Hong Kong Science & Technology Parks Corporation

Laboratory Design Guidelines

SHE Office, HKSTP

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1. INTRODUCTION

The Laboratory Design Guidelines of Hong Kong Science and Technology Parks (HKSTP) Corporation define the requirements for all laboratories and research areas and ensures all new, remodeled, or renovated laboratories at the Science Park illustrate standard health and safety elements.

Given that the research activities undertaken by the stakeholders encompass a wide range of different applications, these guidelines address the basic safety fundamentals common to the design of most laboratory premises. More specific guidelines can be obtained from the references at the end of this document.

These guidelines adopt standards and practices from local guides as well as international standards that are deemed applicable in the context of safe laboratory operation. Nevertheless, the basic emphasis for the building and its facilities shall refer to local building codes and governing statutory obligations in Hong Kong.

The ultimate purpose of these guidelines is to provide a safe environment for laboratory personnel to conduct their research works.

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2. LABORATORY SPACE UTILIZATION & LAYOUT

2.1. Space Utilization and Configuration

2.1.1. In general, design of the laboratory layout and configuration must provide adequate space for safe working and appropriate separation of areas, generally including:

a) Laboratories shall be separated from offices or other non-laboratory areas. If it is not feasible to separate these two types of areas, offices attached to a laboratory shall be located nearby the exits of the laboratory. Laboratory activities involving the handling of hazardous materials shall be as far away from the office areas as possible.

b) Write-up areas can be set up in the laboratories if necessary. However, they should not be used as office workstations and should be as far away from the experimental areas as possible.

c) Support areas such as store rooms and equipment rooms should be located at convenient locations to facilitate operations and minimize influence to laboratory personnel with respect to noise, heat, and transport issues, etc.

d) Separate pantries or rooms for food and drink consumption and/or storage should be provided if necessary to avoid eating and drinking in laboratory areas.

e) Meeting and conference rooms, if provided, should also be separated from the laboratory areas.

f) Provision of adequate areas for safe storage/ movement of personal protective equipment, hazardous substances, compressed gas cylinders, hazardous wastes, etc.

2.2. Floor Loading

For the installation of certain heavy equipment, consultation with the Facilities Management Office is essential to ensure the designed loading capacity of that particular floor of the building is not exceeded.

2.3. Ceiling Heights

Ceiling heights shall be sufficient to accommodate the safe installation of laboratory equipment such as shield room, fume cupboards and biological safety cabinets where applicable. Sufficient head space shall be provided to allow inspection, if required, for the equipment at high level.

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2.4. Clearance for Operations

2.4.1. Sufficient floor space shall be provided for laboratory equipment to facilitate operation. Equipment such as refrigerators, freezers, incubators, autoclaves, large centrifuges shall be installed with sufficient space to cater for operators to maneuver and to allow maintenance works to be carried out as required.

2.4.2. Below is the outline for minimum separation between benches and floor-positioned equipment. Nevertheless, the actual spacing shall be determined by the requirement of the operations. The minimum separation between benches and floor-positioned equipment should meet the following clearance requirements:

a) No operator on either side – 900mm
b) Operators on one side of the aisle, no through traffic – 1000mm
c) Operators on one side of the aisle, plus through traffic – 1000mm
d) Operators on both sides of the aisle, no through traffic – 1400mm
e) Operators on both sides of the aisle, plus through traffic – 1450mm

2.4.3. Heat generating equipment, such as ovens and incubators, should be located away from corridors, aisles, passageways and frequently occupied spaces.

2.5. Entries, Exits and Doors

2.5.1. The laboratory and layout of equipment and laboratory furniture shall be carefully planned to maintain a free path leading from access doors to fire escape exits. The path shall be free from obstruction, such as equipment, furniture, storage boxes or any other items. Dedicated access shall be provided for the movement of compressed gas cylinders, hazardous materials and wastes, etc. The corridor width and escape distances shall meet the requirements of local legislation.

2.5.2. Emergency exits shall have appropriate exit signs. Where emergency exits are not visible, directional exit signs shall be installed. The fire escape route shall also be displayed in the laboratory to create awareness among the operators. The illuminated exit sign shall be maintained as required by local legislation.

2.5.3. Doors shall have vision panels or alternative means of viewing laboratory activities from outside. The vision panel shall offer general view of the laboratory. In order to maintain a clear path for the common corridor or service corridor, the door opening shall open into the laboratory. Doors opening into the corridor shall be recessed.

2.6. Laboratory Signage and Hazard Notices

2.6.1. All laboratories shall be identified clearly at each entrance including display of the name (i.e. the laboratory entity), person in-charge, emergency contact person(s), nature of hazards and protection requirements (see illustrative notice in Figure 1).

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2.6.2. All containers or cabinets for hazardous materials as well as facilities or equipment associated with hazardous materials shall be labeled with the respective hazard warning signs to ensure operators are aware of the potential hazards and operate with care.

Figure 1: A Sample of Illustrative Notice for Laboratory Entrances

COMPANY:	ABC BioTech Limited.	Unit No.	399, 9W

CONTACT	NAME	POSITION	PHONE NO.
Person In Charge	HERO WONG	LAB MANAGER	+852-98765432
Emergency Contact	HERO WONG	LAB MANAGER	+852-98765432
HKSTP FMO	24 HOURS	-	+852-2639 8008
HKSTP LAB FMO	24 HOURS	-	+852-2639 8738

MAJOR HAZARDS		PROTECTION
CORROSIVES		ENTRY RESTRICTIONS
BIOLOGICAL HAZARD		PROTECTIVE CLOTHING
RADIATION		EYE PROTECTION
NON-FLAMMABLE COMPRESSED GAS		

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3. SURFACE FINISHES & MATERIALS

The surface finishes and materials for laboratories associated with the handling of hazardous materials should meet the following requirements.

3.1 Flooring

3.1.1. Floor finish shall be smooth, impervious, easy to clean, slip-and wear-resistant and resistant to chemicals expected to be used in the laboratory. The floor finish shall be seamless with no sharp corners. Floor surface shall be coved where it meets walls and fixed benches.

3.1.2. Vinyl sheets are normally preferred over softer environmental flooring especially where chemicals are in use. Where liquid nitrogen spills and splashes can be expected, the use of other more durable material shall be installed.

3.1.3. Flooring of the corridors next to the laboratories which are associated with the transport of hazardous materials should also be finished with the same materials as for the laboratories.

3.2 Walls

Wall surfaces shall be free from cracks and unsealed penetration. Walls shall be constructed of non-porous material and painted with a durable, impervious finish to facilitate decontamination and cleaning. Corner guards and bumper rails shall be provided to protect wall surfaces in high traffic or impact areas.

3.3 Ceilings

3.3.1. Washable lay-in acoustic ceiling tiles should be provided for laboratory spaces except in areas where the potential for high moisture exists like washing and autoclave rooms. Gypsum board ceilings should be finished with durable and impervious paint.

3.3.2. Ceiling-mounted lighting in laboratories where potentially infectious materials or unsealed radioactive substances are handled should be recessed with a cover/diffuser flush at the ceiling level.

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4. LABORATORY FURNITURE

Laboratory furniture including benches, shelving, storage cabinets, stools and chairs, etc. shall be designed in accordance with safety and ergonomic principles meeting the needs of laboratory workers.

Environmentally friendly materials should also be used for laboratory furniture. Suitable color and surface texture for the furniture should be chosen to reduce glare and reflections and to enhance environmental comfort.

4.1. Benches

4.1.1. Benches in laboratories shall be stable and of adequate structural integrity. Bench tops shall be finished with a material that is easy to clean, smooth, impervious, resistant to chemicals, heat, and scratches. Bench tops should be free from joints as far as possible. Where unavoidable, joints shall be sealed to prevent seepage of spillages into the space below the bench tops. Where there is a wet area, ends of bench tops shall be coved to end walls.

4.1.2. Bench height should depend on the working position of laboratory workers. Typical bench is about 900 mm high for standing and 750 mm high for seated works. A slightly lower bench may be required for the use of tall equipment or apparatus.

4.1.3. Typical bench depth ranges from 600 to 900 mm for ease of access to the rear of the bench. Deeper worktop may be required for certain equipment or apparatus.

4.1.4. Sufficient leg or knee clearance shall be left under the bench top for laboratory workers who use the bench top as an experimental or write-up area.

4.2. Cabinetry

4.2.1. Cabinets in the laboratories should be finished with smooth, impervious, chemical resistant and easy to clean materials. They should also be stable and of adequate structural integrity.

4.2.2. Cabinets or cupboards should be such designed to reduce pinching hazard when opening or closing the drawers or cabinet doors.

4.2.3. Under-bench cabinets may be floor-standing or fitted with castors. The latter types allow for easy floor cleaning and decontamination.

4.3. Shelving

4.3.1. Shelving should be secured to prevent toppling. Adjustable height shelves should be securely retained.

4.3.2. Shelves, both open or closed, should be installed at a height allowing safe and ready access. Open shelves should be fitted with edge guards to prevent containers from falling. Double sided shelves should have a central partition or divider to prevent items being pushed through from one side to another.

4.3.3. Shelves or hanging cabinets should allow sufficient vertical clearance of at least 500 mm from sprinkler heads.

4.4. Stools and Chairs

4.4.1. The upholstery of chairs and stools should be vinyl or other suitable impervious material, such as acid-resistant polyurethane to prevent from absorbing the spills of hazardous substances. The surface of the upholstery should be smooth, non-porous and easy to clean. Upholstery materials shall not be ignited easily (conforming to EN1021 or other similar standards).

4.4.2. The chairs and stools should be ergonomically suited to the task, with adjustable height, back-rest and foot ring /rest for stools.

4.4.3. The chairs shall have a 5-star base with glides providing stability with wheels to facilitate movement. The wheels shall be heavy-duty polyurethane castors with stoppers and able to withstand solid load. Stools are recommended to have a stable base without castors.

5. ELECTRICAL & UTILITY ISSUES

5.1. Electrical Services

5.1.1. General power outlets should be elevated above bench height.

5.1.2. There should be sufficient power outlets for the expected number of appliances to avoid the use of extension boards or adaptors. Power outlets should be fitted with residual current protection devices.

5.1.3. Electrical socket outlets, outlets for telecommunication appliances and outlets for computer networks should not be positioned near water sources such as sinks, emergency showers, etc.

5.1.4. Electrical outlets should also be positioned away from valves for flammable gases.

5.1.5. Specialized facilities or equipment may require uninterrupted power supply for safety or other reasons. Such requirement should be taken into consideration during the laboratory design stage.

5.1.6. Emergency lighting and illuminated exit signs shall be provided to facilitate emergency evacuation in the event of power failure.

5.1.7. Splash-proof or water proof socket outlets should be provided for some special situations where necessary.

5.2. Sinks

5.2.1. Each laboratory where hazardous materials, whether chemicals, biological, or radioactive, are used, should have a sink for hand washing. A separate hand-washing basin should be provided for a biosafety level 2 laboratory.

5.2.2. Hand washing facilities should be installed nearby the exit of the laboratory for hand washing immediately before leaving the laboratory.

5.2.3. Laboratory sinks should preferably be made of epoxy, stainless steel or other chemical resistant materials.

5.2.4. Water taps or faucets in a biosafety level 2 laboratory and radioisotope laboratory should be of hand-free operation (e.g. elbow-, foot-, or sensor-operated) to prevent direct hand contact.

5.3. Plumbing

5.3.1. Drainage systems of the laboratory sinks should be provided with adequate seals or traps to prevent the escape of vapors or gases from the drainage systems.

5.3.2. Floor drains should be provided only in laboratories subject to frequent wet washing.

5.3.3. Drainage system should be constructed of proper materials with the required chemical resistance or heat resistance. However, the construction materials should be carefully chosen to avoid any incompatibility with the possible contaminants in the effluents.

5.4. Compressed Air and Vacuum Systems

5.4.1. Compressed air or vacuum system can be in form of a piped-in service from a central compressor or vacuum system or from a laboratory fitted compressor or vacuum unit.

5.4.2. Compressor units or associated pressure vessels must be registered and inspected in accordance with the Boilers and Pressure Vessels Ordinance of Hong Kong.

5.4.3. Compressors installed in laboratory premises should be separated from laboratory operations to isolate the noise and heat as far as possible. Sufficient make up air should be considered in the design to cater for air intake by the compressor units.

5.4.4. Vacuum systems must be fitted with in-line filters and drain traps at accessible locations, and shall be discharged outside the building at a location away from outdoor air intakes.

5.5. Laboratory Gas Delivery Systems

5.5.1. The laboratory gas delivery system, including pipelines, valves, regulators, alarms, monitors, supports and other accessories shall be designed, constructed and installed in compliance with local legislations, codes of practice and international standards where applicable.

5.5.2. Pipelines shall be constructed with materials compatible with the particular laboratory gases involved. Proprietary products from recognized manufacturers should be used.

5.5.3. Piping components in laboratory gas system shall have been properly cleaned by the manufacturers before installation. Great care shall be exercised during the installation to prevent oil or grease or any contaminants from being introduced into the piping.

5.5.4. All pipelines shall be adequately supported and protected from mechanical damage. As far as possible, pipelines should not run in the means of escape.

5.5.5. All piping, valves, station inlets and outlets, and alarms shall be labeled accordingly.

5.5.6. Manual shut-off device shall be provided in each pipeline at an easily accessible location or near its supply gas cylinder.

5.5.7. Over-pressure relief device shall be provided to each supply pipeline. Such device shall vent to an approved location or to a proper treatment system. The relieved gas shall be discharged to open air only when it will not jeopardize the safety of neighboring life and property.

5.5.8. An automatic shut-off device to be actuated by a suitable detection or monitoring system in the event of leakage shall be provided wherever necessary.

5.5.9. A clearly labeled pipeline diagram showing the piping connection and gas route from a supply cylinder to a tool or workstation shall be provided in a conspicuous position near the gas supply point.

5.5.10. The laboratory gas delivery system shall be designed, installed, tested, inspected, commissioned and maintained by competent persons.

6. VENTILATION REQUIREMENTS

6.1. General Requirements

6.1.1. The general ventilation of a laboratory shall comply with relevant international standards for fresh air supply and thermal comfort. Ventilation shall be designed to provide sufficient fresh air, appropriate working temperature and relative humidity for the comfort of occupants; to provide adequate air movement to remove airborne contaminants; and to provide sufficient make up air for the operation of fume cupboards or other local exhaust equipment.

6.1.2. In designing ventilation for the laboratory, effective separation between potentially contaminated areas and other areas should be considered. Each area should have an independent air-circulating system or 100% fresh air delivery.

6.1.3. Ventilation shall be designed to maintain appropriate pressure differentials between spaces within the laboratory, and between the laboratory and the corridor to prevent cross contamination. The air flow direction should always be from clean to potentially contaminated areas.

6.1.4. Laboratory ventilation systems shall be totally separated from non-laboratory systems.

6.1.5. Air exhausted from a laboratory should not be re-circulated to other laboratories or non-laboratory areas.

6.1.6. Supply air system shall be designed to minimize draught and turbulence to avoid its impacts on the performance of primary containment equipment such as fume cupboards and biological safety cabinets. Air outlets shall not discharge to the faces of fume cupboards and biological safety cabinets.

6.1.7. General ventilation system of a laboratory should be designed in such a way that it can be shut down or isolated to contain contaminants in case of major accidental spill.

6.1.8. Fume cupboards should not be used as the sole means of room air exhaust. General room exhaust should be provided to maintain minimum air change rates when the fume cupboards are turned off.

6.1.9. Heat generated by appliances and activities in the laboratories should be factored into the design of the air conditioning system.

6.2. Relative Room Pressure Differentials

6.2.1. A pressure differential system should be used to control the flow of airborne contaminants. The flow direction should always be from low hazard to high hazard areas.

6.2.2. Laboratories in general should be maintained at a negative pressure relative to the public

corridors and non-laboratory spaces to prevent the escape of contaminants from the laboratories. A gauge displaying the differential pressure should be provided at the entrance of the laboratory.

6.2.3. Special laboratories including certain genome processing rooms, stem cell culture rooms, clean rooms, etc., may require positive pressure in relation to adjacent spaces. The users should be consulted at the design stage and arrange the design of air flow balancing to maintain a negative pressure to public corridor.

6.2.4. If an airlock/anteroom is used to facilitate pressure control, especially for high containment laboratories, the doors to the anteroom should be provided with self-closing mechanisms and interlocked so that both doors cannot be opened at the same time.

6.3. Emergency Exhaust Ventilation

6.3.1. An emergency exhaust system should be installed in laboratories where hazardous materials are used. The system, when activated, should allow the room exhaust to run immediately at its maximum capacity with 100% of laboratory air exhausted to outside

6.3.2. Emergency exhaust fan should be located and discharged at top roof to avoid contamination with any fresh air intake.

6.3.3. A clearly labeled emergency exhaust button should be installed near the exit of the laboratory for activating the system.

6.3.4. The fume cupboards and other local exhaust systems should continue to operate after activation of the button unless manually shut down.

6.3.5. The emergency exhaust button should also activate both an audible and a visual alarm at the entrance of the laboratory. The alarm signal should be connected to the local building management system (BMS) if possible. Where such connection is impracticable, alternative means of direct communication with the building management staff should be established.

6.4. Local Exhaust Ventilation (LEV) Systems

6.4.1. Certain laboratory equipment, facilities or operations may generate air contaminants in the form of fumes, vapors, particulates, steam, heat or odors. Local exhaust ventilation systems should be installed to extract these air contaminants and vented to the outside atmosphere.

6.4.2. Exhaust air should be properly discharged to avoid being drawn into fresh air intakes or ventilation openings, and preferably at roof top level. If this is not possible, contaminants should be removed from the exhausted air by appropriate air cleaning or treatment system to render it safe before discharge.

6.5. Air Cleaning for Laboratory Exhaust Systems

6.5.1. Room HVAC systems generally do not require air cleaning prior to release to the environment

except for high containment laboratories. User should review with the government parties (such as the Environmental Protection Department) for any restriction for discharge.

6.5.2. In case where filters are installed, the flowrate through the filters shall be maintained at design specifications and shall not exceed the rated flow capacity of the filters.

6.5.3. The filtration media used for the cleaning of gases and vapors shall be clearly specified for its intended use.

6.5.4. Main filters shall be protected by pre-filters to minimize the cost and hazards associated with frequent replacement.

6.5.5. Appropriate alert system should be installed to indicate when filters should be replaced. Filtering systems shall be designed in such a way that will allow filter testing and replacement in a safe manner in future.

7. EMERGENCY FACILITIES & EMERGENCY ALARM SYSTEMS

7.1. Fire Service Installations

7.1.1. HKSTP provides and maintains a fixed fire sprinkler system. Any alteration by the Laboratory Operators or its contractors is strictly prohibited without advanced written consent from the management of HKSTP.

7.1.2. Laboratory Operators are responsible to provide and maintain their own supplementary fire service installations and equipment (e.g. portable fire extinguishers, fire blankets, sand buckets, etc.) in accordance with their approved Risk Assessment.

7.2. Fire and Emergency Alarm Systems

7.2.1. HKSTP provides and maintains the statutory required fire alarm systems in the laboratories. Any alteration to these systems by the Laboratory Operators or its contractors is strictly prohibited without advanced written consent from the management of HKSTP.

7.2.2. Besides, HKSTP also provides supplementary emergency alarm systems in certain laboratories. These systems are connected to the building management system (BMS) with visual and audible alarms provided inside and outside the main entrance to each laboratory facility. Any alteration to these systems is not allowed without advanced written consent from the management of HKSTP.

7.3. Emergency Showers and Eyewash Units

7.3.1. Laboratories must have at least an emergency shower and eyewash unit for safe operation. Emergency shower and eyewash unit shall comply with appropriate international standards. They shall be located in unobstructed and accessible locations, preferable close to the hazard as possible and can be accessible within 10 seconds.

7.3.2. Emergency shower and eyewash unit should be preferably located near an emergency exit so that the victim can wash himself in an area where further contamination will not occur, and can be reached easily by any responding emergency personnel.

7.3.3. The clearance between the shower head and the nearest obstruction (wall, vertical supply pipe or similar) shall be a minimum radius of 0.4 m.There should also be no protrusions or sharp objects in this area.

7.3.4. Electrical apparatus, telephones, thermostats, electrical control panels, or power sockets should not be located within 0.5 m of the emergency shower or eyewash unit or within any area that may be considered as a splash or flood zone.

7.3.5. The emergency shower and eyewash unit shall be inspected and tested regularly on an annual basis. Inspection or testing records shall be affixed to the facilities for easy reference. Laboratory operators or workers should activate the eyewash units in the laboratories regularly to ensure the units are fit for use.

7.3.6. Emergency showers and eyewash units shall be clearly signposted for easy recognition.

8. LIGHTING, THERMAL COMFORT, NOISE & VIBRATION

8.1. Lighting

8.1.1. All laboratories shall be naturally or artificially illuminated to a level that is optimal for safe working. Special color-corrected lamps may be required where the correct identification of color is important.

8.1.2. Ceiling-mounted lighting in laboratories where potentially infectious materials or unsealed radioactive substances are handled should be recessed with a cover/diffuser flush at the ceiling level.

8.1.3. Bench tops shall be adequately illuminated to a level of at least 500 lux. Higher levels may be required for fine bench and machine work. Benches located near windows should be protected from direct sunlight with the use of window blinds or protective film.

8.1.4. Supplementary lighting should be provided for equipment or work area if the main room lighting is not sufficient. When shelf-mounted task lighting is used, they should have protective diffusive covers to prevent glare. Glare and distracting reflections should be minimized from surfaces of laboratory benches and other installations.

8.2. Temperature and Thermal Comfort

Equipment generating excessive heat or chill shall be isolated from general workspace. Ambient temperature of the laboratory shall be controlled to a level compatible with laboratory workers' comfort.

8.3. Noise and Vibration

Selection and siting of equipment shall consider noise generated by individual piece of equipment and their contribution to the cumulative noise levels in the work place. High noise-generating equipment shall be segregated from the general work area.

9. LABORATORY & RESEARCH EQUIPMENT / INSTALLATIONS

9.1. Cold Rooms and Specialty Rooms

9.1.1. Cold rooms used for laboratory works should be provided with sufficient ventilation and fresh air during period of occupancy.

9.1.2. Cold rooms must be provided with doors that are openable from inside without the use of key to allow emergency escape.

9.1.3. An alarm button should be installed in the cold room to allow persons entrapped to call for rescue. The alarm should be audible both inside the laboratory and in the outside corridor.

9.1.4. Emergency lighting should be provided in cold rooms to prevent blackout.

9.1.5. Doors of walk-in specialty rooms must have viewing windows and external light switches.

9.2. Fume Cupboards

9.2.1. Fume cupboards shall be provided where laboratory work involves the generation of hazardous vapors, gases, mists or fumes, etc. Fume cupboards shall meet recognized international standards such as BSEN 14175, AS/NZS 2243.8, ASHRAE 110, etc.

9.2.2. Proper operation of fume cupboards shall be tested on site by the supplier/contractor after installation according to the international standards.

9.2.3. Ductless fume cupboards are not to be used unless under exceptional circumstances where only small amounts of specified low-toxicity chemicals are used and there are well controlled procedures to monitor its efficiency. Ductless fume cupboards must have signage prominently posted on them informing operators and maintenance personnel about the allowed chemicals, types of filters in place, filter replacement schedule, and the potential risk of filter break-through.

9.2.4. Special type of fume cupboards shall be employed when handling perchloric acid or radioisotopes. Perchloric acid fume cupboard has built-in wash down system while radioisotope fume cupboard has a robust and easily cleanable workstation. Laboratory operators should select the appropriate types in the laboratory design stage.

9.2.5. Hood exhausts may be manifolded together when a risk assessment deems it safe for exhausts from different fume cupboards to be mixed in the ductwork. Controls shall be arranged so that shutting down one fume cupboard will not reduce or affect the exhaust capacity of other cupboards manifold to the same system.

9.2.6. Fume cupboards used for perchloric / hot acids, radioisotopes, carcinogens and other highly

reactive, incompatible or highly toxic materials should have individual exhaust systems and fans and exhausted directly to the roof level.

9.2.7. Siting of Fume Cupboards

Fume cupboards should be located away from high traffic areas or facilities which produce air currents or turbulence such as air supply diffusers, doors, and operable windows.

Siting of fume cupboard in a laboratory should observe the followings:

a) There should be at least 1 m between the sash and any traffic route so as to preserve an undisturbed zone in front of the fume cupboard.
b) The distance between the sash and any bench opposite it should be at least 1.8 m.
c) There should be no opposing wall or other large obstruction within 1.8 m of the sash.
d) If two fume cupboards are to be installed with sash opposite to each other, they should be at a distance of 3 m apart.
e) No fume cupboard should be positioned with either side closer than 0.3 m from a wall or similar construction.
f) Doorways should not be within 1.5 m of the sash or within 1 m of the side of a fume cupboard.
g) A fume cupboard should not be located adjacent to an exit, in particular if there is only one single exit in the laboratory.
h) Fume cupboard openings should not be installed opposite a biological safety cabinet or workstations where personnel will spend much of their working day, such as desks or microscope benches.

9.2.8. Exhaust ducts and fans

a) Basic material of exhaust ductwork should be fire and corrosion resistant for the intended use.
b) As far as possible, ductwork should follow the most direct route from the fume cupboard to the point of discharge.
c) Bends should be kept to a minimum and have the largest radii practicable.
d) Horizontal runs should be kept to a minimum.
e) Ductwork should have no pockets where airborne gases or particles can be trapped.
f) Automatic fire dampers shall not be used in laboratory fume exhaust systems.
g) Treatment such as filtration and scrubbing, etc. is not generally required for fume cupboard exhaust except where risk assessment shows the need for such installation.
h) Exhaust fans shall be powered with dual motor to provide redundancy. They should be located outside the building at the point of final discharge so that the ductwork through the building is under negative pressure. They should also be readily accessible for maintenance and inspection.
i) The exhaust stack outlet should be at least 3.0 m above the roof. If parapet walls are present, stacks should be further extended. They should be located as far away from air intakes of buildings as possible to avoid re-entrainment of exhausted air into the building air supplies.
j) Discharge from exhaust stacks must have an upward velocity of at least 10 m/s. Cone

type reducer should not be used to achieve this velocity. Rain caps that divert the exhaust back towards the roof must not be used.

k) Each exhaust fan and duct system should be labeled to identify the fume cupboard in the laboratory to which they are connected.

9.3. Biological Safety Cabinets (BSC)

9.3.1. Biological safety cabinets shall be provided in laboratories where work involves the handling of infectious or potentially infectious biological agents. These include pathogenic microorganisms, human or animal body fluids, tissues, cell lines, etc. In addition, nanomaterials can also be handled safely in a biological safety cabinet.

9.3.2. There are three main classes of biological safety cabinets, i.e. Class I, II and III. Class II biological safety cabinets are further divided into 4 subclasses: A1, A2, B1 and B2. Laboratory operators should select the most appropriate class of biological safety cabinets for use.

9.3.3. Biological safety cabinets shall be certified to meet the specifications of recognized international standards such as NSF/ANSI 49, BS EN 12469, etc.

9.3.4. Siting of Biological Safety Cabinets

Biological safety cabinets should be located away from doorways, passageways, air diffusers, operable windows, fume cupboards or equipment that create air movements affecting the cabinet flows and containment.

Siting of biological safety cabinet should observe the followings:

a) The distance from the sash to any traffic route shall be at least 1 m in order to preserve an undisturbed zone in front of the biological safety cabinet.
b) The distance between the sash and any bench opposite it should be at least 1.5 m.
c) There should be no opposing wall or other large obstruction within 2 m of the sash.
d) The distance to the aperture of an opposing biological safety cabinet, fume cupboard or the edge of a local exhaust ventilation outlet should not be less than 3 m.
e) A 0.3 m clearance should be provided on each side and at the back of the cabinet. Clearance on top of the cabinet should preferably be 0.6 m to allow free air flow and room for testing and maintenance of the HEPA filter.
f) Doorways should not be within 1.5 m of the aperture or within 1 m of the side of a biological safety cabinet.
g) Any room air supply diffuser should not be within 1.5 m of the front aperture.
h) A local exhaust ventilation should be in the vicinity of a biological safety cabinet to allow proper exhaust of fumigant gases.

9.4. Controlled Atmosphere Glove Boxes

9.4.1. Controlled atmosphere glove boxes are sealed containers, commonly filled with inert gases, that are sufficiently leak-tight to protect chemicals or materials that may be sensitive to air or water vapor.

9.4.2. During the laboratory design stage, space for placement of gas cylinders and the associated gas delivery systems to be connected with the glove boxes should be planned and allocated.

9.4.3. Sufficient exhaust ventilation systems should also be installed in the vicinity of the glove boxes to allow venting of gases from the glove boxes during operation and other processes such as purging and regeneration.

9.4.4. Exhaust ventilation systems should be connected to the rooftop by ductwork for discharge.

9.5. Gas Cabinets

9.5.1. Compressed gas cylinders containing hazardous gases (e.g. highly toxic or flammable gases) used in the laboratories shall be kept in ventilated gas storage cabinets.

9.5.2. Gas cabinets should be located in the laboratory areas that have non-recirculated exhaust ventilation and preferably operate at negative pressure in relation to the surrounding area, and shall be connected to the exhaust ventilation systems.

9.5.3. Gas cabinets shall be designed and constructed in accordance with relevant international standards or local legislations where applicable. Basic requirements for a gas cabinet include the followings:

a) It should be constructed of non-combustible material and of robust design.
b) It should be provided with a view panel made of transparent wired glass for unobstructed viewing of its content and access to the cylinder valve groups.
c) Its doors shall be closely fitted and self-closing with a self-latching device.
d) Its interiors should be treated, coated or constructed of materials that are compatible with the hazardous gases stored.
e) It should provide the necessary air changes for the particular hazardous gases stored, i.e. at least 10 air changes per hour for flammable and fire supporting gases, and 120 air changes per hour for highly toxic gases. The pressure drop should not exceed 150 Pa.
f) It should be connected to non-recirculating exhaust ventilation and discharged at the rooftop.
g) Air inside the cabinet shall be vented both at the top and bottom level to ensure adequate purging from minor gas leakage.
h) It should be fitted with sensors connected to alarms to notify personnel in the event of a leak or exhaust system failure.
i) It should contain no more than 3 gas cylinders.
j) It should be constructed in such a way that cylinders can be moved in and out with minimal difficulty.
k) Restraining devices should be installed within the cabinet for securing cylinders.

10. STORAGE OF HAZARDOUS MATERIALS

10.1. Chemicals / Dangerous Goods

10.1.1. In general, chemicals shall be stored in well ventilated, cool places and protected from direct sunlight or other direct sources of heat following recommendations from the corresponding Materials Safety Data Sheets (MSDS). They should be located away from traffic zones; not in any common passageways, stairways or doorways.

10.1.2. Hazardous chemicals (at least corrosives, flammables and highly toxics) should be stored in purpose-made storage cabinets. Incompatible classes of chemicals should be stored in separate cabinets. Excessive chemicals (exceeding the exempted quantities as specified in the Dangerous Goods (General) Regulation) should be kept in the respective dangerous goods stores. Lockable cabinets or other means of limiting access should be designed for specifically regulated materials.

10.1.3. Chemical storage cabinets should meet the following safety requirements:

a) The design and construction of chemical storage cabinets should be in compliance with relevant international standards.
b) The shelving inside storage cabinets shall be designed to contain spillage of the stored contents.
c) Chemical storage cabinets should be of double wall construction with adequate fire resistance rating. Self-closing and three-point latch doors are recommended.
d) If chemical storage cabinets are vented, they shall be connected directly to an exterior exhaust duct with appropriate fire rating or materials compatible with the contents of the cabinets. It shall be vented outdoors to an appropriate location. If they are not vented, the vent openings should be sealed by the manufacturer.
e) Flammable storage cabinets shall not be located near exits, doorways or at locations that would impede egress.
f) Metal cabinets shall not be used for the storage of corrosive materials unless the materials are specifically treated to be corrosion-resistant.
g) All chemical storage cabinets shall have appropriate hazard symbols and warning signs for the contents they are designed to store.

10.1.4 In addition, flammable liquids must not be stored in hanging cabinets. Metal storage containers for flammable liquids shall be properly earthed to avoid static charge. Flammable liquids that require refrigeration shall be stored only in “explosion-proof” or “spark-proof” refrigerators. Domestic refrigerators shall not be used for this purpose.

10.2. Compressed Gas Cylinders

10.2.1. The numbers of gas cylinders stored in any laboratory should be kept to a minimum and should not exceed the exempted quantities specified in the Dangerous Goods (General)

Regulation. Enquiry with the Fire Services Department (FSD) for usage of any compressed gas cylinder without exempted quantities is necessary before works in the laboratory.

10.2.2. Gas cylinders should be stored in well ventilated and cool places and protected from direct sunlight or other direct sources of heat.

10.2.3. Gas cylinders should be located away from traffic zones; not in any common passageways, stairways or doorways.

10.2.4. Flammable or toxic gas cylinders should be placed as close to the equipment as possible to minimize the length of connecting pipe. Piping-in of these hazardous gases from external sources or over long distance should be avoided.

10.2.5. Exposed pipe work for these gases should be protected from accidental damage and marked clearly. For more safety requirements about the laboratory gas delivery systems, please refer to the particular section on this topic.

10.2.6. Adequate space should be provided for the segregation of gases by hazard class (e.g., flammable, oxidizing, toxic or corrosive).

10.2.7. Enclosed storage area for gas cylinders should be ventilated to prevent the potential build-up of leaked gases.

10.2.8. Oxygen level detector is recommended in rooms for the storage of large amount of asphyxiant gases such as liquid nitrogen, carbon dioxide, argon and helium where ventilation to the room is limited.

10.2.9. Suitable gas detectors should be installed for early detection of possible leaks from the toxic or flammable gas cylinders where ventilation is limited.

10.2.10. Proper restraints such as chains or straps to prevent the gas cylinders from moving and toppling should be provided. They should be secured to firm fixtures, e.g. a wall bracket fixed to a solid wall or the solid frame in a plaster board partition, etc.

10.2.11. Gas cylinders must be individually restrained. Each individual restraint shall have two separate anchorage points to the wall, and at about 2/3 the height for each gas cylinder. Non-combustible chains or straps should be used.

10.2.12. Storage and use of cylinders of highly toxic or flammable gases shall be within ventilated gas cabinets. For more safety requirements about the gas cabinets, please refer to the particular section on this topic.

10.3. Liquid Nitrogen and Other Cryogenic Liquids

10.3.1. Areas for storage of liquid nitrogen and other cryogenic liquids shall have good and sufficient ventilation to prevent the build-up of gases. Calibrated oxygen deficiency detectors shall be

installed for those storage areas.

10.3.2. Means of transport of liquid nitrogen tanks to and from the laboratories, e.g. service lifts and movement path for trolley, shall be carefully considered. Paths of transport of such tanks should also be separated from heavily used public thoroughfare.

10.4. Hazardous Wastes

10.4.1. Suitable areas shall be provided for the safe temporary storage of solid or liquid hazardous wastes (biological / clinical, chemical or radioactive) from laboratories.

10.4.2. Storage areas shall be designed to contain any spills that may occur during handling of the waste.

10.4.3. These areas shall be posted with proper warning signs / notices, and have access control but be accessible to both the laboratory personnel and approved waste collector. Alternately, the laboratory personnel can escort the waste collector during collection of waste.

10.4.4. Different types of hazardous wastes have different requirements. The laboratory operators shall consult the related statutory bodies, such as Environmental Protection Department (EPD), register as waste producer and engage approved waste collector. For storage and disposal of radioactive waste, requirements from the Radiation Health Unit of the Department of Health shall be strictly followed.

10.4.5. The concerned laboratory operator shall keep the record of registration of waste producer and engagement of waste collector. The respective certificates shall be available for checking during laboratory inspection or audit.

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11. LABORATORIES OF SPECIAL FUNCTIONS

11.1. Biosafety Level 2 Laboratory

Biological agents of Risk Group 2 should be handled in a Biosafety Level 2 (BSL-2) Laboratory. In addition to the general laboratory safety features, the followings are also required in accordance with the design specifications of WHO Laboratory Biosafety Manual:

11.1.1 Access must be restricted to authorized persons.
11.1.2 Doors should have vision panels, appropriate fire ratings and be self-closing.
11.1.3 A biohazard warning sign shall be posted at the entrance.
11.1.4 Negative pressure should be maintained to allow an inward flow of air into the laboratory. Exhaust air should not be recirculated to other areas.
11.1.5 Hand-wash basins, preferably with elbow-operated tap, should be provided near the exit door as far as possible.
11.1.6 Open spaces between the under benches, cabinets and equipment should be accessible for cleaning.
11.1.7 Emergency shower and eyewash facilities should be available at a convenient location.
11.1.8 An appropriate number of biological safety cabinets should be provided.
11.1.9 An autoclave or other means of decontamination should be available on site or in appropriate proximity.
11.1.10 Essential equipment such as biological safety cabinets, freezers, etc. should be on connected to emergency power supply.

11.2. Laboratory with High Power Laser Equipment

A high power laser equipment refers to any laser equipment classified as Class 3B or 4 in accordance with international standards such as ANSI Z136.1 and BSEN 60825-1, etc. Basic design features for a laboratory with the use of high power laser equipment include the followings:

11.2.1 A high power laser laboratory shall be such designed that no specular reflective surfaces are present which may inadvertently reflect laser beams.
11.2.2 Access shall be restricted to authorized persons.
11.2.3 Wherever possible, adequate levels of room illumination and light-colored but diffusely reflecting walls should be used.
11.2.4 The door giving access into a high power laser laboratory should have an interlock connected to the high power laser equipment or the beam shutter inside the laboratory so that laser emission is terminated or laser beam is blocked when the door is opened.
11.2.5 The high power laser equipment should be such positioned that its laser beam is not directing towards the doorway, aisles or other areas which might be occupied with laboratory personnel. It should also be mounted at proper height level so that its laser beam is not at the eye level of a seated or standing person.
11.2.6 Emission indicator device such as a warning light or other means of alarm should be installed at the entrance of the laboratory when the high power laser equipment is energized.

11.2.7 A laser hazard warning sign shall be affixed at the entrance.
11.2.8 Local exhaust ventilation system should be installed wherever hazardous vapors or fumes may be generated during the high power laser operation.
11.2.9 Appropriate firefighting equipment should be available in the vicinity of a Class 4 laser equipment.

11.3. Radioisotope Laboratory

A radioisotope laboratory refers to any laboratory which involves in the handling of unsealed radioactive substances or radiochemicals. In addition to the general laboratory safety features, the followings should also be incorporated:

11.3.1 Access must be restricted to authorized persons.
11.3.2 A radiation warning sign shall be affixed at the entrance.
11.3.3 Lighting fixtures should be flush with the ceiling to eliminate dust collection.
11.3.4 Ceiling panels should be of metal or other suitable materials that can be cleaned easily.
11.3.5 Negative pressure should be maintained to allow an inward flow of air into the laboratory. Exhaust air should not be recirculated to other areas.
11.3.6 Hand-wash basins, preferably with elbow-operated tap, should be provided near the exit door as far as possible.
11.3.7 Drainage piping should be connected directly to the manhole (avoid running through other areas).
11.3.8 Floor drain should be avoided.
11.3.9 Special fume cupboard for radioisotopes should be installed if necessary.
11.3.10 Emergency shower and eyewash facilities should be available at a convenient location.
11.3.11 As the use of radioactive substances is strictly governed by law (Radiation Ordinance and Regulations; Cap 303, Laws of HKSAR), additional radiation protection features (in particular shielding) may also be required subject to recommendations by the Radiation Health Unit of the Department of Health.

11.4. Laboratory with Open-beam X-ray Machine

An open-beam X-ray machine refers to any industrial, medical or analytical X-ray machine having the X-ray tube not total enclosed in an interlocked housing or cabinet. The design for a laboratory bearing open-beam X-ray machine shall meet legislative requirements as stated in the Radiation Ordinance and Regulations; Cap 303, Laws of HKSAR). Basic radiation protection features include the followings:

11.4.1 Access must be restricted to authorized persons.
11.4.2 All the walls and the door of the room shall be embedded with lead sheets with appropriate thickness and design (for more detailed information please refer to Radiation Health Series No. 7 : “Guidance Notes on the Design of Protective Shielding for Medical, Dental and Veterinary Diagnostic X-ray Facilities” issued from the Radiation Health Unit of the Department of Health).
11.4.3 A red warning light shall be installed at the entrance such that it can be manually or automatically switched on whenever the X-ray machine is energized.

11.4.4 A radiation warning sign shall be affixed at the entrance.

11.5. Laboratory with MRI or NMR

MRI (Magnetic Resonance Imaging) or NMR (Nuclear Magnetic Resonance) are instruments capable of generating strong magnetic fields. The following safety features should be taken into consideration during planning and design of a laboratory or premises having these instruments:

11.5.1 The location of the laboratory and the sitting of these instruments should be carefully planned in order to minimize the stray magnetic fields in the nearby areas including the upper and lower floors.

11.5.2 These instruments should preferably be located at the lowest or uppermost floor (with sufficient loading capacity) of a building and should be separated from areas with high occupancies as far as possible.

11.5.3 They shall be such located that the 5 Gauss (or 0.5 mT) lateral region (within which the magnetic flux density caused by the MRI/NMR magnet exceeds 5 Gauss) should be within the same laboratory. The 5 Gauss region should also be clearly marked on the floor or fenced off with safety chains.

11.5.4 Warning signs shall be posted at the entrance of the laboratory and also nearby any 5 Gauss regions (including areas of the upper or lower floors) to alert:

a) individuals with medical devices (e.g., cardiac pacemakers and metal prostheses) to remain outside the 5 Gauss perimeter; and
b) all metal objects must be kept outside the 5 Gauss perimeter.

11.5.5 Access must be restricted to authorized persons.

11.5.6 Appropriate discharge mechanism or emergency exhaust mechanism shall be provided to exhaust cryogenic gases from quenched superconducting magnets to outside to avoid creating an oxygen deficient atmosphere.

11.5.7 The discharge point should have appropriate weatherhead that prevents horizontal, wind-driven precipitation from entering, collecting, or freezing in the quench exhaust pipe.

11.5.8 To protect persons from cryogen exposure at the point of discharge, a quench safety exclusion zone should be established and clearly marked with surface warnings, signage or alarm.

11.5.9 Doors of the laboratory that may be subject to the effects of gas expansion during a quench shall open outwards to ensure that they are still openable during pressurization.

11.5.10 An oxygen sensor should be installed in the vicinity of the instruments to monitor the oxygen level.

12. REFERENCES

- ACR Guidance Document on MR Safe Practices: 2013. Expert Panel on MR Safety (American College of Radiology). Journal of Magnetic Resonance Imaging 37:501 – 530.
- ANSI/ASHRAE 110 - 1995 Method for testing performance of laboratory fume hoods. American National Standards Institute, Inc. / American Society of Heating, Refrigerating, and Air-conditioning Engineers.
- ANSI/ASHRAE 62.1 - 2010 Ventilation for acceptable indoor air quality. American National Standards Institute, Inc. / American Society of Heating, Refrigerating, and Air-conditioning Engineers.
- ANSI Z358.1 - 2014 Emergency eyewash and shower equipment. American National Standards Institute, Inc.
- AS/NZS 2243.1: 2005 Safety in laboratories Part 1: Planning and operational aspects. Standards Australia / Standards New Zealand.
- AS/NZS 2243.8: 2006 Safety in laboratories Part 8: Fume cupboards. Standards Australia / Standards New Zealand.
- AS/NZS 2982:2010 Laboratory design and construction. Standards Australia / Standards New Zealand.
- British Occupational Hygiene Society (1992) Technical Guide No. 10 – Laboratory Design Issues
- BS EN 1021-1: 2014 Furniture. Assessment of the ignitability of upholstered furniture. Ignition source smouldering cigarette. British Standards / European Committee for Standardization.
- BS EN 14056: 2003 Laboratory furniture – Recommendations for design and installation. British Standards / European Committee for Standardization.
- BS EN 12464-1: 2011 Light and lighting – Lighting of work places – Part 1: Indoor work places. British Standards / European Committee for Standardization.
- BS EN 12469: 2000 Biotechnology. Performance criteria for microbiological safety cabinets. British Standards / European Committee for Standardization.
- BS EN 14175-2: 2003 Fume cupboards – Part 2: Safety and performance requirements. British Standards / European Committee for Standardization.
- BS EN 14470-1: 2004 Fire safety storage cabinets – Part 1: Safety storage cabinets for flammable liquids. British Standards / European Committee for Standardization.
- BS EN 14470-2: 2006 Fire safety storage cabinets – Part 2: Safety cabinets for pressurized gas cylinders. British Standards / European Committee for Standardization.
- BS EN 15154-1: 2006 Emergency safety showers – Part 1: Plumbed-in body showers for laboratories. British Standards / European Committee for Standardization.
- BS EN 60825-1: 2014 Safety of laser products – Part 1: Equipment and requirements. British Standards / European Committee for Standardization.
- Ductless Fume Hood Review 2005. National Institutes of Health, Office of Research Facilities.
- Guidance Notes on the Design of Protective Shielding for Medical, Dental and Veterinary Diagnostic X-ray Facilities (2004). Radiation Health Series No. 7. Radiation Health Unit, Department of Health.
- Guidelines for Planning and Design of Biomedical Research Laboratory Facilities 1999. The American Institute of Architects.
- Laboratory Biosafety Manual 3rd Edition (2004). World Health Organization.
- Laboratory Design Guide 2013. The University of Hong Kong.
- Laboratory Design Standard 2010. Office of Safety, Health & Environment, National University of Singapore.

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- Laboratory Safety Design Guide 2007. Environmental Health and Safety, University of California.
- Laboratory Safety Design Guide 2006. Environmental Health and Safety, University of Washington.
- Laboratory Standard and Design Guidelines 2018. Environmental Health and Safety, Stanford University.
- NIH Design Policy and Guidelines 2003. National Institutes of Health, Office of Research Facilities.
- NSF 49 – 2018 Biosafety Cabinetry: Design construction, performance and field certification. National Sanitation Foundation.