1.0 Purpose

A. This section discusses the safety features that must be included in university laboratories and the design standards for various classifications of laboratories and laboratory equipment.

2.0 General Requirements

A. Design shall comply with ANSI Z9.5 and NIH and CDC guidelines.

B. Labs shall be separated from classrooms, offices, conference rooms and other places of assembly.

C. Labs shall include storage space for equipment and supplies. Storage is prohibited in service corridors.

D. Break areas for food and beverage service shall be separated from lab areas.

E. Two means of egress is preferred from all labs. Labs which are larger than 200 SF and contain hazardous materials shall have two means of egress. Where secondary egress is required, egress may not be through adjoining lab space.

F. Each laboratory building shall have a designated hazardous material receiving area that includes a separate waste-storage removal area.

G. In HPM designs shall include designated corridors for transportation of hazardous materials.

H. Service elevators capable of transporting chemicals and equipment shall be provided. A service elevator which extends to the roof and is capable of transporting chemical and equipment shall allow only restricted service to the roof.

I. Counter tops shall be impervious, stain resistant, seamless, and chemical-resistant.

J. Laboratory door safety sign holders shall be installed at eye level of entrance doors. Holders shall be 8.5x11 inches mounted in landscape orientation.

K. Drains shall not be located under equipment and floors shall be sloped to drain.

L. Eyewash/Safety Shower

1. An ANSI-Z358.1 approved eyewash shall be provided in each laboratory where chemicals will be handled. Eyewash shall be provided within 10 seconds travel

time from all areas of the laboratory. The path to the eyewash shall not include a door or any other physical restriction.

a) Plumbed- to drain eyewashes shall be provided in each work area where chemical or biological material are in use /handled. Recessed /wall-mounted eyewash stations without water collecting pans are not acceptable. Any laboratory furnished with fume hood, shall have at least one eyewash station installed within the room.

b) Drench hoses and sink faucets are not acceptable in lieu of eyewash facilities. Drench hoses may be installed in addition to eyewashes.

c) Quantity, location, and type of the eyewash stations shall be approved by NC State.

d) Installation of additional eyewash stations in the hallways adjacent to laboratories is recommended.

e) Tempered water shall be provided for all units.

2. Safety showers shall meet ANSI requirements. Emergency showers shall be provided for all work areas where chemical contact may occur. One additional safety shower shall be installed in both Men and Women toilet rooms on each floor.

a) Safety showers shall be installed adjacent to a floor drain.

b) ANSI compliant safety showers shall be provided within 10 seconds travel time from all areas of the laboratory and may be located in adjoining hallways if unobstructed access is maintained.

c) Tempered water shall be supplied for all units. Provide activation alarm.

3. Teaching labs require both eyewashes and safety showers.

M. Lab alarm panels which prompt evacuation or response by maintenance, safety or fire personnel shall be located outside of the lab and reviewed for appropriate interaction with building alarm systems.

N. Adequate work clearances around lab experimental equipment shall be maintained.

O. Mechanical Systems

1. Air handling systems shall be zoned where toxic gases are used. Design shall include the ability to isolate a building section by negative pressure via remote control of air supply systems.

2. Biosafety cabinets and laminar flow chemical hoods may be used with pre-approval by NC State.

3. Each fan shall be labeled with the identification of connected exhaust devices.

4. Connections to the facilities chill water system shall meet the following minimum requirements:
   a) Rigid piping capable of maintaining strength over variations in pressure and temperature.
   b) A device to shut off the water flow upon leak detection.
   c) Proper filtration which protects user equipment.
5. The HVAC and the hood system balancing shall be coordinated by AABC or NEBB certified balancers. Hoods and other exhaust devices shall be balanced after all HVAC construction and balancing is complete. Staged occupancy shall require special planning for air supply/exhaust balancing.
6. A general room ventilation system shall be designed such that the placement of supply and exhaust maximize the clearance of contaminants from the lab. Lab and hood exhaust ventilation shall be continuous. Fan controls for start/stop of fume hood fans shall not be provided at the hood.
7. The mechanical system shall meet the following requirements:
   a) An individual zone reheat in lab spaces
   b) Low velocity diffusers in laboratories where fume hoods are present.
   c) Pressure differential maintained between labs and corridor.
   d) Local exhaust of instruments, gas cabinets, vented storage cabinets and special operations not requiring the use of local capture devices.
   e) Design shall comply with latest version of the American Conference of Governmental Industrial Hygienists (ACGIH) Ventilation Manual.
   f) Emergency power is required for exhaust fans controlling hazardous material emissions. Exhaust fans may run at 50% capacity when operating on emergency power with adequate make up air provided.
   g) Exhaust continuously monitored by an exhaust flow monitoring device.
   h) Exhaust stacks which terminate at least eight (8) feet above roof level. Exhaust cap rain protection shall be provided via a zero pressure loss design.
   i) Exhaust ductwork within the building maintained under negative pressure. Exhaust fans shall be located on the building roof.
   j) Perchloric acid hoods served by a dedicated fan and ductwork with water wash-down capability. Special hood and duct construction shall be required.

P. Electrical Systems.

1. Labs shall have circuit breaker panels that provide emergency shutdown capability. All electrical panels shall clearly indicate the devices and the locations that they control. Each lab shall be powered from a separate panel located near the exit door.
2. Emergency Power Off (EPO) buttons shall be installed at the entrance to the laboratory.
3. All flammable liquid storage cabinets, gas lines carrying flammable gases, laser optical tables, and spark producing or current transmitting metal tables and equipment shall be grounded.
4. Adequate power shall be provided to avoid extension cords in labs. Outlets served by emergency power shall be labeled or color coded. Outlets on fume hoods shall be located outside of the hood interior. Outlets at lab benches shall be 3'-0" on center.
5. Electrical breaker panels shall be accessible to both maintenance and lab user if serving as sole means for emergency shutdown of lab power.
6. Hazardous equipment shall be on a dedicated circuit.
7. Emergency power shall be provided in lieu of standby power for exhaust ventilation, treatment systems, gas detection systems, emergency alarm systems, and fume hoods.

3.0 Laboratory Standards

A. High-Level Radiation Facilities require coordination and review by NC State.

B. Biological Safety Level Three (BSL3) Labs

1. Designs shall comply with the NC State Laboratory Biological Safety Manual (http://www.ncsu.edu/ncsu/ehs/www99/left/bioSafe/index.pdf).
2. Ventilation
   a) A ventilated air lock shall separate the common corridors from the lab.
   b) Ventilation system shall be a single pass air system. All BSL3 space shall be kept negative with respect adjacent spaces.
   c) Supply/exhaust ducts shall be supplied with gas-tight dampers. Duct work between the lab and the damper shall also be gas-tight.
   d) Notification to Building Automation System (BAS) shall occur when reverse directional airflow is detected.
      (1) Notification devices shall indicate the failure to maintain a negative pressure differential.

(2) Alarm systems shall be validated prior to occupancy of the containment space by research personnel.

e) Lab shall have emergency backup power for the ventilation system, lighting, and critical equipment.

f) HEPA filtration shall be determined on a case-by-case basis by NC State.

g) Third Party BSL3 certified agent to preform commissioning from design through acceptance.

h) Minimum HVAC system requirements:

(1) Temperature: 68-74° F.

(2) Humidity: 30-60% RH.

(3) Room static pressure: -0.1" WG across adjacent zone.

(4) Biosafety cabinet face velocity: Follow NSF 49 Standard.

(5) Convective airflow pattern: exhaust at lab rear; supply at lab entrance.

(6) Air handling and exhaust systems independent from main system.

3. Fixtures

a) Sinks shall be located near the exit door in each BSL3 lab. Sink faucets shall be foot or elbow operated (hands-free).

b) If a biosafety cabinet is connected to the building exhaust, system shall be capable of maintaining air balance of both cabinet and building. Hard ducted cabinets shall have a one (1) foot minimum clearance between exhaust and ceiling. Thimble connection is required for hard ducted class II type A2 biosafety cabinets

c) Continuous-flow centrifuges and other aerosol-producing equipment shall be contained in devices that exhaust air through HEPA filters prior to discharge into the lab.

d) Service clearance for autoclave s shall follow manufacturer's recommendations.

e) Vacuum systems shall be protected by a filtration system.

f) The biosafety cabinet shall be located at a minimum of five (5) feet away from the supply diffuser and main traffic area of lab. The biosafety cabinet may be located opposite a fume hood if a 10 foot minimum horizontal clearance is maintained. The biosafety cabinet shall not be hard-duct exhausted unless approved by NC State.

g) Non-fixed casework is required with impervious and seamless surfaces.

h) Lab bench shall have at a minimum:
   (1) A drip groove.
   (2) PVC/nylon shoes on adjustable legs.
   (3) Nylon rollers for drawers.
   (4) Heavy-duty door hinges.
   (5) Raised edges around sinks.
   (6) Reagent/chemical shelves with lips.
   (7) Electric services provided in sealed raceway with multiple voltages.

4. Location on building interior is preferred. Lab shall not have exterior windows. If an existing space has windows, windows shall be rendered inoperable and walled over.
5. Plumbing shall have backflow prevention devices. With the exception of lab faucet vacuum breaker, backflow preventers shall be outside of the lab, preferably on the clean side.
   a) Preventers shall be accessible for regular inspection and testing.
   b) Potable and non-potable supply systems shall be separated and each shall have a backflow preventer.
6. Provide card access through all anterooms.
7. Finishes
   a) Interior surfaces of walls, floor, and ceiling shall be water resistant, gas-tight, and smooth.
   b) Flooring shall have a six (6) inch seamless cove.
   c) Access to mechanical equipment shall be external to the containment facility.
8. Penetrations through walls, floors, and ceilings shall be sealed.
9. Light fixtures, conduits, and supply and exhaust ducts shall be gasketed or sealed at the point of penetration into the lab.

C. Class 3b and Class 4 Laser Labs

1. Design shall meet requirements set forth by end user and in NC State Laser Safety Manual. (http://www.ncsu.edu/ehs/www99/right/handsMan/lasers/laser.html) and ANSI 136.1 – Safe Use of Lasers.
2. At a minimum labs shall have:
   a) A controlled entry to the lab via card reader access.
   b) A door closer.

c) Single doors or double door with both leaves interlocking

d) Proper laser signage on the door to the lab.

e) A warning light indicating that laser power is on.

f) An emergency off button at the lab entrance.

g) An interlocked curtain at the inside entry to the laser controlled area.

h) No windows.

3. Floors shall be capable of bearing laser table weight.

D. Wet Teaching Laboratories

1. A prep room containing a fume hood and facilities for chemical storage shall be provided.
2. Fume hoods and enclosed exhausted bench top work stations shall be provided.

E. Nuclear Magnetic Resonance (NMR) Facility

a) Labs containing equipment which will generate strong magnetic fields shall be designed to contain both radial and axial fields to within five (5) gauss at the ceiling, floor and walls (the axial field is larger than the radial).

b) Active room exhaust is required similar to that of a research lab with a minimum of six (6) air changes per hour.

c) Space for the control station shall be located outside of the five (5) gauss limit area.

d) Door into lab shall have a minimum clear width of 48 inches.

e) NC State shall indicate if a chilled water supply and extra cooling capacity is required for this equipment.

f) Oxygen sensor shall be installed within the room.

g) Provide proper lab signage on door into lab.

F. Gross Anatomy Preparation Room

1. Work surfaces shall be impermeable, nonporous, seamless, and smooth.
2. Floors shall be a seamless slip-resistant material, with an integral cove that extends eight (8) inches up each wall. Drains shall have chemical interceptors.
3. Walls shall be either glazed tile or epoxy paint on either concrete block or water-resistant gypsum board.
4. Ceilings shall be easily cleanable and non-porous.
5. Light fixtures, wall outlets, and switches shall be vapor proof.
6. Bulk chemicals shall be stored in a separate room.

7. Support areas for materials and chemical storage, sample preparation, and staff locker and shower facilities should be adjacent to the preparation room.
8. A fume hood shall be required for chemical preparation.

G. Gross Anatomy Dissection Lab

1. Work surfaces shall be impermeable, nonporous, seamless, and smooth.
2. Sinks and furnishings shall be stainless steel with welded and coved joints. Wood and plastic materials are not acceptable.
3. Floors shall be a seamless slip-resistant material, with an integral cove that extends eight (8) inches up each wall.
4. Walls shall be either glazed tile or epoxy paint on either concrete block or water-resistant gypsum board.
5. Ceilings shall be easily cleanable and non-porous and have acoustical dampening qualities.
6. Floor and sink drains shall have chemical interceptors.
7. Dissection tables shall have a minimum clearance of 60 inches head and toe and 40-50 inches to each side.
8. Tables shall be down draft and have direct lighting.
9. Scrub sinks shall be provided for hand washing and general cleanup in each lab.
10. Countertops and display cases shall be located along the perimeter of the room.
11. Blackboards and projection screens shall be positioned to allow student view from the dissection tables.
12. Mechanical Systems
    a) The minimum outside air change rate shall be 15 to 20 per hour. Effective use of localized exhaust ventilation, such as downdraft tables, may allow for reduced air flow rates.
    b) Recirculation of air is unacceptable
    c) Supply and exhaust ventilation shall effectively remove airborne room contaminants in all room spaces to below allowable limits.
    d) Welded stainless steel ventilation ducts are required.
    e) The room shall have a negative pressure with respect to adjacent areas.

H. Pathology Laboratories

1. Work surfaces shall be impermeable, nonporous, seamless, and smooth.
2. Floors shall be a seamless slip-resistant material, with an integral cove that extends eight (8) inches up each wall. Drains shall have chemical interceptors.

3. Walls shall be either glazed tile or epoxy paint on either concrete block or water-resistant gypsum board.
4. Ceilings shall be easily cleanable and non-porous
5. A designated clear area for gurney storage shall be provided that does not overlap with circulation area.
6. Bone saws require a separate chamber with local exhaust.
7. Preparation sinks shall have local exhaust.
8. All furnishings shall be free standing stainless steel. Surfaces shall be impervious and countertops shall be seamless.
9. Floor mounted equipment shall be mounted with clearance to clean around equipment and furniture.
10. Surfaces shall be impervious and countertops shall be seamless
11. Mechanical Systems
    a) Welded stainless steel ducts, air outlets, and other mechanical equipment are required.
    b) The room shall have a negative pressure with respect to adjacent areas.
    c) Recirculation of air shall not occur.
    d) HEPA filters shall be placed in the exhaust air system.
    e) System shall be capable of paraformaldehyde vapor decontamination of the entire room by through the use of airtight shutoff dampers in the supply and exhaust ducts, gasketing doors, and sealing utility penetrations.
    f) Local exhaust devices for work stations with hazardous procedures
    g) Systems shall be capable of handling high concentrations of formaldehyde.
    h) Local Exhaust
        (1) Formaldehyde exposure shall be controlled with capture hoods or other local exhaust placed at work level.
        (2) Autoclaves shall have fan operated exhaust. Hoods above the access door are required and shall be placed close to the autoclave.

I. Clinical Laboratory

1. A fume-hood or local exhaust system shall be provided when ethylene oxide is used.
2. Local exhaust facilities shall have
    a) A canopy hood directly over the process or equipment.

b) An engineered slot-type capture hood designed for a specific application.

c) A flexible exhaust hose for small emission sources.

J. Environmental Chambers

1. Rooms 400 NSF and over shall have a second egress. Rooms between 200 and 400NSF may require two means of egress, depending on programmatic needs.
2. Mechanical System
   a) Outside air exchange requirements for controlled environment rooms shall be minimal. Fresh air shall be provided when personnel work inside controlled environmental chamber. Rates shall be determined by programmatic needs.
   b) The building exhaust system shall exhaust air through an adjustable damper.
   c) Local exhaust ventilation or chemical fume hoods are required when toxic chemicals are used.
   d) The refrigeration system shall contain a direct expansion unit of industrial quality, designed to operate continuously with an integral evaporator coil.
   e) Adequate service access to mechanical systems shall be provided.
   f) Room temperature controller and other instrumentation shall be designed to control coil temperature over the full temperature range on a precise demand basis. Integration with existing BAS will be determined on a case by case basis.
   g) Localized reporting capability shall be provided on a case by case basis.
3. When chamber has high humidity, materials of construction shall be a non-rusting material.
4. A vapor-tight electrical system shall be used.

K. General Chemistry laboratory - Chemical hoods shall be installed in low traffic areas, away from entrance doors and at least four (4) feet from diffusers and supply units.

L. Analytical Chemistry - Local exhaust systems shall be provided for equipment that exhausts effluent gases.

M. High Toxicity Laboratory

1. Floor coverings shall be a seamless chemical resistant vinyl or chemical resistant poured epoxy, with a seamless cove that extends eight (8) inches up the wall.
2. Cracks, openings, and utility conduits shall be sealed.

N. Semiconductor Labs, Cleanrooms

1. Appropriate SEMI guidelines and NFPA guidelines, (particularly NFPA 318) is required.
2. Automatic extinguishing systems (CO2) and recessed heated system safeguards addressed in SEMI –S3—91 Safety Guidelines for Heated Chemical Baths shall be required.
3. Rapid response smoke detection systems shall be required.
4. Access to mechanical systems shall be exterior to the clean space/lab.

O. Dark Rooms

1. Circuits within a darkroom shall have ground fault circuit interrupters.
2. Emergency eyewash shall be provided. The eyewash station shall comply with the ANSI Z358.1
3. Ventilation will follow the ASHRAE 62-89 standard.
4. Air shall not be recirculated.
5. Local exhaust devices shall be used for exhausting chemical vapors from the room.
6. Humidity control shall be provided.
7. Floors shall be slip resistant.
8. A revolving door is required.
9. Proper storage cabinets for chemicals, equipment and supplies shall be provided.
10. Photo processes involving potential silver wastes shall have silver recovery or no connection to drains. Signage shall be posted indicating the presence of a silver recovery unit.
11. Signage shall be posted indicating the presence of a silver recovery unit.

4.0 Equipment

A. Device selection and other design decisions for laboratory gas controls, will be based on a NC State process safety review

B. Autoclaves shall be provided with local exhaust ventilation. Autoclave rooms should have a minimum of 10 air changes per hour.

C. Lab refrigerators shall be UL approved for flammable materials storage, unless located in Class 1 Division 1 areas as defined in the National Electrical Code, where an explosion proof refrigerator is required.

D. Flammable liquid storage cabinets shall be NFPA approved with self-closing doors. These cabinets shall not be connected to the exhaust ventilation system and flash arrestors shall not be removed. Shelving shall include retaining lips.

E. Gas Cabinets

1. Gas Purge Panels used for corrosive, toxic, highly toxic, or pyrophoric gases shall meet the minimum requirements listed in the NC State Health and Safety Manual, Compressed Gas Safety section. Power and pneumatic service shall be provided to each gas cabinet.
2. Average velocity at the face of access ports or windows shall not be less than 200 fpm with a minimum of 150 fpm at any point of the access port or window.
3. Gas Supply Lines
    a) Where high purity is required, refer to SEMI specifications and user requirements.
    b) Double walled piping shall be used for higher hazard gases.
    c) Hazardous gas piping shall be tested according to the appropriate SEMI specification, including a high and low-pressure leak test for adequate hold times.
4. Gas Connections
    a) Auxiliary valves for gas and vacuum lines shall be located outside the lab.
    b) A shutoff valve shall be located within sight of the connection and clearly marked
    c) Flexible connections shall be used for connecting gas and other plumbed utilities to any freestanding device, including but not limited to biosafety cabinets, incubators, and liquid nitrogen freezers. Flexible connections shall be appropriate for unregulated supply pressure and shall be constructed of material compatible with the transport gas.

F. Gas monitoring: Monitoring equipment shall be approved by NC State prior to purchase. Selected equipment shall meet the requirements set forth in the NC State Gas Monitoring Program.

G. Cooling Water

1. A point of use chiller is preferred for the purpose of cooling lab equipment.
2. Connections to the facilities chilled water system shall meet the following minimum requirements:
    a) Rigid piping capable of maintaining strength over variations in pressure and temperature.

b) A device to shut off the water flow upon leak detection.

c) Proper filtration which protects user equipment.

H. Building vacuum systems shall be protected with a 0.3 micron hydrophobic filter or the equivalent. Filters shall be on the suction side of the pumps, and system exhaust directly to the outside. Filters shall be located as close as possible to the laboratory. Filter housings shall be designed for replacement which minimizes contamination.

I. Radio Frequency (RF) Electromagnetic Equipment.

1. Dedicated grounding is required to minimize the transmission of RF to nearby equipment.
2. Shielding of room and or area may be needed to prevent interference with other sensitive equipment.

J. The design of all commercial cranes and hoists shall comply with the requirements of ASME/ANSI B30 standards and Crane Manufacturer's Association of America standards (CMAA-70 and CMAA-74).

K. Glass Washer

1. Glass wash area shall have a large sink and local exhaust ventilation.
2. Tables shall be free standing stainless steel.
3. Work surfaces shall be impermeable, nonporous, seamless, and smooth.
4. Floors shall be a seamless slip-resistant material, with an integral cove that extends eight (8) inches up each wall. Drains shall have chemical interceptors.
5. Walls shall be either glazed tile or epoxy paint on either concrete block or water-resistant gypsum board.
6. Ceilings shall be easily cleanable and non-porous.

L. Electron Microscope

1. Ceiling shall be a minimum of 10’-0”.
2. Electron Microscope shall be isolated from vibrations and electromagnetic fields per manufacturer’s recommendations.
   a) Chillers, compressors, pumps, and other noisy components shall be located in an equipment room. Sample preparation shall occur in an adjacent space.
   b) Low impedance clean ground power supply shall be provided. High voltage, multiphase electric services may be required based on manufacturers recommendations.

c) Cooling water supply and return humidity and temperature control with air distribution around the microscope is critical to equipment performance (laminar airflow is preferred).

d) Storage space for and distribution of cylinder gases and liquid nitrogen shall be provided.