameter; routers, planers, laminate trimmers, nibblers, shears, scroll saws and jigsaws with blade shanks <-inch wide or less.

Other hand-held powered tools such as circular saws having a blade diameter greater than 2 inches, chain saws, and percussion tools without positive accessory holding means must be equipped with a constant pressure switch that will shut off the power when the pressure is released.

Electric Tools



Staff, contractors using electric tools must be aware of several hazards; the most significant is the possibility of electrocution.

Among the primary hazards of electric-powered tools are burns and slight shocks which can lead to injuries or even heart failure. Under certain conditions, even a small amount of current can result in fibrillation of the heart and eventual death. A shock also can cause the user to fall off a ladder or other elevated work surface.

To protect the user from shock, tools must either have a three-core cord with ground and be grounded, or be powered by a low-voltage isolation transformer. Three-core cords contain two current-carrying conductors and a grounding conductor. One end of the grounding conductor connects to the tool's metal housing. The other end is grounded through a prong on the plug. Anytime an adapter is used to accommodate a two-hole receptacle, the adapter wire must be attached to a known ground.

These general practices should be followed when using electric tools:

- Electric tools should be operated within their design limitations.
- Gloves and safety footwear are recommended during use of electric tools.
- When not in use, tools should be stored in a dry place.
- Electric tools should not be used in damp or wet locations.
- Work areas should be well lighted.
- Electric cords shall be inspected periodically and kept in good condition. Heavy-duty plugs that clamp to the cord should be used to prevent strain on the current-carrying parts, if the cord is accidentally pulled.
- Although no guards are available for drill bits, some protection is afforded if drill bits are carefully chosen for the work to be done, e.g. not be long than necessary.
- Where the operator must guide the drill with the hand, the drill is to be equipped with a sleeve that fits over the drill bit. Oversized bits shall not be ground down to fit small electric drills; instead, an adapter should be used that will fit the large bit and provide extra power through a speed reduction gear; however this again is an indication of improper drill size. When drills are used, the pieces of work are to be clamped or anchored to prevent whipping.
- Electric saws are usually well guarded by the manufacturer, but staff must be trained to use the guard as intended. The guard should be checked frequently to be sure that it operates freely and encloses the teeth completely when it is cutting.
- Circular saws shall not be jammed or crowded into the work. The saw is to be started and stopped outside the work.

Powered Abrasive Wheel Tools

Powered abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments.

Before an abrasive wheel is mounted, it should be inspected closely and sound- or ring-tested to be sure that it is free from cracks or defects. To test, wheels should be tapped gently with a light non-metallic instrument. If they sound cracked or dead, they could fly apart in operation and so must not be used. A sound and undamaged wheel will give a clear metallic tone or "ring."

To prevent the wheel from cracking, the user should be sure it fits freely on the spindle. The spindle nut must be tightened enough to hold the wheel in place, without distorting the flange. Follow the manufacturer's recommendations. Care must be taken to assure that the spindle wheel will not exceed the abrasive wheel specifications. Furthermore, the design RPM speed of the disc shall be equal to or greater than the operating RPM speed of the equipment to be used, to ensure that the disc will withstand the loading of the equipment.

Due to the possibility of a wheel disintegrating (exploding) during start-up, the staff should never stand directly in front of the wheel as it accelerates to full operating speed.

Portable grinding tools need to be equipped with safety guards to protect workers not only from the moving wheel surface, but also from flying fragments in case of breakage.

In addition, when using a powered grinder:

- Always use eye protection.
- Turn off the power when not in use.
- Never clamp a hand-held grinder in a vise.

Floor stand and bench mounted abrasive wheels, used for external grinding shall be provided with safety guards (protection hoods). The maximum regular exposure of the grinding wheel periphery and sides shall be not more than 90 degrees except that, when work requires contact with the wheel below the horizontal plane of the spindle, the angular exposure shall not exceed 125 degrees.

Safety guards shall be strong enough to withstand the effect of a bursting wheel.

Floor and bench-mounted grinders shall be provided with work rests which are rigidly supported and readily adjustable.

Such work rests shall be kept at a distance not to exceed one-eighth inch from the surface of the wheel.

Cup type wheels used for external grinding shall be protected by either a revolving cup guard or a band type guard. All other portable abrasive wheels used for external grinding shall be provided with safety guards (protection hoods), except as follows:

When the work location makes it impossible, a wheel equipped with safety flanges shall be used.

When wheels are 2 inches or less in diameter which are securely mounted on the end of a steel mandrel are used.

All abrasive wheels shall be closely inspected and ring-tested before mounting to ensure that they are free from cracks and defects.

Grinding wheels shall fit freely on the spindle and shall not be forced on. The spindle nut shall be tightened only enough to hold the wheel in place.

All staff using abrasive wheels shall be protected by eye protection equipment.

Dust-type safety goggles or plastic face shields should be worn and, if dust is created, a respirator approved by the National Institute for Occupational Safety & Health (NIOSH) for the exposure should be worn.

If a sander is used steadily, it should be dismantled periodically, as well as thoroughly cleaned every day by being blown out with low-pressure air. If compressed air is used the operator shall wear safety goggles or work with a transparent chip guard between his body and the air blast.

Because wood dust presents a fire and explosion hazard, keep dust to a minimum; sanders can be equipped with a dust collection or vacuum bag. Electrical equipment shall be designed to minimize the explosion hazard. Fire extinguishers approved for Class C (electrical) fires should be available

4.8.7. Pneumatic Tools

Pneumatic tools are powered by compressed air and include chippers, drills, hammers, and sanders.

There are several dangers encountered in the use of pneumatic tools. The main one is the danger of getting hit by one of the tool's attachments or by some kind of fastener the worker is using with the tool.

Eye protection is required and face protection is recommended for staff working with pneumatic tools.

Noise is another hazard. Working with noisy tools such as jackhammers requires proper, effective use of hearing protection.

When using pneumatic tools, staff must check to see that they are fastened securely to the hose to prevent them from becoming disconnected. A short wire or positive locking device attaching the air hose to the tool will serve as an added safeguard.

A safety clip or retainer must be installed to prevent attachments, such as chisels on a chipping hammer, from being unintentionally shot from the barrel.

Screens must be set up to protect nearby workers from being struck by flying fragments around chippers, riveting guns, staplers, or air drills.

Compressed air guns should never be pointed toward anyone. Users should never "dead-end" it against themselves or anyone else.

The following safety practices will be applied when using pneumatic tools:

- The operating trigger on portable hand-operated utilization equipment shall be so located as to minimize the possibility of its accidental operation and shall be arranged to close the air inlet valve automatically when the pressure of the operator's hand is removed.
- Pneumatic power tools shall be secured to the hose or whip by some positive means to prevent the tools from becoming accidentally disconnected.
- Safety clips or retainers shall be securely installed and maintained on pneumatic impact (percussion) tools to prevent attachments from being accidentally expelled.
- All pneumatically driven Nailers, staplers, and other similar equipment provided with automatic fastener feed, which operate at more than 100 p.s.i. pressure at the tool shall have a safety device on the muzzle to prevent the tool from ejecting fasteners, unless the muzzle is in contact with the work surface.
- Compressed air shall not be used for cleaning purposes except with an air blow gun limited to 30 p. s. i. static pressure at the outlet nozzle and then only with effective chip guard and personal protective equipment.

- The manufacturer's safe operating pressure for hoses, pipes, valves, filters, and other fitting shall not be exceeded.
- The use of hoses for hoisting or lowering tools shall not be permitted.
- All hoses exceeding 1/2-inch inside diameter shall have a safety device at the source of supply or branch line to reduce pressure in case of hose failure.
- Airless spray guns of the type which atomize paints and fluids at high pressures (1,000 pounds or more per square inch) shall be equipped with automatic or visible manual safety devices which will prevent pulling of the trigger to prevent release of the paint or fluid until the safety device is manually released.
- In lieu of the above, a diffuser net which will prevent high pressure, high velocity release, while the nozzle tip is removed, plus a nozzle tip guard which will prevent the tip from coming in contact with the operator, or other equivalent protection shall be provided.

4.8.8. Fuel Powered Tools

The following safety practices will be applied when using Fuel Powered tools:

- All fuel powered tools shall be stopped while being refueled, serviced, or maintained, and fuel shall be transported, handled, and stored in approved safety cans.
- Leakage or spillage of flammable or combustible liquids shall be disposed of promptly and safely.
- When fuel powered tools are used in enclosed spaces, the applicable requirement for concentrations of toxic gases and use of personal protective equipment shall apply.

4.8.9. Hydraulic Power Tools

The following safety practices will be applied when using Hydraulic Power tools:

- The fluid used in hydraulic powered tools shall be fire-resistant and shall retain its operating characteristics at the most extreme temperatures to which it will be exposed.
- The manufacturer's safe operating pressures for hoses, valves, pipes, filters, and other fittings shall not be exceeded.
- All jacks – lever and rachet jacks, screw jacks, and hydraulic jacks - must have a device that stops them from jacking up too high. Also, the manufacturer's load limit must be permanently marked in a prominent place on the jack and should not be exceeded.
- A jack should never be used to support a lifted load. Once the load has been lifted, it must immediately be blocked up.
- Use wooden blocking under the base if necessary to make the jack level and secure. If the lift surface is metal, place a 1-inch-thick hardwood block or equivalent between it and the metal jack head to reduce the danger of slippage.
- When setting up a jack, ensure:
  - the base rests on a firm level surface,
  - the jack is correctly cantered,
  - the jack head bears against a level surface, and
  - the lift force is applied evenly.
- Proper maintenance of jacks is essential for safety. All jacks must be inspected before each use and lubricated regularly. If a jack is subjected to an abnormal load or shock, it should be thoroughly examined to make sure it has not been damaged.

4.8.10. Use and Maintenance of Power Tools

The following safety practices will be applied when using Power tools:

- These tools should not be used in an explosive or flammable atmosphere.
- Only personnel who have been trained in the operation of the particular tool in use shall be allowed to operate a power tool.
- The tool shall be tested each day before loading to see that safety devices are in proper working condition. The method of testing shall be in accordance with the manufacturer's recommended procedure.
- Any tool found not in proper working order or one that has developed a defect during use shall be removed from service immediately and not used until properly repaired.
- Adequate eye, head, face and/or personal protective equipment as necessitated by working conditions shall be utilized by the operators and persons working in the area.
- The tool shall be designed so that it cannot be fired unless it is equipped with a standard protective shield or guard or a special shield, guard, fixture, or jib.
- The firing mechanism shall be designed so that the tool cannot fire during loading or preparation to fire or if the tool is dropped while loaded. Firing of the tools shall be dependent upon at least two separate and distinct operations of the operator, with the final firing movement being separate from the operation of bringing the tool into the firing position
- The tool shall be designed so as not to be operable other than against a work surface and unless the operator is holding the tool against the work surface with force at least 5 pounds greater than the weight of the tool.
- The tool shall be designed so that it will not operate when equipped with the standard guard indexed to the center position if any bearing surface of the guard is tilted more than 8 degrees from contact with the work surface.
- The tool shall be designed so that positive means of varying the power are available or can be made available to the operator as part of the tool or as an auxiliary, to facilitate selection of a power level adequate to perform the desired work without excessive force.
- The tool shall be designed so that all breeching parts will be reasonably visible to allow a check for any foreign matter that may be present.
- Tools shall not be loaded until just prior to the intended firing time. Neither loaded nor empty tools are to be pointed at any staff. Hands shall be kept clear of the open barrel end.
- Loaded tools shall not be left unattended.
- Fasteners shall not be driven into very hard or brittle materials including, but not limited to, cast iron, glazed tile, surface-hardened steel, glass block, live rock, face brick, or hollow tile.
- Driving into materials easily penetrated shall be avoided unless such materials are backed by a substance that will prevent the pin or fastener from passing completely through and creating a flying missile hazard on the other side.
- Power-assisted, hammer-driven tools are used for the same purposes as power tools and generally the same precautions are to be followed.

4.8.11. Woodworking Tools

The following safety practices will be applied when using woodworking tools:

- Personal Protective Equipment - All personnel using woodworking tools shall be protected by eye protection equipment.
- Guarding - All portable, power-driven circular saws shall be equipped with guards above and below the base plate or shoe. The upper guard shall cover the saw to the depth of the teeth, except for the minimum arc required to permit the base to be tilted for beveled cuts. The lower guard shall cover the saw to the depth of the teeth, except for the minimum arc required to allow proper retraction and contact with the work. When the tool is withdrawn from the work, the lower guard shall automatically and instantly return to the covering position.
- Disconnect Switches All "fixed" power driven wood-working tools shall be provided with a disconnect switch that can either be locked or tagged in the "off" position.
- Self-feed - Automatic feeding devices shall be installed on machines whenever the nature of the work will permit. Feeder attachments shall have the feed rolls/other moving parts covered/guarded so as to protect the operator from hazardous points
- Speeds - The operating speed shall be etched or otherwise permanently marked on all circular saws over 20 inches in diameter or operating at over 10,000 peripheral feet per minute. Any saw so marked shall not be operated at a speed other than that marked on the blade. When a marked saw is re-tensioned for a different speed, the marking shall be corrected to show the new speed.

4.9 Welding and Cutting Materials

4.9.1. Definitions

Gas – Slower and easier to control than electric arc. Uses gas flame over metals until molten puddle is formed. Most popular fuels used with oxygen include acetylene.

Arc – Two metals are joined by generating an electric arc between a covered metal electrode and the base metal.

Oxygen Cutting - Metal is heated by gas flame and an oxygen jet does the cutting

Arc Cutting - Intense heat of electric arc melts away the metal.

4.9.2. General Requirement

The following safety practices will be applied when welding and cutting materials:

- When combustibles cannot be moved from the welding/cutting area, the requirements of NFPA 51B shall be followed. No cutting and welding operation will be permitted without authorization in the PTW.
- Suitable fire extinguishers shall be available.
- Fire watches are required if welding of cutting and combustibles in the area could be easily ignited by sparks. This could be greater than or less than (10.67 meters) from point of operation.
- Cutting or welding shall not be conducted in areas not specifically authorized by the PTW, in the presence of explosive atmospheres.
- For contractor operations, the contractor's nominated Maintenance Engineer is responsible for the safe handling and use of the cutting and welding equipment.
- No welding or cutting shall be done on used drums, barrels, tanks, or containers until they have been cleaned thoroughly.
- All welding cables shall be placed so they are clear of passageways, ladders and stairways.

4.9.3. Oxygen-Fuel, Gas Welding and Cutting

When transporting, moving, and storing Compressed Gas Cylinders, follow the safety practices detailed in *QU SOP-03 Compressed Gas Cylinders*.

When using fuel gases, the following safety practices will be applied:

- Only properly instructed and qualified staff, contractors will operate equipment using fuel gases.
- Fuel gas shall not be taken into confined spaces.
- Fuel gas and oxygen manifolds must be clearly identified and placed in well-ventilated area. The manifold hose connections must be such that the hose cannot be interchanged between fuel gas and oxygen manifolds. Header connections will be supplied.
- Oxygen and fuel gas hoses must be easily distinguished from each other by color or surface characteristics. Torches must be inspected at the beginning of each shift for leaking valves, couplings, and connections. Pressure regulators must be in proper working order while in use.
- Cylinders not having fixed hand wheels shall have keys, handles or non-adjustable wrenches on valves stems while in service.
- Valves shall be closed before moving cylinders.
- Valves shall be closed when work is finished.
- Empty cylinder valves shall be closed.
- Before connecting the regulator, the valve shall be opened slightly and closed immediately while the operator stands to one side of the outlet.
- Acetylene cylinder valves shall be opened as little as one-half turn of the spindle - preferably no more than three-fourths of a turn.
- When a special wrench is required, it shall be left in position on the stem of the valve while the cylinder is in use.
- Acetylene shall never be utilized at a pressure in excess of 15 pounds per square inch gage (p.s.i.g.) (1.06 kilograms per square centimeter).

When Arc Welding and Cutting the following safety practices will be applied:

- Oxygen cylinders and fitting shall be kept away from combustible material, especially oil and grease, as oxygen is not compatible with these products.
- Only the correct manual electrode holders shall be used. If the portion gripped by the hand contains current, it must be fully insulated against the maximum voltage encountered to ground.
- Proper welding cables and connectors must be used and must be completely insulated. Splicing, if used, shall be equal to the insulating quality of the cable and shall not be located within 3.05 meters (10 feet) of the electrode holder.
- Ground return cables must have a safe current-carrying capacity equal to or greater than the specified maximum output capacity of the units serviced. When a structure or pipeline is employed as a ground circuit, a determination must be made that the required electric contact exists at all joints.
- The frames of all arc welding and cutting machines shall be grounded with a third wire or a separate wire which is grounded at the source of the current.
- Arc welding or cutting operations shall be shielded by noncombustible or flameproof screens to protect staff and other persons in the vicinity from the direct rays of the arc.
- Staff and contractors performing any type of welding, cutting or heating shall be protected by suitable eye protection equipment.

When Resistance welding, the following safety practices will be applied

- All equipment shall be installed by a qualified electrician.
- A safety type disconnecting switch, circuit breaker or circuit interrupter shall be provided near the machine.
- Operators shall be properly trained and judged competent to operate the equipment before being designated to do so.
- Controls of all automatic air and hydraulic chargers shall be guarded against accidental activation.
- All doors and panels shall be kept blocked on the resistance welding machines.
- Appropriate shields shall be provided to protect workers and passing staff from the sparks.
- Fire curtains shall be provided.
- For spot and seam welding, voltage shall not exceed 480 volts during operation.

When welding, Cutting, and Heating Relative to Preservation Coatings:

- The flammability of protective coatings must be determined before welding, cutting, or heating is commenced on such surfaces.
- When coatings are highly flammable, they shall be stripped from the area to prevent ignition. Protective measures must be taken when the preservative coating is toxic.

4.10 Heat Stress Management

4.10.1. Background

Heat Stress is influenced by several risk factors: climatic conditions, the work environment, demands of the work, clothing and personal characteristics.

Climatic and environmental conditions that affect the risk of heat-related disorders are air temperature and humidity, air movement, and the temperature of surrounding surfaces which affects radiant heat exchange.

Demands of the work influence the stress on the temperature regulation system. Individual responses to a given work load vary but, as a staff expends more energy, the body's internal metabolic heat production rises. This increases stress on the cardiovascular system to regulate body temperature (i.e., by increasing blood flow to skin). Work-related factors that influence heat stress include work rate, level of physical effort, and duration of activity.

Clothing characteristics such as insulation, permeability, weight, fit and ventilation affect the body's ability to regulate internal temperatures. Other factors that may increase the risk of heat-related disorders include additional equipment, the use of a respirator, or other personal protective equipment (PPE).

Personal characteristics such as age, weight, previous heat stress injury, underlying medical conditions (e.g., diabetes, cardiovascular disorders, chronic pulmonary disease, and thyroid disorders), medication use and overall health and physical fitness contribute to a staff susceptibility of contracting a heat-related illness.

Working in an environment with heat stress not only increases the risk for specific heat related conditions such as heat exhaustion and heat stroke, but also increases the risk for other adverse events.

4.10.2. Signs and Symptoms of Heat-Related Disorders

Heat related disorders may occur when there is an exposure to heat risk factors. The table below illustrates some of the signs and symptoms associated with heat stress. If the staff is experiencing any of these symptoms, the staff should be taken to the medical clinic for treatment immediately.

DISORDER	SIGNS	SYMPTOMS
Dehydration	• Loss of work capacity • Delayed response to stimuli	• Fatigue • Weakness • Dry mouth
Heat Exhaustion	• High pulse rate, confusion, anxiety • Profuse sweating • Low blood pressure • Pale face, or flushing • Body temperature increased but below 104 degrees F. • Excessive thirst, decreased urine output	• Fatigue, malaise • Weakness • Blurred vision • Dizziness • Headache • Nausea • Loss of appetite
Heat rash	• Skin eruptions	• Itching skin, prickly sensation
Heat Stroke	• Red face • Mental status changes such as disorientation, • confusion or irritability • Hot, dry skin • Erratic behavior • Collapse • Shivering • Body temperature >104 F	• May be same as those for heat exhaustion (see above)
Heat Cramps	• Incapacitating pain in muscle	• Muscle cramps (abdominal and lower extremities) • Fatigued muscles
Heat Syncope	• Brief fainting or near fainting behaviour	• Blurred vision

4.10.3. Preventive Controls

A control is a mechanism used to minimize or eliminate an exposure to a hazard, such as heat. There are three types of controls (e.g. engineering, administrative and personal protective equipment) that can be implemented to reduce exposure to excessive heat.

Each person and situation is unique, so controls and their application will vary. HS can be contacted to assist in selecting the most appropriate preventive measures for specific situations.

Administrative Controls

Administrative controls, also known as work strategy controls, are strategies used by supervisors to limit exposure to a hazard. For example, changes to the work schedule (i.e., when and how the job is performed) can limit the amount of time an staff is exposed to elevated temperatures

Engineering Controls

Engineering controls are physical changes made to the work environment, such as adding fans or air conditioning to an indoor environment.

Work Practices and Personal Protective Equipment (PPE)

Other than hats and loose-fitting clothing, there is a limited selection of personal protective equipment to reduce the risk of heat stress. Contact HS for help in evaluating the effectiveness of available personal protective equipment.

In some cases, personal protective equipment—such as impermeable protective clothing and respirators—may increase the risk of developing a heat-related disorder. If such PPE is truly necessary, administrative and engineering controls may be necessary to allow work in heat risk environments.

4.10.4. Monitoring for Signs and Symptoms of Heat Stress

Supervisors, co-workers and staff themselves are responsible for monitoring for the signs and symptoms of heat-related disorders. See the above table for information on recognizing the signs and symptoms of impending heat stress. A supervisor or co-worker is often in the best position to observe the onset of a heat-related disorder.

When heat stress risks are present, supervisors should regularly check workers (by observation and questions) for signs and symptoms of heat stress.

Extra care shall be taken to monitor those at high risk, such as staff who are older or overweight, staff who overexert themselves, and staff with chronic medical conditions including diabetes, heart or lung disease, thyroid disease or high blood pressure. Staff who takes certain medications may also be at increased risk.

Personnel working outdoors or within indoor environments with elevated temperatures should self-monitor for the signs and symptoms of heat-related illness.

4.10.5. Issue Heat Alerts

When conditions are present that contribute to heat stress, departments and work units are to alert at risk staff and implement their preventive measures for working in heat. The alert should include a reminder of signs and symptoms, how to control exposure, and a re-emphasis of the preventive work strategies to be followed.

4.11 Confined Space Procedures

A Confined Space is defined as a space with limited or restricted means for entry and exit and is not intended for continuous staff occupancy. Confined spaces include but are not limited to manholes, pipelines, sewers, tunnels, and pressure vessels.

4.11.1. Permit-Required Confined Space (PRCS)

A Permit-Required Confined Space is a confined space where one or more of the following characteristics are met:

- Contains or has a known potential to contain a hazardous atmosphere. Three of the most common atmospheric conditions that constitute hazards are oxygen deficiency, presence of combustible gases and vapors, and toxic gases and vapors.
- Contains a material with the potential for engulfment of an entrant.
- Contains any other recognized serious safety or health hazard.

4.11.2. Identification of Permit-Required Confined Spaces

Each department is to identify all confined spaces and those suspected of being a PRCS. Subsequent to identification, the department should contact the HS to assist in the evaluation of those spaces.

A Confined Space and PRCS Recognition Checklist is provided in *Appendix B* to enable a systematic and consistent assessment and identification process.

4.11.3. Warning Signage

PRCSs must be posted with warning signs notifying staff of any hazards that are present, and that only authorized entrants may enter the PRCS. An example warning sign may be:

DANGER
PERMIT- REQUIRED CONFINED SPACE
DO NOT ENTER

4.11.4. Evaluation of Permit to Confined Space Condition

Each PRCS must be evaluated to identify hazards; determine the severity the hazards; and establish control procedures and practices by which the space may be entered safely. A "Confined Space Hazard Evaluation" form must be completed for each PRCS.

Before entry into a PRCS is authorized, the conditions within the space must be tested to determine if acceptable entry conditions exist. The space must be monitored during the course of entry operations to determine if acceptable entry conditions are being maintained. When testing for atmospheric hazards first test for oxygen deficiency, then for combustible gases and vapors, and then for toxic gases and vapors.

4.11.5. PTW System

Before entering a PRCS an authorized staff must complete a PTW for the activity. Please refer to *QU HSMS Section 7.1 - PTW procedure* for further guidance.

4.11.6. Authorized Personnel

Definitions and roles for personnel involved in confined space operations are as follows:

- Authorized Entrant - A staff member who is authorized by the employer to enter a permit required space. Only staff that are trained as an entrant and have obtained a permit signed by the entry supervisor may enter a permit required confined space.
- Attendant - An individual who is stationed outside and monitors authorized entrants. At least one individual must be stationed outside the permit required confined space.
- Entry Supervisor – is a supervisor or foreman responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry, for overseeing entry, and for terminating entry.

4.11.7. Pre-Entry and Entry Practices and Procedures

The HS shall review and approve the pre-entry and entry procedures prior to entry. Practices and procedures to be addressed include:

- Isolating (locking and tagging) the PRCS.
- Ventilation of the PRCS.
- Providing vehicle and pedestrian barriers to protect entrants from external hazards.
- Verifying that conditions are acceptable for entry.

4.11.8. Locking and Tagging

No work is to be performed until appropriate locking, tagging and/or isolation is accomplished to prevent the inadvertent actuation of operations or processes associated with the space which might expose personnel to hazardous conditions.
Refer to *QU SOP 01 – Lockout / Tag out*.

4.11.9. Required Equipment

The following equipment is to be provided and maintained to ensure their proper use:

- Testing and monitoring equipment
- Ventilating equipment
- Communications equipment
- Personal protective equipment
- Lighting equipment
- Barriers and shields
- Ladders
- Rescue equipment
- Other equipment necessary for safe entry

4.11.10. Rescue Team

If an emergency arises that requires a rescue team, the Emergency Medical Service is to be contacted through CSU Control Room 4403 3600. Control Operator shall call 3999.

The rescue service is to be provided access to all PRCSs from which rescue may be necessary so that the rescue service can develop appropriate rescue plans and practice rescue operations.

Non-entry retrieval methods are to be used unless the retrieval equipment would increase the overall risk of entry. Each authorized entrant is to use a chest or full body harness, with a retrieval line attached at the center of the entrant's back near shoulder level. For vertical type PRCSs more than 5 feet deep, a mechanical device for retrieval is to be available.

Refer to *QU HSMS – Emergency Management procedure* for further guidance.

4.11.11. Training

Personnel who are assigned duties that may require entry into PRCS must receive training on confined space entry procedures, the permit system, and hazard recognition and control procedures. Authorized entrants, attendants, and supervisors in charge of entry are to receive training in their respective confined space duties and responsibilities. Training is to be provided: before staff are first assigned duties pertaining to PRCSs; whenever there is a change in assigned duties; whenever there is a change in PRCS operations that present a hazard about which an staff has not been trained; and whenever there are deviations from the entry permit procedures or inadequacies in the staff use or knowledge of these procedures.

Refer to *QU HSMS – Training and Competency procedure* for further guidance.

4.11.12. Entry Into Non-Permit Confined Spaces

Precautions must be taken also for entry into non-permit required spaces. The space atmosphere must be tested for oxygen concentration, combustible gas or vapor, and potential toxic contaminants. Any hazardous conditions detected must be reported to the supervisor and HS. Manholes and confined spaces with limited ventilation must be power ventilated with a blower (minimum capacity 750 cfm) operating at its maximum rated speed for a minimum of 5 minutes. Larger confined spaces (greater than 1000 cubic feet) must be ventilated for at least 10 minutes. The blower must be in continuous operation while anyone is in the confined space.

4.12 Emergency Preparedness and Response

Emergency preparedness and response will be managed in accordance with *QU HSMS – Emergency Management Procedure*, and subordinate procedures, i.e.:

- **QU HSMS - First Aid and Medical Emergency Plan**
- **QU HSMS - Fire Safety and Response Plan**
- **QU HSMS - Earthquake Response Plan**
- **QU HSMS - Spill Response Plan**
- **QU HSMS - Power Outage Response Plan**

4.12.1.1. Fire Safety

General fire safety management requirements applicable to all QU facilities and activities will be applied in operations and maintenance activities in accordance with **QU HSMS - Fire and Safety Response Procedure**, and **– Emergency Management Procedure.**

Additionally, some specific fire safety precautions to be observed for any QU operations and maintenance activities are:

- Smoking is one of the major causes of fires in the work area. At Qatar University, smoking is prohibited in all work area where the staff and contractor/s perform their specific activities.
- Access key custody of offices, laboratories, stores, etc. should be assigned to the Security in-charged at respective buildings. Users should maintain a duplicate key.

4.13 Incidents and Accidents

Incidents, accidents and near-misses, and associated incident investigations will be reported and managed in accordance with **QU HSMS Incident Reporting and Investigation.**

4.14 Waste Management

- Waste minimization through efficient design, procurement and material management practices.
- Implement procurement / purchasing policies, such as:
  - Specifying the exact quantity of material required;
  - Preference of materials with limited packaging, or ordering of materials in bulk to minimize packaging waste;
  - Negotiate return or buy-back arrangements with suppliers for containers (e.g. chemical containers) and packing materials; and
  - Purchase environmentally-friendly materials (i.e. materials with recycled content or with energy-efficient features).
- Where practical, incorporate the use of pre-fabricated materials to minimise onsite waste generation.
- Use of disposal materials such as plastic cups will be discouraged.
- Adopt a policy on double-sided printing to minimize paper use and waste paper generation.
- Establish waste segregation program including:
  - Provision of designated areas and suitable containers for each type of waste;
  - As a minimum, hazardous waste will be segregated from non-hazardous.
  - Establish a labelling system for waste storage and containers to prevent cross-contamination. Where possible, labels will be in English and Arabic.
- Consider reuse of scrap materials, where possible, e.g.:
  - Reuse of paper for drafts;
  - Reuse of excavated materials for site filling purposes;
  - Reuse of scrap wood for pallets, signage and temporary structures onsite; and
  - Reuse of scrap metal sheets for drip trays.
- Ensure efficient use of chemicals and other hazardous materials via establishing standard procedures and providing training / toolbox talk to relevant staff.
- Send recyclable wastes (including waste fuel / oil) to a suitable recycling facility.

- Provide waste management training to relevant site staff and workers. Training will include waste minimization, reuse, segregation and recycling procedures relevant to their line of work.
- Engage services of an approved waste contractor for waste management.
- Keep records of the following:
  - Types and volume of wastes generated;
  - Date of collection; and
  - Waste manifest form.
- Prohibit open burning, burying and indiscriminate dumping of waste.
- Provide appropriate containers (water-tight) according to the type of waste (i.e. food waste containers should be provided with lids to prevent infestation).
- Locate waste bins strategically such that these can readily be accessed by workers, and at areas where wastes are mostly generated.
- Avoid overfill waste bins.
- Conduct regular housekeeping.
- Provide suitable storage facilities with impervious surfaces / floor in order to prevent leaching materials into soil and groundwater.
- Label waste containers, storage / stockpile areas, and other waste facilities to avoid cross contamination issues. Where practical, labels will be written in English and Arabic or any other languages where applicable).
- Locate waste facilities such that these are protected from potential wind dispersion.
- Locate waste facilities at least 50 feet away from storm water flow paths / network.
- Waste storage areas will be restricted, warning sign put in place.

4.15 HS Training and Induction

HS-related induction and training for QU staff, students, contractors and visitors conducting operations and maintenance procedures will be planned and conducted in accordance with **QU HSMS – Training and competency Procedure**.
At a minimum training shall cover the requirements of this Technical Guidance document and any specific training as identified by the risk assessment.

4.16 HS Inspections and Audits

HSMS compliance audits and inspections of operations and maintenance activities on QU facilities will be performed in accordance with **QU HSMS – Inspection and Audit Procedure**. Any non-conformances identified during inspections and audits will be recorded and managed via the Corrective Action Request process presented in this procedure.

5 Document Control

This Technical Guideline is a controlled document. The controlled version of this guideline is located on QU Electronic Documentation Management System.
Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.
Refer to *QU HSMS – Document Control and Record Retention*.

6 Appendices

Appendix A: Work Equipment Assessment Checklist
Appendix B: Confined Space and PRCS Recognition Checklist

Appendix A – Work Equipment Assessment Checklist

WORK EQUIPMENT ASSESSMENT CHECKLIST

Equipment Description: _____ **Ref No:** _____

Assessment No.: _____ **Assessor:** _____

Assessment Date: _____ **Signature:** _____

Suitability	YES	NO	Is Action Required		Action Taken
			YES	NO	
Is the equipment suitable for:					
• The purpose for which it is intended?					
• The location in which it is being used?					
• Does the equipment itself pose any significant risks (fumes etc.)?					
For maintenance purposes does the equipment require:					
• A simple visual inspection?					
• Portable electrical appliance test?					
• Statutory inspection?					
• Planned preventive maintenance?					
• Maintenance log?					
Are there any specific risk that require the equipment to be:					
Used by authorized person only?					
Maintained by authorized person only?					
Information, Instruction, Training & Supervision					
Have all the users been given use instruction?					
Is documentary evidence for the above available?					
Have all the users been given Health and Safety information?					
• Verbal					
• Written					
Dangerous Parts					
Does the equipment present any specific hazards?					
If "yes" have adequate control measures been implemented?					
Does the equipment have any guards fitted?					
If "yes" are they inspected in a regular basis?					
Does the equipment present any risk from high or low temperature?					
If "yes" have adequate control measures been taken?					
Does the equipment require Personal Protective Equipment?					
If "yes" have the adequate control measures been under taken?					
Is the documentary evidence for the above available?					
Is there a written defect reporting system?					
If "yes" are defects signed off when complete?					

Appendix B –Confined Space and PRCS Recognition Checklist

Confined Space and PRCS Recognition Checklist

Part 1

- Is the space large enough so an staff can bodily enter and perform work?
- Does the space have limited or restricted means of entry and exit?
- Is the space not designed for continuous occupancy?

If the answer is yes to all items in Part I, continue to Part II. If the answer is no to any of the items in Part I, the space is not considered a confined space.

Part 2

- Does the space contain or potentially contain a hazardous atmosphere?
- Does the space contain any chemicals or chemical residues?
- Does the space contain any flammable/combustible substances?
- Does the space contain or potentially contain any decomposing organic matter?
- Does the space have any pipes which bring chemicals into it?
- Does the space have any materials that can trap or potentially trap, engulf, or drown an entrant?
- Is vision obscured by dust at 5 feet or less?
- Does the space contain any mechanical equipment servicing the space?
- Does the space have converging walls, sloped floors or tapered floor to smaller cross-sections which could trap or asphyxiate an entrant?
- Does the tank or vessel contain rusted interior surfaces?
- Does the space contain thermal hazards (e.g. cold, hot)?
- Does the space contain excessive noise levels which could interfere with communication with an attendant?
- Does the space presents any slip, trip, or fall hazards?
- Are there any operations conducted near the space opening which could present a hazard to the entrant?
- Are there any hazards from falling objects?
- Are there lines under pressure servicing the space?
- Are cleaning solvents or paints going to be used in the space?
- Is welding, cutting, brazing, riveting, scraping, or sanding going to be performed in the space?
- Is electrical equipment located in or required to be used in the space?
- Does the space have poor natural ventilation which would allow an atmospheric hazard to develop?

- Are there any corrosives which could irritate the eyes in the space?
- Are there any conditions which could prevent any entrant's self rescue from the space?
- Are there any substances used in the space which have acute hazards?
- Is mechanical ventilation needed to maintain a safe environment?
- Is air monitoring necessary to ensure the space is safe for entry due to a potential hazardous atmosphere?
- Will the entry be made into a dike area where the dike is 5 feet or more in height?
- Are residues going to be scraped off the interior surfaces of the vessel?
- Are non-sparking tools required to remove residues?
- Does the space restrict mobility to the extent that it could trap an irritant?
- Is respiratory protection required because of a hazardous atmosphere?
- Does the space present a hazard other than those noted above which would make it a permit space?

If any other questions in PART 2 have been checked yes, the confined space is a Permit-Required Confined Space (PRCS). As such, entry into these spaces must be performed under the protection of PRCS program.