



UNC Chapel Hill Design Requirements for Level 3 Biological Safety Laboratories & Animals

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| I | <u>General Criteria</u> | | |
| A | The purpose of this Guideline is to establish the criteria for Design and Construction of Level 3 Biological Safety Laboratories (BSL3) at UNC-Chapel Hill. In addition to these criteria, any BSL3 shall conform to the latest edition of Biosafety in Microbiologic and Biomedical Laboratories (BMBL) in effect at the start of construction. | | |
| B | A BSL3 should be designed to allow it to perform independently of other building systems. This is to allow normal building maintenance to occur without disruption to lab operations. Additionally, systems critical to lab operation shall be redundant. | | |
| C | At project close out a verification statement signed by all members of the Design Team will be submitted to the University stating that any BSL3 included in the project scope meets the requirements of the latest edition of the BMBL and the National Institutes of Health (NIH) Biosafety Level 3-Laboratory Certification, and the requirements of this guideline. | | |
| D | All building system equipment (HVAC, plumbing, controls) that will require regular maintenance shall be accessible to maintenance personnel without having to enter the laboratory space and shall not have the potential for exposure to pathogens/agents. External services shall have emergency shut off external to lab. | | |
| E | All mechanical and electrical equipment serving the BSL3 lab suite shall be specifically labeled through out the building. | | |
| F | A laboratory system description shall be provided for a new lab. This document shall be updated anytime a laboratory is modified. The system description shall include the follow sections; General Description, Subsystems and Major Equipment, Operations and Maintenance, Periodic Testing, Drawings and Tables, and Attachments. Appendix A contains the Table of Contents for a typical system description document. This will be a living document that supports the operations and maintenance of the laboratory for the life of the laboratory. | | |
| II | <u>Architectural</u> | | |
| A | Containment Zones (Refer to Figures 1 and 2): Containment zones shall be identified on plans. | | |
| | 1 | Primary Containment Zone (PCZ): | All air is HEPA filtered by Biological Safety Cabinet (BSC) prior to exhaust either by direct ducting or room exhaust. The PCZ is within the Secondary Zone. The PCZ has live agent present |
| | 2 | Secondary Containment Zone (SCZ): | All air is exhausted to the outside and is HEPA filtered. A SCZ may have live agent present |



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| | 3 | Tertiary Containment Zone (TCZ) | All air is exhausted via HEPA filtered room exhaust or to a higher containment zone. Examples of Tertiary zones include but are not limited to Anterooms, changing rooms and showers, etc. A TCZ never has live agent present |
| B | The laboratory must be separated from areas that are open to unrestricted traffic flow within the building. | | |
| C | Access through two (2) self closing doors to reach the inner laboratory is the minimum requirement. The outer door shall be a self locking security door that opens inward. | | |
| D | A clothing change room (anteroom) shall be included in the passageway between the two self-closing doors. A hands-free sink or automatically operated sink shall be provided in the anteroom. | | |
| E | The anteroom (TCZ) shall be designed to accommodate at a minimum a sink, autoclave, and shelves for protective equipment and lockers. | | |
| F | Each lab in SCZ shall have a hands-free sink or automatically operated sink available for hand washing. | | |
| G | The lab entry should be designed to accommodate moving large equipment into and out of the laboratory. | | |
| H | The anteroom should have shower in\shower out capability. The shower and hand washing sinks should be plumbed for effluent decontamination | | |
| I | An air pressure status panel shall be visible from the ante room to provide assurance upon entry that all rooms are under negative pressure. | | |
| J | All laboratory surfaces (walls, floors, ceilings) shall be designed to be easily cleaned and decontaminated. | | |
| | 1 | Bench tops shall be impervious to water and be chemical and heat resistant. | |
| | 2 | Floors shall be monolithic/seamless or with welded seams and covered up the wall 4 inches. The floors shall be continuous under permanent casework. | |
| | 3 | Ceilings shall be monolithic (no removable tiles). | |
| | 4 | Walls and ceilings shall be painted with durable glossy acrylic or epoxy paint with adequate coverage to provide a “no pinholes evident” finish. | |
| K | No outside windows shall be present in the laboratory. | | |
| L | All BSL3 doors shall have full length door stops and the doors provided with adjustable door sweeps. | | |



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| M | All laboratory furniture must be capable of supporting anticipated loads and uses and, shall be made of non-porous material (including chairs). Adequate spacing shall be provided between benches, cabinets and equipment to allow for cleaning and decontamination. | |
| N | All refrigerators, freezers and incubators used to store BSL3 agents shall be located within the inner laboratory (SCZ). | |
| O | All penetrations (including electrical and plumbing) into the laboratory shall be sealed using long life fire rated sealant. All junction boxes and cover plates shall be sealed air tight. | |
| P | Ceiling access doors are not recommended. If required ceiling access doors in the laboratory shall have gas-tight gaskets and piano hinges. | |
| Q | An autoclave shall be available in the laboratory. | |
| | 1 | Autoclaves should be large enough to accommodate large animal cages (i.e. turkeys) |
| | 2 | A pass-through autoclave is required. |
| | 3 | Steam isolation shut off valve shall be outside of the lab. |
| | 4 | An autoclave shall have an effluent decontamination system for the autoclave discharge to the drain. |
| | 5 | The drain for the autoclave shall be in the anteroom if the effluent decontamination option is available on the autoclave. |
| | 6 | Any autoclave steam relief valve discharge and condensate drain shall discharge to the SCZ side of a pass through autoclave and not the anteroom or exit areas. |
| | 7 | A Bioseal or other equivalent means shall be used to create a seal between the autoclave and the SCZ wall. |
| | 8 | Access for autoclave repair shall be outside of the SCZ. |
| | 9 | Canopy hoods over the autoclave are required to contain heat and steam from each end of the autoclave. |
| R | A Class II Type A or Type B Biological Safety Cabinet (BSC) shall be available in the laboratory | |
| | 1 | BSCs must be installed so the room supply and exhaust air does not interfere with proper operation. Additionally, BSCs shall be located away from doors, high traffic laboratory areas. |



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| | 2 | Cabinets must comply with and be installed and certified in accordance with NSF/ANSI 49-2002 |
| | 3 | If a cabinet contains both a down flow fan and an exhaust fan, the fans shall be interlocked so that the down flow fan shuts off whenever the exhaust fan fails. |
| | 4 | Class II Type A thimble ducted cabinets are not allowed. |
| S | | Vacuum lines shall be independent of the building vacuum. Vacuum lines must be protected with HEPA filters or an equivalent. |
| T | | An eyewash station shall be in each laboratory. |
| U | | HEPA filters shall be located as close as possible to the containment barrier penetration. HEPA filters shall be rated for 99.99 efficiency at 0.3 microns. These filters shall include provisions for bag-in/bag-out filter replacement. HEPA filters shall be located with consideration to replacement and testing procedures. HEPA filters should be zoned so that shutdowns can be coordinated. Consideration shall be given to provide redundant filter banks in case of unplanned laboratory shut downs. |
| III | | <u>Electrical</u> |
| A | | Cast electrical boxes are recommended for outlets. |
| B | | All components of the HVAC system (supply and exhaust), alarms, emergency lighting and laboratory outlets for essential equipment (Biological Safety Cabinets, freezers, autoclave, etc.) shall be on a backup power system. All BSL3 equipment and controls on backup power shall be supplied backup power through a closed transition transfer switch. BAS controllers and BSCs shall have UPS with a run time of at least 120 seconds. |
| C | | Backup power to the lab and associated systems shall be on dedicated circuits from the generator. These shall be in compliance with Article 700 of the NEC. |
| D | | Light fixtures shall be surface mounted and designed to maintain gas tight requirements. |
| E | | Circuit breakers shall not be located within the SCZ. |
| F | | At least one light fixture in the inner lab and one in the anteroom shall be equipped with battery backup. |
| IV | | <u>HVAC\BAS Controls</u> |
| A | | The laboratory shall be designed to have directional airflow from the hallway, through the TRZ into the SCZ. |
| B | | Laboratory Design must comply with the latest edition of ANSI Z 9.5 and NIH BSL3 design guidelines in effect at the start of construction. |



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| C | The supply and exhaust system for the laboratory shall be completely separate from other building HVAC systems. |
| D | The pressure relationship of SCZ, TCZ, and corridor shall be actively controlled by laboratory grade supply and exhaust terminal units. Blade damper style terminal boxes are not permitted. |
| E | The brand, generation, and software tools for the BSL3 BAS shall be the same as that used throughout the building. |
| F | Digital readout /visual monitoring devices that indicate directional airflow are required in the laboratory. These air pressure monitoring (APM) devices shall have audible alarms to indicate HVAC system failure. The devices shall be equivalent to Tek-Air Systems Iso-Tek Space Pressurization Monitor (SPM-2200) or Phoenix Controls Active Pressure Monitor APM100. The range of the room APM shall be from 0.25 to - 0.25 INWC. |
| G | The APM shall have both a dry set of contacts for an alarm dialer and analog outputs to enable remote monitoring via the Building Automation System (BAS) and alarming to Public Safety. |
| H | The exhaust system shall be designed with redundant 100% capacity exhaust fans. Failure of the either fan will cause the other fan to energize in minimum time to maintain lab pressurization, unless both fans are designed to run continuously. All general exhaust fans shall have dedicated variable frequency drives (VFD) with manual bypass capability to enable fan operation even when the VFD fails. |
| I | Each ducted BSC shall have dedicated redundant exhaust fans. |
| J | BSC controllers should be provided with one digital input and one digital output. The digital input will be from the BAS for future volume/velocity reset. The BSC digital output will be for an alarm input to the BAS. (Refer to Table 1) |
| K | All exhaust ductwork shall be welded stainless steel, gas tight to allow for formaldehyde decontamination. Round ducts are recommended. Leakage tests of the ductwork should be done as part of the commissioning process. All welds, gaskets, penetrations or seals on exterior surfaces of ducts shall be able to sustain air pressure for 20 minutes and be free of soap bubbles at 4 inches WG and the gas leak rate should not exceed 2×10^{-8} cubic feet per minute (CFM). (reference ductwork leakage testing in the HVAC section of the UNC guidelines) |
| L | Consideration shall be made for uninterrupted straight lengths of ductwork to enable accurate airflow measurements. |
| M | Sealable, gas-tight isolation dampers are required in the air supply and exhaust ducts for the laboratory. |
| N | A switch labeled "Emergency Supply Air Shutdown" which will de-energize the air handler via a safety circuit (not BAS logic) shall be located in the anteroom. |



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| O | Environmental room sensors (e.g. T-stat) will not have local user adjustment features. The associated room air supply terminal unit shall be provided with a discharge air sensor, which along with the room sensor will be used in a cascade loop to limit space temperature swings. | |
| P | Any BSL3 room housing an autoclave, served by an HVAC system that is capable of humidification or any other device using steam shall have a room humidity sensor. | |
| Q | The supply duct shall include sensors and logic to shut down the humidifiers upon a loss of humidity control. | |
| R | The supply side of the air distribution system shall be designed with redundant full_capacity fans. If both fans are in a common air handling unit they will be partitioned to allow servicing without loss of supply air. | |
| S | Class II Type A BSC shall have exhaust grilles located directly above the exhaust filter. | |
| T | All exhaust air from the laboratory shall be HEPA filtered. | |
| | 1 | Test ports and isolation dampers shall be installed on both sides of the filter to allow for filter testing and decontamination. Refer to Figure 1. |
| | 2 | Valved ports with magnahelic gauges shall be installed to measure pressure drop across the filter and fans. These shall be separate gauges for the filter and fan sections. |
| | 3 | Clearance should be maintained around the filter housing to allow for filter changes. |
| | 4 | Polydisperse Dioctyl Phthalate (DOP) filter test is required to insure that HEPA filters or the areas around the filter do not leak. |
| | 5 | All exhaust discharge shall be vertical. |
| U | All HVAC equipment failures including exhaust and supply fans and heating water pumps shall alarm through the building automation system to the Energy Management Control System (EMCS) shop. APM alarms shall be sent to the Department of Public Safety (DPS) and EMCS. Refer to Figures 1 & 2 and, Table 1 for alarms and notification. | |
| V | The BAS shall include a Local Control Station (LCS) with all graphics and controls hosted locally such that full BAS functionality including trending exists in the building when internet connectivity to the outside is lost. A second (redundant) fully functional LCS with a documented manual change over process is required. | |
| W | The BAS network for the BSL3 area shall be physically separate from the other parts of the building such that network problems in one area do not affect the other and problems may be isolated. | |



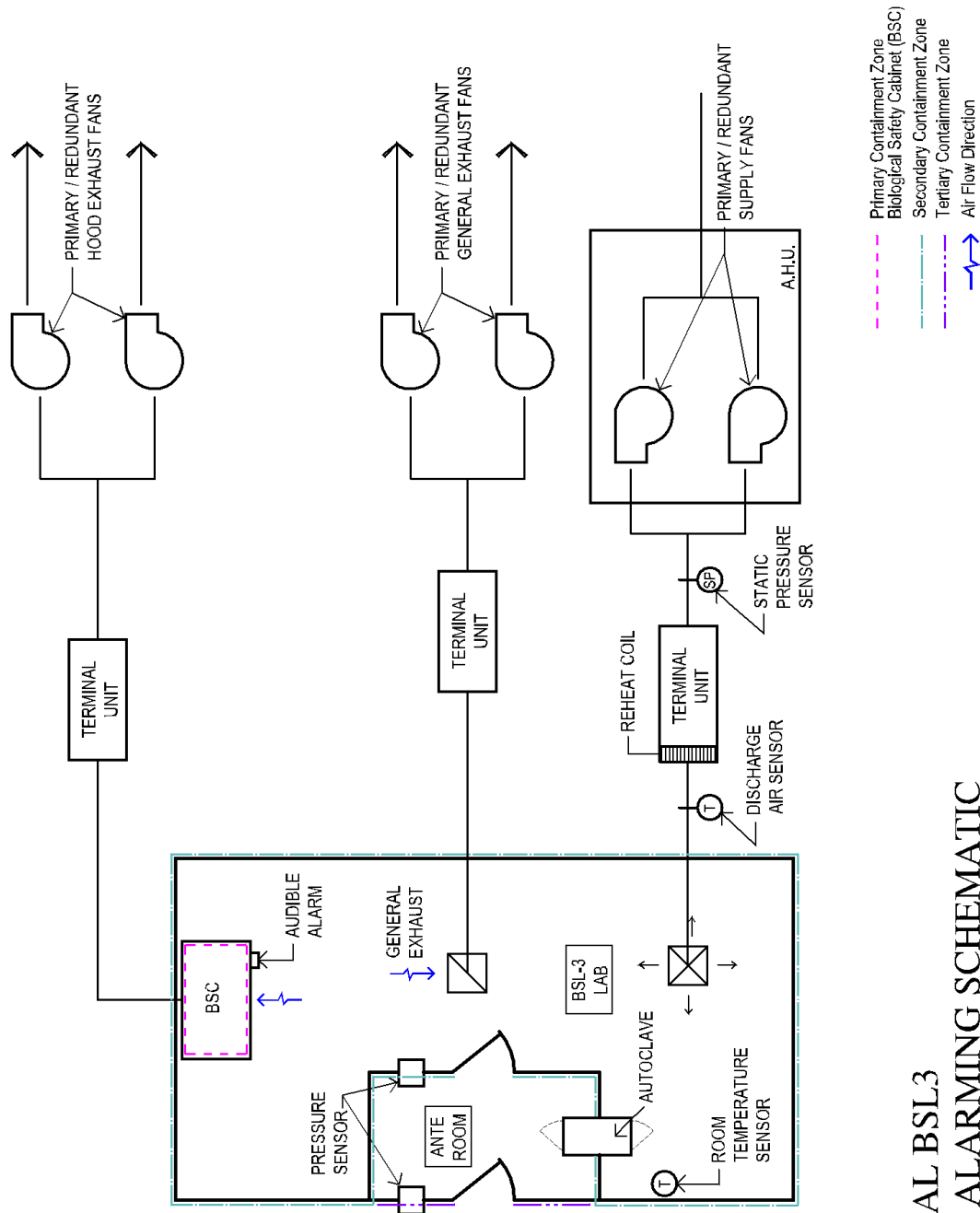
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| X | The BAS contractor shall collaborate with UNC-IT staff to provide automatic backups of the BAS databases on a weekly basis to both the LCS and a remote location. |
| Y | The BAS contractor shall provide a web page with limited rights to enable the lab users to change their room temperature set point within adjustable boundaries. |
| Z | For each BSL3 room, any general room exhaust, BSC and, any autoclave hood exhaust flow shall be measured by the BAS. Total room exhaust shall be summed and the total room exhausts flow tracked by the room supply flow to ensure proper room CFM offset and pressurization control. Both the supply and exhaust air terminals shall be under the same controller. Refer to UNC HVAC standards for lab control requirements. |
| ZA | Consideration shall be given to providing an exhaust system that has more inertia than the supply system, such that upon a major failure that includes all fans where the lab will be failed neutral, the supply system stops before the exhaust and the lab never goes positive. |
| V | <u>Plumbing</u> |
| A | A hands-free sink must be available in the inner laboratory near the exit door. Foot controls are recommended. EHS will review alternative controls. |
| B | An eye wash must be available in the inner laboratory. An “Eyewash” sign must be posted near the eyewash. |
| C | Provide exterior access to isolation valves for hot and cold water supply cutoff. |
| D | Water service to the laboratory shall be protected by backflow prevention devices to prevent contamination of areas exterior to the BSL3. |
| E | Provide a hands-free sink in the anteroom. |
| F | An emergency shower is required in the TCZ. |
| G | Trap Primers are prohibited. All traps shall be extra deep. |
| H | Compressed gas tanks should not be placed in the inner laboratory. If compressed gas will be needed for experiments, piping should be run into the SCZ from a manifold in a gas cabinet outside the SCZ. |
| I | Natural gas cannot be plumbed into the laboratory. |
| J | All effluent shall be captured and decontaminated prior to release to sewer. |
| K | Provide redundant reduced pressure backflow prevention specific to BSL3 laboratories to prevent contamination of non-BSL3 piping. |



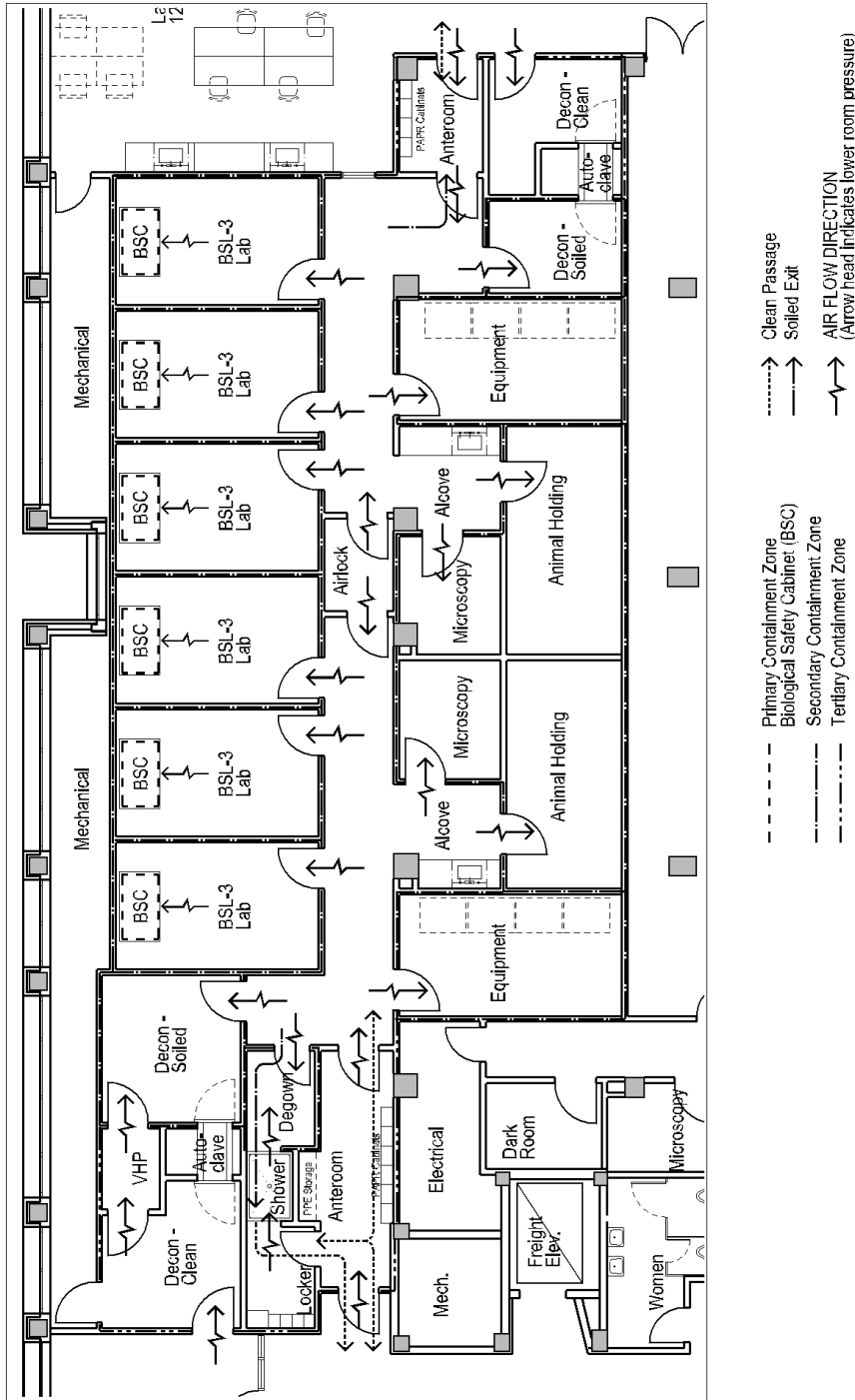
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| VI | <u>Security\Life Safety</u> | |
| A | A strobe light fire alarm and a fire alarm pull station are required in the laboratory. The strobe light must be visible in all locations of the laboratory. | |
| B | Laboratory shall be secured by electronic locks and/or combination locks, accessible only by authorized personnel. | |
| C | A keycard access system shall be required for tracking entry into the lab. | |
| D | A medical alarm system shall be available for individuals working in the laboratory alone. | |
| E | A telephone that functions during power outages shall be available in the inner lab for emergency purposes. | |
| F | The anteroom and inner laboratory doors should be electronically interlocked to prevent both from being opened at the same time. | |
| G | A telephone shall be available in each anteroom | |
| H | <u>Additional Life Safety Requirements for Select Agent Labs</u> | |
| | 1 | Provide and install a keycard swipe recorder outside the main laboratory door and inside the main laboratory door to record entry and exit from the lab. |
| | 2 | Provide and install a keycard access on the door leading from anteroom to the laboratory proper, operable from 6 p.m. to 6 a.m. |
| | 3 | All keycard use shall record the time and date of entry or exit and the name of keycard owner. |
| I | An area or floor on which a single secure laboratory is located does not need to be secured by electronic locks. | |
| J | A master status panel (refer to architectural section) is required in the anteroom to the suite for visual status of all air pressure monitors. | |
| K | An area or floor with a number of adjacent secure laboratories shall be secured by electronic locks accessible only by authorized keycards, in addition to the keycard locks on the main door to each select agent laboratory. A Knox-box, accessible by emergency responders, shall be installed at the entrance for holding keys to the secure area. When area/floor keycard security is utilized, keycard access is not necessary for the door leading from anteroom to the laboratory proper for select agent laboratories within this secure area/floor. | |
| L | As is normal for most campus operations, the electronic locks should be disabled (open) to facilitate egress in the event of a fire alarm. In the event of a fire alarm, the combination lock on the laboratory's main door | |



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| | will continue to function and keep the laboratory secure (i.e., fire alarm secure). |
| M | Video surveillance shall monitor hallway entrance to the select agent laboratory. The most recent thirty days of video shall be stored on a digital recorder with removable media. |
| N | Shatterproof glass, no larger than two square feet, shall be installed on the door between the anteroom and inner laboratory rooms. |
| VII | <u>Commissioning</u> |
| A | The BSL3 Laboratory space and all supporting systems shall be commissioned by an independent commissioning agent. Submit a commissioning plan for approval by Facilities Services and The Environmental Health and Safety Department. |
| B | The commissioning Plan shall be included with the system description (refer to Section I-D). |
| C. | All specific pass/fail criteria that will be used to functionally test the lab shall be developed prior to detailed design and submitted to the designer such that hardware and software selected will meet the final test standard. |
| VIII | <u>Exception Process</u> |
| | If during the design and construction phase the requirements of this document can not be met, it is required that a written explanation be provided documenting why and what alternative approach was agreed to. This document will require the signoff of the Department of Environment, Health and Safety, Facilities Services, and all members of the Design team. |



TYPICAL BSL3
HVAC ALARMING SCHEMATIC
FIGURE 1



**TYPICAL BSL3
MULTIPLE LABS
FIGURE 2**



UNC-Chapel Hill BSL3 Lab Alarming Standards
Table 1

| Item | Condition | Notify | | Alarm Limits | Alarm Text | Notes |
|------|---|--------|------|--|--|---|
| | | DPS | EMCS | | | |
| 1 | Anteroom to Lab High Pressure | x | x | Differential Pressure > -0.005 inWG (field verify) | BLG xx Room xx BL-3 Secondary Containment Zone High Neg. Pressure | Provide local audible alarm after condition exists for 30 seconds. Provide 45 second delay prior to initiating alarm to BMS and DPS. Field verify delay and high limit. |
| 2 | Anteroom to Lab Low Pressure | x | x | Differential Pressure < 0.15 inWG (field verify) | BLG xx Room xx BL-3 Secondary Containment Zone Low Neg. Pressure | Provide 45 second delay prior to initiating alarm. Field verify low limit. |
| 3 | Anteroom to Hall High Pressure | x | x | Differential Pressure > -0.005 inWG (field verify) | BLG xx Room xx BL-3 Tertiary Containment Zone High Neg. Pressure | Provide local audible alarm after condition exists for 30 seconds. Provide 45 second delay prior to initiating alarm. Field verify delay and high limit. |
| 4 | Anteroom to Hall Low Pressure | x | x | Differential Pressure < 0.15 inWG (field verify) | BLG xx Room xx BL-3 Tertiary Containment Zone Low Neg. Pressure | Provide 45 second delay prior to initiating alarm. Field verify low limit. |
| 5 | Ducted Cabinet Face Velocity Alarm | x | x | 80 FPM | N/A | Provide visible alarm at cabinet. Provide 15 second delay on alarm. |
| 6 | Ducted Cabinet Terminal Unit | x | x | Designer to cal. flow equivalent to 80FPM. Alarm when flow drops below. | BL-3 Ducted Cabinet airflow too low. Check for fan failure. | |
| 7 | Ducted Cabinet primary exhaust fan | x | x | Pressure switch or CT indicates fan failure. | BLG xx EF-x BL-3 primary exhaust fan failure for ducted BSC. | Confirm operation of redundant fan. Investigate power failure, belt breakage, motor failure. |
| 8 | Ducted Cabinet backup exhaust fan | x | x | Pressure switches indicates fan failure of both primary AND backup exhaust fans. | BLG xx EF-x BL-3 primary AND backup BSC exhaust fan failure | |
| 9 | Room Temperature (non-animal holding) | x | x | Deviation from setpoint by 1 degF | BLG xx Room xx BL-3 Temperature exceeds setpoint limits. | Check air handler and reheat valve. |
| 10 | Room Temperature (animal holding) | x | x | Deviation from setpoint by 1 degF | BLG xx Room xx BL-3 High Temperature (animal holding) | |
| 11 | General Exhaust airflow | x | x | Deviation from setpoint by 10% | BLG xx Room xx BL-3 General Exhaust airflow differs from setpoint. Check exhaust fan operation and terminal box operation. | |
| 12 | General Exhaust primary fan | x | x | Pressure switch or CT indicates fan failure. | BLG xx EF-x BL-3 primary exhaust fan failure for general exhaust. Confirm operation of redundant fan. Investigate power failure, belt breakage, motor failure. | |
| 13 | General Exhaust backup fan | x | x | Pressure switches/indicates fan failure of both primary AND backup exhaust fans. | BLG xx EF-x BL-3 primary AND backup general exhaust fan failure | |
| 14 | Supply air low static pressure | x | x | Static Pressure Setpoint - Actual Static pressure > 0.2 inWG | BLG xx EF-x BL-3 supply air static pressure low | |
| 15 | Air Handler primary supply fan | x | x | Pressure switch or CT indicates fan failure. | BLG xx SF-x BL-3 primary supply fan failure for ducted cabinet. | Confirm operation of redundant fan. Investigate power failure, belt breakage, motor failure. |
| 16 | Air Handler backup supply fan | x | x | Pressure switches indicates fan failure of both primary AND backup exhaust fans. | BLG xx SF-x BL-3 primary AND backup supply fan failure | |
| 17 | Animal Cage system failure | x | x | TRD-lim Edwards and Doug Fleming failure | BLG xx Ultra-low/freezer high temperature | |
| 18 | Door Access Unauthorized access attempt | x | x | Unauthorized access | BLG xx Room xx BL-3 Animal Cage xx failure | |
| 19 | Door Access-Door left ajar | x | x | Door left open too long | BLG xx Room xx BL-3 Door left open | Provide 30 second delay prior to initiating alarm. |
| 20 | SLPRA Box | x | x | Notify when access is gained to the box | BLG xx RL-3 SLPRA Box accessed | Field verify delay. |
| 21 | Medical Emergency Button | x | x | Notify when person is down | Medical Alarm | |