UNIVERSITY OF CALIFORNIA

Animal Biosafety Level 3 (ABSL-3) Laboratory

Design Standards

March 2023

Introduction

The University of California (UC) is home to some of the world's most advanced and pioneering biomedical science and clinical research. Consistently ranked among the leaders in the field of Infectious Disease research, the UC is often called upon to provide critical expertise in response to worldwide public health crises. Infectious Disease research involving highly pathogenic and primarily aerosol transmissible agents (i.e., Risk Group 3 agents) has the potential to present significant risk to individuals, the community, and the environment. The ability to safely conduct these research activities is largely dependent upon the highly engineered Biosafety Level 3 (ABSL-3) laboratory, the highest-level containment facilities currently operated by the UC. The primary objective of these laboratories is to provide the best possible physical containment of Risk Group 3 agents. Hence, the design and engineering of these laboratories must be maintained at the highest attainable standards.

Several authorities have published standards for the design of ABSL-3 laboratories. Development of the UC Biosafety Level 3 Design Standards has incorporated input from several of these sources, including the following:

- CDC Biosafety in Microbiological and Biomedical Laboratories (BMBL), 6th Edition, 2020
- NIH Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities (DRM), 2019
- NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (NIH Guidelines), 2016
- National Institutes of Health Biosafety Level 3 Laboratory Certification Requirements, 2006
- Industry Standards and Best Practices

The information presented in these Standards addresses facility design and engineering systems for ABSL-3 containment laboratories and incorporates additional design elements to assist campuses in conducting facility risk assessments. It is important to note that an effective ABSL-3 program is not only reliant upon the facility and engineering, but also operation and maintenance (O&M) protocols, robust training programs, administrative controls, and standard operating procedures (SOPs).

Application

In addition to all relevant sections of Title 24 that are interpreted and applied by the Designated

Campus Fire Marshal and Campus Building Official assigned to the campus (collectively, the Authority Having Jurisdiction (AHJ)), the ABSL-3 Laboratory Design Standards represent the UC requirements for constructing ABSL-3 laboratories. The ABSL-3 Laboratory Design Standards do not supersede Title 24 and are intended as a reference for the UC design teams including the AHJ, researchers, architects and engineers, as well as outside contractors. They provide necessary tools and information for ABSL-3 planning, construction, and commissioning on UC campuses. Where these Standards contradict existing building codes, the AHJ shall have final authority to interpret and apply the relevant design requirements with respect to ABSL-3 laboratories.

While incorporating all applicable regulatory requirements, the standards identify UC requirements, provide explanations of those standards, and document best practices for consideration during the facility risk assessment. This range of acceptable parameters will allow campuses to build each laboratory with a level of features commensurate with the facility risk assessment. These Standards pertain to new facility builds and/or major renovations or retrofits of existing ABSL-3 laboratory space. It is not the intent of these Standards to require upgrades to existing ABSL-3 spaces, but to provide design standards and guidance when embarking on a new construction or major renovation project.

This Standard is applicable to the specific retrofit and not meant to apply to the entire facility. The applicability of this Standard to a major retrofit should be determined by the campus High Containment Laboratory Oversight Group (HCLOG). For questions or clarification, consult with the High Containment Laboratory Oversight Committee (HCLOC). For the purposes of these Design Standards, major renovations/retrofits are defined as any of the following: 1. Changes to fixed primary containment equipment (e.g. ducted BSCs or any other devices connected to the ABSL-3 exhaust system); 2. Changes to major HVAC systems/components (e.g. exhaust fans, air handling units, airflow control valves, isolation dampers, Building Management Systems / Building Automation Systems (BMS/BAS), ductwork, etc.); 3. Changes to floorplans or structural components of the secondary containment boundaries (e.g. walls, ceilings, or attached fixtures); 4. Any other changes to the facility that could impact overall safety, operations, or ventilation system performance. As plans to renovate specific features of an existing facility evolve, it is important to address any identified issues that may affect the safe operations of an ABSL-3 laboratory, potentially presenting a risk to the UC community or the environment. These Standards have been approved by the UC systemwide HCLOC, and shall be incorporated or referenced in Campus Building Standards.

Notes:

1) Facilities required to comply with the Federal Select Agent Program and/or Dual Use Research of Concern may have additional biosafety or biosecurity design features beyond these UC Standards. In addition to the UC Standards, campuses must reference and comply with the applicable Federal regulatory standards when designing Federal Select Agent or Dual Use Research high-containment facilities.
2) These standards apply to facilities designed for standard, contained animal care that will be housed in primary containment. For larger animals requiring primary containment that will be loose-housed or in open pens, additional facility requirements will apply that are not addressed with these standards. Applicable additional standards will need to be assessed individually by campuses as appropriate.

Campus Involvement

At the onset of a new ABSL-3 laboratory or existing laboratory renovation design project, locations must involve all relevant stakeholders to ensure the success of the design and construction of the facility. Campus officials designated as the AHJ shall be involved in any construction project. The AHJs have the final authority to reject or approve design and construction elements and will need the support of biosafety professionals to address risk assessment and containment considerations. In addition, consultation with other key campus members will provide insight into critical design flaws that may affect specific aspects of the laboratory's functionality. These contributions could prove to be exceptionally cost-effective in terms of both time and resources. Involvement from the following campus members is recommended:

- Designated Campus Fire Marshal and Campus Building Official (AHJ) (required)
- PI (researcher)/Department Chair
- EH&S Biosafety
- High Containment Laboratory Director
- Campus Design Management Group
- Capital Programs
- Campus ADA Reviewer
- Campus Security or Campus Police Department
- Campus Emergency Response
- Campus Facilities Operations & Management Group
- Campus Veterinarians and Animal Resources Directors

Deviations

Campuses must comply with the UC Animal Biosafety Level 3 Design Standards and Best Practices

should be considered when appropriate. When justified by a documented risk assessment and in coordination with the AHJ and HCLOG, a deviation may be considered. A campus seeking a deviation approval must first complete the **UC ABSL3 Design Standards Deviation Request Form**, **Appendix I**. The completed form and requested documentation shall be presented to the campus High Containment Laboratory Oversight Group (HCLOG) for approval. With campus AHJ and HCLOG approval, the deviation request will be presented to the UC systemwide HCLOC, for approval.

Revisions to the Standards

A full review and revision of the UC ABSL3 Design Standards shall be conducted every two years, on even years. Between full revisions, the Design Standards may be revised on an as needed basis via continual evaluation and application. Through the use of these Design Standards, any identified gaps, errors, or sections requiring further clarification will be noted and highlighted by local EH&S and Design professionals. Corrections, clarifications and all identified issues shall be presented to the UC systemwide HCLOC for confirmation and approval. Once approved by the HCLOC, updates will be completed and distributed to each location. Revised versions of the Standards must receive approval by the UC systemwide HCLOC prior to implementation.

Table of Contents

List of Codes, Standards and Guidelines

- Biosafety in Microbiological and Biomedical Laboratories (BMBL) 6th Edition, 2020
  https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final-3.pdf

  The BMBL is published jointly by the U.S. Department of Health and Human Services, the Centers for Disease Control and the National Institutes of Health. The document describes biological risk assessment, lab practices, safety equipment, and facilities requirements required for designing and operating laboratories at Biosafety Levels (BSL) 1 through 4. Although not a code, certification of BSL facilities is dependent on following the recommendations in this document.

- NIH Design Requirements Manual (DRM) 2019 Rev 1.4: 4/24/19
  https://www.orf.od.nih.gov/TechnicalResources/Documents/DRM/DRM1.4042419.pdf

- National Institutes of Health Biosafety Level 3 Laboratory Certification Requirements, July 2006
  https://s3.documentcloud.org/documents/6785602/NIH-Biosafety-Level-3-Laboratory-Certification.pdf

- ANSI/ASSE Z9.14-2014 Testing and Performance-Verification Methodologies for Ventilation Systems for Biosafety Level 3 (BSL-3) and Animal Biosafety Level 3 (ABSL-3) Facilities -
  This document can be purchased at: https://store.assp.org/PersonifyEbusiness/Store/Product-Details/productId/11562952

- NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (NIH Guidelines), 2016

- University of California Environment, Health & Safety (EH&S) Laboratory Safety Design Guide, Second Edition, September 2007

ABSL-3 Architectural

General

An ABSL-3 facility should be designed to contain the research materials, manage aerosols generated during procedures, and accommodate all necessary equipment and allow for regular decontamination. This section discusses general design standards for such a facility.

Standard	Explanation	Best Design Practice
1. New UC ABSL-3 laboratories and designated retrofits must be reviewed for compliance with applicable provisions of the American with Disabilities Act (ADA) and related codes and regulations.	1. Access to the ABSL-3 laboratory and work activities conducted in the facility must be evaluated on a case-by-case basis to determine appropriate accommodations and accessibility. Work with the appropriate units on campus to determine specific ADA design requirements and compliance with Title 24 California Building Code Chapter 11 Accessibility.	1. N/A
2. Design the laboratory to be easily cleaned and decontaminated. [1, 2, 3, 4]	2. Smooth walls, floors, and ceilings with finish that is resistant to repeated chemical decontamination.	2. N/A
3. Keep the ABSL-3 laboratory separate from un-secured high traffic areas. [5, 6, 7]	3. N/A	3. Consider locating the facility on an upper floor. Consider location of ABSL-3 laboratories in relation to other zones such as BSL-2 support laboratories, offices and break rooms, elevators, loading docks, etc. for effects on laboratory pressurization and airflow.

4. Provide dedicated anteroom to include space for personal protective equipment (PPE) and waste. Doors are self-closing. [8, 9, 10, 11, 12]	4. Dedicated anteroom is accessed through self-closing doors that should be physically interlocked with over-ride for emergency use.	4. N/A
5. Provide access to non-containment laboratory support spaces in close proximity to the ABSL-3 laboratory, including but not limited to BSL-2 workspace, storage, and break rooms. [13, 14, 15, 16]	5. The needs of the research program and research staff must be considered in design and location of support spaces.	5. Workflow should be mapped during initial design phase.
6. Sealed penetrations (through partitions, walls, floors and ceilings) are required. [17, 18, 19, 20]	6. Sealed penetrations should be visible for ease of inspection and verification.	6. Escutcheons are not required or desired for penetrations. Sprinkler heads should protrude and be sealed directly to the ceiling.
7. Primary containment devices must be placed in such a way as to minimize impact of room airflow on function/containment. This must be determined in conjunction with the High Containment Laboratory Director (HCLD). [21, 22, 23, 24]	7. Primary containment equipment such as BSCs shall be placed in the room so that containment is not impacted by supply diffusers, exhaust grilles, doors, traffic flow, or other equipment.	7. Consider Appendix A of the DRM and Appendix A of the BMBL for exact distances from features and for placement in a space.
8. Design must provide appropriate access to accommodate equipment and supplies necessary to support laboratory animal care	8. Large animal racks will need to be brought in. Animal food bags, bedding, caging, etc., will need space to then bring into facility.	8. Consider additional space/room that will be a dedicated pass-through, interlock chamber

Containment Barrier

The ABSL-3 facility should have an outer containment barrier. This barrier is part of the facility and acts to separate the zone of containment and the exterior. The barrier will need to withstand pressure changes, chemical disinfectants, gas decontamination, high heat from autoclave exhaust, and serves to maintain biosecurity.

Standard	Explanation	Best Design Practice
9. Partitions must be designed to resist damage from differential air pressure surges during HVAC testing, and to withstand water and moisture. Interior partitions (walls) must extend slab to slab. [25]	9. N/A	9. Single leaf doors should be used whenever possible. Single door size should be planned to be large enough to accommodate larger equipment.
10. Construct ABSL-3 containment barrier with steel studs, sheet rock and appropriate backing material. [26, 27]	10. Frame partition assemblies shall include gypsum board that is selected and detailed to be appropriately impact, moisture and water resistant. Standard gypsum board is not acceptable. Light-gauge steel studs used for partition framing shall be 18-gauge minimum thickness and spacing should be consistent with local codes. Vertical screw spacing in gypsum wallboard assemblies shall not exceed 152 mm (6 in.). Structural adequacy shall be verified, and additional lateral reinforcement provided if required. All partitions that do not extend to the underside of the structure shall be capped. Concrete masonry units (CMU) walls shall include masonry units utilizing fine sand aggregate or ground face to provide an appropriate substrate for block filler and epoxy paint. Voids in CMU partitions shall be sealed above the ceiling.	10. Acoustic consultants should comment on the effect of stud gauge on vivarium sound transmission requirements.

Anterooms

An anteroom is the support room prior to entry into the zone of containment. The anteroom is an enclosed room that is separate from the zone of containment and surrounding spaces. An anteroom should be designed to support storage of personal protective equipment, supplies, clothes changing, showering, waste management, and other functions as needed.

In some cases, an ABSL-3 can be designed with an entry anteroom and an exit anteroom for unidirectional flow of personnel depending on the donning, doffing, clothe changing, or showering requirements associated with the agents in use and based on risk assessment for the scope of work.

Standard	Explanation	Best Design Practice
11. Anteroom doors must be self-closing and have a mechanism for interlocking. Mechanically interlocked doors must have an emergency override. [28, 29, 30, 31, 32]	11. N/A	11. N/A
12. Anterooms must be appropriately sized for program requirements based on risk assessment and considerations for future expansion of research focus. Anterooms must be sized to meet local Fire Code requirements. ** Consider: If anteroom will be used when bringing in equipment and supplies, room must be appropriately sized to accommodate transfer of equipment and supplies necessary for support of animal care and research.	12. Provide anteroom large enough to allow for a change bench, storage shelves for clean PPE, laundry receptacle and waste container.	12. Anteroom should also include space for a logbook and wall calendar. If the anteroom will be the main entryway for equipment, size appropriately for largest piece of equipment, including door sizes. If exit anterooms are present, consideration should be given for their suitability as gaseous or vapor decontamination chambers.

Doors

Doors within an ABSL-3 facility serve multiple functions, including security, physical containment barriers, and evacuation points. The door in an ABSL-3 is also used as an inward airflow leak point where most make-up air is brought into the space.

Standard	Explanation	Best Design Practice
13. Doors must have door locks access controls that allows for fast and efficient removal of access clearance, such as card keys. Hard key access must be off master and provided as a backup to electronic lock systems. Electronic locks must fail secure with a bypass for egress. [33, 34, 35]	13. Electronic lock systems shall be linked to restricted remote access management software. Adhere to any local/UC policy (UCOP IS-3 policy)	13. Consider including biometric or PIN devices for locks on doors access control based on risk assessment.
14. Doors must be self-closing and self- latching. Doors with locks must be self-locking. [36, 37, 38]	14. N/A	14. N/A
15. Door must be welded steel or fiberglass constructed of sufficiently durable material (e.g.: stainless steel, FRP, or epoxy-painted welded steel) with welded steel frames, and large enough for passage of equipment. [39]	15. Wooden doors and frames are not permitted.	15. Provide 42 in. single leaf doors.
16. Doors shall be seamless with no top or bottom recesses. Cutouts in doors and frames shall be sealed to enhance sanitation and resist air infiltration. Doors and door hardware shall be free of sharp edges. Door hardware shall be easily operated with PPE. [40]	16. N/A	16. N/A
17. Rubber door sweeps must be provided for pest control, but must be adjustable to facilitate inward airflow movement. [41, 42]	17. Use rubber sweeps as animals can chew through bristles.	17. Can install small port with closeable flap to allow inward airflow movement.

18. Provide stainless steel kick plates. [43]	18. N/A	18. N/A
19. Vision panels must be in all interior doors unless prohibited for programmatic reasons. [44, 45]	19. Vision panels in exterior doors should be sealed and rated for fifteen-minute forced entry break resistance.	19. N/A
20. Access to the laboratory must be through two interlocked doors; provide interlock over-ride for emergency use. [46, 47, 48]	20. Egress only doors may be single door configuration. No hardware on outside of the door.	20. N/A
21. Door swing direction must be determined in discussion with EH&S and Fire Marshal. [49]	21. N/A	21. Doors should swing in the direction of airflow (clean to dirty).
22. No pocket doors, bifold or sliding doors. [50, 51]	22. N/A	22. N/A
23. Doors serving locations that require directional airflow shall be configured to allow for sufficient air movement at the undercut to achieve proper operation without excessive pull or closure pressure so as to be compliant with existing Fire Code.[52]	23. Airflow through undercut doors allows for containment airflow and plays a role in establishing operating pressure differential between spaces, which requires verification of height and airflow to ensure proper cascading pressurization control of the facility.	23. N/A

Windows

The inclusion of windows in ABSL-3 facilities requires careful consideration. Design should balance the favorable features of windows, such as visualization for safe entry and egress, against security needs. Windows within facilities, such as door insets, may be desirable.

Standard	Explanation	Best Design Practice
24. All windows must be appropriately sealed and non-operable. [53, 54, 55, 56, 57]	24. N/A	24. Windows on perimeter walls or doors should be considered only after a security assessment.
25. Window frames must be fully welded and	25. N/A	25. If windows are located on perimeter

sealed. [58] • Provide laminated and tempered glass at all windows		walls, they should be appropriately glazed, as described in the DRM.
26. Sills must be sloped for ease of cleaning. [59]	26. N/A	26. N/A
27. Doors must be large enough to accommodate large equipment (e.g., animal cage racks).		

Floors

The floors of ABSL-3 facilities should withstand harsh, repeated chemical disinfection, gas decontamination, and have heat and crack resistance. When considering slip resistant finishes, consider the interaction of the user and the surface. For example, flooring with too large grit may catch or tear at the user's foot protection.

Standard	Explanation	Best Design Practice
28. Carpets and rugs are not permitted. [63, 64]	28. N/A	28. N/A
29. Provide monolithic seamless welded sheet vinyl or troweled-on epoxy floors with integral coved base. Floor must be chemical resistant and impermeable to liquids. [65, 66, 67, 68, 69] • Floors shall have a slip resistant finish.	29. N/A	29. N/A
30. Floors of mechanical rooms and interstitial levels located above biocontainment areas shall be designed to prevent leaks. Penetrations through the floor shall be protected by raised curbs or sleeves. [70, 71]	30. N/A	30. Floors of mechanical rooms and interstitial levels located directly above biocontainment areas should be marked to indicate the location of rooms and utility distribution below where possible.

Base

The base of sealed flooring in an ABSL-3 is intended to isolate the walls from moisture penetration and should be poured with sufficient rise to accomplish this purpose.

Standard	Explanation	Best Design Practice
31. Floors shall be monolithic with an integral coved base 6 inches' minimum height, sealed to the wall finish. [72, 73]	31. N/A	31. N/A

Walls

Walls in an ABSL-3 facility should be built to withstand pressure changes, chemical disinfectants, gas decontamination, and high heat from autoclave exhaust.

Standard	Explanation	Best Design Practice
32. Walls shall be durable, monolithic, and resistant to chemicals and disinfectants. Walls shall be sealed to the base, ceiling, doorframes, cover plates, and all other openings and penetrations. Epoxy paint or panelized composite systems are standard. Wall construction and materials must be selected to ensure compatibility with finish systems, and to provide a smooth, void-free substrate. [74, 75, 76]	32. N/A	32. Corner guards and bumper rails should be provided to protect wall surface in high traffic/impact areas. Wall corners and ceiling junctions shall be detailed to avoid cracks from minor seismic movement.
33. Suite walls must be full height, extending to the structural deck above. [77, 78]	33. N/A	33. N/A

Ceilings

Ceilings in ABSL-3 facilities should be designed to withstand pressure changes, chemical disinfectants, gas decontamination, and high heat from autoclave exhaust. The ceiling is the point in the facility the most vulnerable to sag due to extreme pressure changes.

Standard	Explanation	Best Design Practice
34. Finish monolithic ceiling with a durable moisture resistant substrate such as epoxy paint that is resistant to all chemical and cleaning agents that may be used. [79, 80, 81, 82, 83]	34. Ceilings shall be monolithic, seamless construction. Ceiling systems shall be designed to resist damage from deflection caused by differential air pressure surges that may occur during HVAC fan-failure testing. Ceiling material and support systems shall be designed to be moisture and sag resistant. • Ceilings shall be durable and resistant to moisture, wash-downs and pressurization. Ceilings shall be monolithic, seal to the walls, and with sealed access panel, lights, diffusers, and other ceiling-mounted devices. Epoxy painted gypsum board or panelized composite systems are standard. Gypsum board shall not be standard wallboard, but must be specified and detailed to be appropriately moisture and sag resistant. Acoustical tile celling systems are not acceptable.	34. N/A
35. The ceiling must be high enough over BSCs to allow appropriate duct or thimble connections. Allowances for maintenance access must be included. Clearances must be per NSF49. [84]	35. N/A	35. N/A

Access Panels

Access panels in an ABSL-3 facility should be minimized wherever possible, in line with general reduction of wall penetrations. If required, access panels must be gasket sealed.

Standard	Explanation	Best Design Practice
36. Minimize access panels. Any access panels must be gasketed and latched to allow for room decontamination. Access panels must be piano type hinged. [85, 86]	36. N/A	36. Locate access panels outside the BSL-3 suite and have access restricted.

Finishes

All finished surfaces in the ABSL-3 must be able to withstand pressure changes, chemical disinfectants, gas decontamination, high heat from autoclave exhaust, and should be heat and crack resistant. Seams between surfaces should be minimized and sealed.

Standard	Explanation	Best Design Practice
37. The interior finishes of a ABSL-3 shall form a durable, monolithic, impermeable enclosure. Mock-ups of all finishes shall be provided for review and approval, and as a basis for acceptance of the final installation. The mock-ups shall be constructed in the same conditions and using the same materials and techniques as the final installation. The mock-ups shall include all typical conditions, including sealants, transitions between materials, inside and outside corners. [87, 88, 89]	37. N/A	37. ABSL-3 wall and ceiling finishes, unless factory finished, should have high performance reinforced multi-coat resinous paint finish (reinforced epoxy paint or equivalent). Paint applicators should be Society for Protective Coatings (SSPC) Coating Application Specialist (CAS Level II) Certified, and should be trained and approved by the paint manufacturer. All high performance resinous paint applications should be inspected by an independent third party Coating Inspector Program (CIP) level 3 certified inspector.

38. All finishes in the BSL-3 laboratory shall be chemical resistant and resistant to decontamination agents.	38. N/A	38. N/A

Furniture

Furniture in an ABSL-3 must be high-performance, resilient to chemical and liquid exposure and suitable for frequent decontamination. Consider the estimated life of movable furniture and ease of repair during selection, to account for the logistics of installation, decontamination, and removal.

Standard	Explanation	Best Design Practice
39. Laboratory furniture must be sturdy and capable of supporting anticipated loads and uses. [90]	39. N/A	39. N/A
40. Spaces between benches, cabinets and equipment must be accessible for cleaning. [91, 92]	40. Fixed millwork, casework, and countertops shall either be sealed to walls and floors or positioned with sufficient spacing to facilitate cleaning and minimize harborage of pests.	40. N/A
41. Bench tops must be impervious to water and resistant to heat, organic solvents acids, alkalis, and other chemicals. [60, 61, 62, 93, 94]	41. N/A	41. Bench tops should be epoxy, stainless steel, or phenolic resin.
42. Chairs must be covered with non-porous chemical and decontaminant resistant material. [95]	42. N/A	42. Consider ergonomic needs when choosing chairs. Adhere to any local/UC policy.
43. Shelving standards shall be open fronted or otherwise detailed to allow for full sanitation. Slotted standards with inaccessible concealed areas are not allowed. [96]	43. N/A	43. N/A

44. Cabinets shall be designed without inaccessible areas that cannot be easily sanitized or disinfected. Joints, holes, and anchors shall be sealed. [97]	44. N/A	44. N/A
45. Casework finishes shall be resistant to agents used for decontamination. Stainless steel, phenolic resin, or other corrosion-resistant materials shall be used in damp or corrosive environments. [98]	45. N/A	45. N/A
46. Minimize cabinet space in the BSL-3 laboratory. Movable tables, mobile base units, and cantilevered bench tops shall be used whenever possible. Where fixed casework components must be used, they must be set on monolithic bases to facilitate installation of integral cover flooring base. Void areas behind fixed case work must be sealed to walls. All fixed items must be sealed to the floor, wall, and adjacent items. [99]	46. N/A	46. Provide mobile cabinets or suspended cabinets. If mobile cabinets are installed, provide method for decontaminating casters. Suspended cabinets allow space below the bench to be easily cleaned. Cabinets should have 45° sloped tops or be built up to the ceiling to maintain cleanliness.

Sealing

Penetrations and partitions of the containment barriers must be sealed. Sealant selection, application, inspection and maintenance should be an integral component of regular maintenance of an ABSL-3.

Standard	Explanation	Best Design Practice
47. Refer to NIH DRM Appendix L, Sealant Table for areas to be sealed and sealant type.	47. N/A	47. N/A
48. Doorframes, hinges and latches must be sealed. [100]	48. N/A	48. N/A

49. Ductwork must be sealed where it penetrates the barrier. Supply and exhaust grills must be sealed where it meets barrier surface. [101]	49. N/A	49. N/A
50. All windows in the laboratory must be sealed. [102, 103]	50. N/A	50. N/A
51. All penetrations into and through partitions, floors, and ceilings shall be sealed to enhance sanitation, facilitate gas and vapor decontamination, and resist air infiltration. Piping, ductwork, electrical boxes, and other penetrating items shall be firmly anchored to resist movement that could damage seals. Penetrations shall be visible for inspection and maintenance. [104, 105, 106]	51. N/A	51. N/A
52. Seams between walls, floors, and ceilings and between all dissimilar materials shall be fully sealed. Sealant at movement joints shall be applied after installation of high-performance finishes to resist cracking. [107, 108]	52. N/A	52. N/A
53. Sealant shall be applied in a uniform, smooth, and continuous manner, resulting in a finish free of voids, pinholes, sharp edges, or excess sealant. Sealant must be compatible with all material that comes in contact with it, including other sealant. Sealant must have chemical resistance, flexibility, durability, adherence, and other characteristics appropriate for its use. [109] • Where required, apply sealant before application of fire stopping.	53. N/A	53. N/A

ABSL-3 Architectural References

1. The laboratory is designed, constructed, and maintained to facilitate cleaning, decontamination, and housekeeping. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
2. The interior finishes of an ABSL-3 facility shall form a durable, monolithic, impermeable enclosure. **NIH DRM Section 4.9.5**
3. Clean ability of all surfaces including furniture. **NIH BSL-3 Certification Section I.2.A**
4. Visual inspection of the Architectural features of the laboratory spaces. **ANSI Z9.14 Section 8.3.2**
5. The laboratory is separated from areas that are open to unrestricted traffic flow within the building. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
6. A biocontainment laboratory shall not be accessed from the exterior, but through a lower-risk laboratory area (generally BSL-2) with locks, card readers, and other appropriate security devices. **NIH DRM Section 4.9.2.1**
7. The laboratory is separated from areas which are open to unrestricted traffic flow within the building. **NIH Guidelines Appendix G-II-C-4-a**
8. Access to the laboratory is through two consecutive self-closing doors. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
9. Movement of staff, materials, equipment, and waste in and out of the containment zone requires the use of a directionally pressurized anteroom to provide separation from areas with unrestricted traffic flow. Anterooms shall be designed to accommodate the storage and donning of required PPE. This Passage shall be arranged with two sets of self-closing doors. The anteroom doors shall be interlocks to prevent simultaneous opening of doors between the outside corridor and containment areas. Entrance interlocks, when present, shall be provided with a manual override for use in case of emergency. **NIH DRM Section 2.5.3.5**
10. Visual inspection: Access to the laboratory should be through a series of two self-closing interlocked doors. **ANSI Z9.14 Section 8.3.2**
11. Inspect two self-closing doors. Doors should not open simultaneously. Ensure that doors automatically close and latch. Check function of door interlock systems or facility SOPs as appropriate. Check the distance between entrance door from the anteroom for adequate door operation. Check emergency over-rides of door interlocks. **ANSI Z9.14 Section 8.3.3**
12. Passage through two sets of doors is the basic requirement for entry into the laboratory from access corridors or other contiguous areas. Physical separation of the high containment laboratory from access corridors or other laboratories or activities may be provided by double-door clothes change room (showers may be included), airlock, or other access facility which requires passage through two sets of doors before entering the laboratory. **NIH Guidelines Appendix G-II-C-4-a**
13. Food is stored outside the laboratory area. **BMBL 6th ed. Section IV. Biosafety Level 3.A**
14. Personnel support areas required for the safe conduct of laboratory work shall be provided at appropriate locations. **NIH DRM Section 2.1.3.3**
15. Assess location of BSL-3 laboratories in relation to BSL-2 support laboratories, offices and break rooms, elevators, loading docks, etc. for effects on laboratory pressurization and airflow. **NIH ABSL-3 Certification Section I.3**
16. Appropriate directional airflow between containment support spaces and adjacent areas shall be maintained and verified in accordance with the risk assessment. **ANSI Z9.14 Section 8.4.10**
17. Seams, floors, walls, and ceiling surfaces are sealed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
18. All penetrations into and through partitions, floors, and ceiling shall be sealed to enhance sanitation, facilitate gas and vapor decontamination, and resist air infiltration. Penetrations shall be visible for inspection and maintenance. **NIH DRM Section 4.9.6**
19. Inspect, & Evaluate Architectural Features for Maintenance, Operations (Finishes, penetrations & caulking integrity such as doors, around the ceilings, lighting fixtures, electrical devices, etc. within containment to meet requirements) **NIH BSL-3 Certification Section 1.2**

20. Properly sealed laboratory surfaces are essential to maintain controlled directional airflow and ventilation system performance. Room leakage or tightness is also critical when gaseous fumigants are used for decontamination. **ANSI Z9.14 Section 8.3.2**
21. BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, heavily traveled laboratory areas, and other possible airflow disruptions. **BMBL 6th ed. Section IV. Biosafety Level 3.D.10**
22. Primary containment equipment such as BSCs and individual ventilated caging (IVC) shall be placed in the room so that containment is not impacted by supply diffusers or exhaust grilles or doors or traffic flow. **NIH DRM Section 6.6.1.F**
23. Verify correct placement of biological safety cabinets with respect to supply and exhaust diffusers, doors and traffic patterns. **NIH BSL-3 Certification Section II.26**
24. Verify correct placement of primary containment equipment (fume hoods, BSCs, etc.) with respect to air devices, doors, and traffic patterns. **ANSI Z9.14 Section 8.3.7**
25. Partitions in a biocontainment facility shall be selected to withstand pressurization, impacts and water or moisture. Partition material and detailing shall minimize differential movement. Interior partitions which are part of the secondary barrier shall extend to and be sealed to the underside of the structure. Additionally, partitions shall comply with all physical security requirements as dictated by a threat risk assessment. **NIH DRM Section 4.9.4**
26. Frame partition assemblies shall include gypsum board that is selected and detailed to be appropriately impact and moisture or water resistant. Standard gypsum board is not acceptable. Light-gauge steel studs used for partition framing shall be 18-gauge minimum thickness. **NIH DRM Section 4.9.4**
27. Screw spacing in gypsum wallboard assemblies shall not exceed 152 mm (6 in.). Structural adequacy shall be verified, and additional lateral reinforcement provided if required. All partitions that do not extend to the underside of the structure shall be capped. Concrete masonry units (CMU) walls shall include masonry units utilizing fine sand aggregate or ground face to provide an appropriate substrate for block filler and epoxy paint. Voids in CMU partitions shall be sealed above the ceiling. **NIH DRM Section 4.9.4**
28. A clothing change room (anteroom) may be included in the passageway between the two self-closing doors. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
29. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. These laboratory enhancements may include one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas-tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; containment of other piped services; or advanced access control devices, such as biometrics. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
30. Movement of staff, materials, equipment, and waste in and out of the containment zone requires the use of a directionally pressurized anteroom to provide separation from areas with unrestricted traffic flow. Anterooms shall be designed to accommodate the storage and donning of required PPE. This Passage shall be arranged with two sets of self-closing doors. The anteroom doors shall be interlocks to prevent simultaneous opening of doors between the outside corridor and containment areas. Entrance interlocks, when present, shall be provided with a manual override for use in case of emergency. **NIH DRM Section 2.5.3.5**
31. Anteroom doors are far enough apart that large pieces of equipment can be moved in or out. **ANSI Z9.14 Section 8.4.3**
32. Passage through two sets of doors is the basic requirement for entry into the laboratory from access corridors or other contiguous areas. Physical separation of the high containment laboratory from access corridors or other laboratories or activities may be provided by a double-door clothes change room (showers may be included), airlock, or other access facility which requires passage through two sets of doors

before entering the laboratory. **NIH Guidelines Appendix G-II-C-4-a.**

33. Laboratory doors are lockable in accordance with institutional policies. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
34. A biocontainment laboratory shall not be access from the exterior, but through a lower-risk laboratory area, with locks, card readers, and other appropriate security devices. **NIH DRM Section 4.9.2.1.A**
35. Laboratory doors are kept closed when experiments are in progress. **NIH Guidelines Appendix G-II-C-2-a**
36. Laboratory access is restricted. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
37. The BMBL requires directional airflow into the containment zone through two self-closing doors. **NIH DRM Section 2.5.3.7.E**
38. Access doors to the laboratory or containment module are self-closing. **NIH Guidelines Appendix G-II-C-4-g**
39. Doors shall be stainless steel, fiberglass-reinforced polymer (FRP), epoxy –painted welded steel or another durable material. Frames shall be fully welded, sized for the passage of large equipment, and shall have stainless steel protection plates. Knock-down frames are not permitted. **NIH DRM Section 4.9.3.2**
40. Doors shall be seamless with no top or bottom recesses. Cutouts in doors and frames shall be sealed to enhance sanitation and resist air infiltration. Doors and door hardware shall be free of sharp edges. Door hardware shall be easily operated with PPE. **NIH DRM Section 2.6.2.6**
41. An effective integrated pest management program is implemented. **BMBL 6th ed. Section IV. Biosafety Level 3.A**
42. Door sweeps shall be adjustable to facilitate air movement. **NIH DRM Section 4.9.3.2**
43. Provide stainless steel armor, kick, mop, and stretcher plates on doors based on door location and room use. Center plates horizontally on the door at a width 2 inches less than the door width. Door plates shall maintain UL rating, and must be specified in the door schedule. **NIH DRM Section 4.2.1.6.E**
44. Vision panels shall be in all doors unless prohibited for programmatic reasons. **NIH DRM Section 4.9.3.2**
45. Select Agent Laboratories: Vison panels shall be sealed and rated for fifteen minute forced entry break resistance. **NIH DRM Section 4.2.2.8.D**
46. Laboratory access is restricted. Laboratory doors are lockable in accordance with institutional policies. Access to the laboratory is through two consecutive self-closing doors. A clothing change room and/or an anteroom may be included in the passageway between the two self-closing doors. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
47. Required entrances and exits must be configured in vestibules with interlocking doors and directional airflow to maintain the integrity of the barrier. **NIH DRM Section 2.5.0.2.a**
48. Access to the laboratory should be through a series of two self-closing interlocked doors. **ANSI Z9.14 Section 8.3.2**
49. Doors serving biocontainment laboratories ordinarily swing in the direction of air movement (clean to dirty). **NIH DRM Section 4.2.2.3.A**
50. Pocket doors, bifold doors, and accordion doors are not permitted in HIH biomedical laboratories or animal research facilities. **NIH DRM Section 4.2.1**
51. Manual surface mounted sliding doors may be allowed under the following conditions: Serving rooms which are low hazard and low occupancy. Serving a room with a non-laboratory function. Not required for fire rating or pressurization. **NIH DRM Section 4.2.1**
52. Doors serving locations that require directional airflow shall be configured to allow for sufficient air movement at the undercut to achieve proper operation without excessive pull or closure pressure. **NIH DRM Section 4.9.3.2**
53. All windows in the laboratory are sealed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
54. Operable windows are not permitted in NIH research laboratories and ARFs (animal research facilities). **NIH DRM Section 4.1.4.A**
55. Inspect caulking integrity for non-operable windows. **NIH BSL-3 Certification Section I.2**

56. Inspect: Windows on containment perimeter wall are non-operable and sealed-in-place type construction. **ANSI Z9.14 Section 8.3.2**
57. Windows in the laboratory are closed and sealed. **NIH Guidelines Appendix G-II-C-4-f**
58. All window frames shall be fully welded and sealed. Frames shall be foam filled or otherwise seal to prevent infiltration. When windows are located in the barrier wall, removable glazing stops shall be located on the non-containment side of the barrier. Glazing shall be tempered safety or laminated glass. **NIH DRM Section 2.6.2.7**
59. All interior windowsills shall be sloped, and all windows shall be sealed to ensure ease of cleaning and decontamination. **NIH DRM Section 4.1.4.E**
60. Bench tops are impervious to water and resistant to heat, organic solvents acids, alkalis, and other chemicals. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
61. Bench tops shall be epoxy, stainless steel, or phenolic resin. **NIH DRM Section 4.9.8.E**
62. Bench tops are impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat. **NIH Guidelines Appendix G-II-C-4-c.**
63. Carpets and rugs are not permitted. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
64. Carpeting is not permitted in any area of the laboratory, including office areas that can only be accessed by passing through a laboratory. **NIH DRM Section 4.4.3.2.C**
65. Floors are slip resistant. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
66. Floors are impervious to liquids. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
67. Flooring is seamless, sealed, resilient, or poured floors, with integral coves. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
68. Floors must be resistant to chemicals. **BMBL 6th ed. Section IV. Biosafety Level 3.D.4**
69. Floors shall be durable, slip-resistant and resistant to degradation from chemicals, disinfectants, and decontaminants. Floors shall be monolithic with an integral coved base 6 in. minimum height, sealed to the wall finish. The floor shall extend under all equipment and casework. Heat-welded sheet vinyl is most typically used in ABSL-3 laboratories, and epoxy is standard where high durability or load capacity is required. **NIH DRM Section 4.9.5.1**
70. Floors of mechanical rooms and interstitial levels located above biocontainment areas shall be designed to prevent leaks. Penetrations through the floor shall be protected by raised curbs or sleeves. **NIH DRM Section 4.9.5.1**
71. Floors of mechanical rooms and interstitial levels located directly above biocontainment areas shall be marked to indicate the location of rooms and utility distribution below where possible. **NIH DRM Section 4.9.5.1**
72. Consideration should be given to the installation of seamless, sealed, resilient, or poured floors, with integral coves. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
73. Floors shall be monolithic with an integral coved base 6 inches minimum height, sealed to the wall finish. **NIH DRM Section 4.9.5.1**
74. Walls should be constructed to produce a sealed smooth finish that can be easily cleaned and decontaminated. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
75. Walls shall be durable, monolithic, and resistant to chemicals and disinfectants. Walls shall be sealed to the base, ceiling, door frames, cover plates, and all other openings and penetrations. Epoxy paint or panelized composite systems are standard. Wall construction and materials must be selected to ensure compatibility with finish systems, and to provide a smooth, void-free substrate. **NIH DRM Section 4.9.5.2**
76. The integrity of all surfaces, penetrations, and seals on the containment perimeter shall be visually inspected. **ANSI Z9.14 Section 8.3.2**
77. Interior partitions which are part of the secondary barrier shall extend to and be sealed to the underside of the structure. **NIH DRM Section**

4.9.4

78. Wall finishes shall be protected from impact and wear utilizing corner guards, crash rails, FRP panels or other methods in vulnerable areas. **NIH DRM Section 4.9.5.2**
79. Walls and ceilings are constructed to produce a sealed smooth finish that can be easily cleaned and decontaminated. **BMBL 6th ed. Section IV. Biosafety Level 3.D.4.e**
80. Ceilings shall be monolithic, seamless construction. Ceiling systems shall be designed to resist damage from deflection caused by differential air pressure surges that may occur during HVAC fan-failure testing. Ceiling material and support systems shall be designed to be moisture and sag resistant. **NIH DRM Section 2.6.2.4**
81. Ceilings shall be durable and resistant to moisture, wash-downs and pressurization. Ceilings shall be monolithic, seal to the walls, and with sealed access panel. Lights, diffusers, and other ceiling-mounted devices. Epoxy painted gypsum board or panelized composite systems are standard. Gypsum board shall not be standard wall board but must be specified and detailed to be appropriately moisture and sag resistant. Acoustical tile celling systems are not acceptable. **NIH DRM Section 4.9.5.3**
82. Verify structural capability of wall and ceiling systems prior to determining leak test pressures. **ANSI Z9.14 Section 8.4.8.2**
83. The interior surfaces of walls, floors, and ceilings are water resistant so that they can be easily cleaned. Penetrations in these surfaces are sealed or capable of being sealed to facilitate decontaminating the area. **NIH Guidelines Appendix G-II-C-4-b**
84. Ceiling height to be coordinated with cabinet requirements to ensure proper airflow and containment within the cabinet. **NIH DRM Section 4.6.1.11.A.8**
85. All utility systems shall be configured to minimize the need for access panels within the containment barrier. **NIH DRM Section 4.9.7**
86. Access panel frames shall be sealed to the wall or ceiling, and fitted with a continuous, gastight door gasket. Panel design shall ensure compression of the gasket around the entire panel door perimeter without discontinuity at the hinge or latch when in the latched position. Access door assemblies shall be stainless steel or another non-coated, corrosion-resistant material. **NIH DRM Section 4.9.7**
87. The interior finishes of an ABSL-3 shall form a durable, monolithic, impermeable enclosure. Mock-ups of all finishes shall be provided for review and approval, and as a basis for acceptance of the final installation. The mock-ups shall be constructed in the same conditions and using the same materials and techniques as the final installation. The mock-ups shall include all typical conditions, including sealants, transitions between materials, inside and outside corners. **NIH DRM Section 4.9.5**
88. ABSL-3 wall and ceiling finishes, unless factory finished, shall have high performance reinforced multi-coat resinous paint finish (reinforced epoxy paint or equivalent). Paint applicators shall be Society for Protective Coatings (SSPC) Coating Application Specialist (CAS Level II) Certified and must be trained and approved by the paint manufacturer. All high-performance resinous paint applications must be inspected by an independent third-party Coating Inspector Program (CIP) level 3 certified inspector. **NIH DRM Section 4.9.5**
89. Inspect and evaluate finishes. **NIH ABSL-3 Certification Section I.2**
90. Laboratory furniture can be capable of support anticipated loads and uses. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
91. Spaces between benches, cabinets, and equipment must be accessible for cleaning. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
92. Fixed millwork, casework, and countertops shall either be sealed to walls and floors or positioned with sufficient spacing to facilitate cleaning and minimize harborage of pests. **NIH DRM Section 4.5.1.4**
93. Bench tops must be impervious to water and resistant to heat, organic solvents acids, alkalis, and other chemicals. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
94. Bench tops shall be epoxy, stainless steel, or phenolic resin. **NIH DRM Section 4.9.8.E**
95. Chairs used in laboratory work are covered with a non-porous material that can be easily cleaned and decontaminated with appropriate

disinfectant. **BMBL 6th ed. Section IV. Biosafety Level 3.D**

96. Shelving standards shall be open fronted or otherwise detailed to allow for full sanitation. Slotted standards with inaccessible concealed areas are not allowed. **NIH DRM Section 4.9.8.A**
97. Cabinets shall be designed without inaccessible areas that cannot be easily sanitized or disinfected. Joints, holes, and anchors shall be sealed. **NIH DRM Section 4.9.8.B**
98. Casework finishes shall be resistant to agents used for decontamination. Stainless steel, phenolic resin, or other corrosion-resistant materials shall be used in damp or corrosive environments. **NIH DRM Section 4.9.8.F**
99. Movable tables, mobile base units, and cantilevered bench tops shall be used whenever possible. Where fixed casework components must be used, they shall be set on monolithic bases to facilitate installation of integral cover flooring base. Void areas behind fixed case work shall be sealed to walls. All items shall have smooth corners and edges and be free of open joints and voids. All fixed items shall be sealed to the floor, wall, and adjacent items. Welded stainless steel is standard in ABSL-3 laboratories where moisture or frequent cleaning is required. **NIH DRM Section 4.9.8**
100. Spaces around doors and ventilation openings are capable of being sealed to facilitate space decontamination. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
101. Spaces around and ventilation openings are capable of being sealed to facilitate space decontamination **BMBL 6th ed. Section IV. Biosafety Level 3.D**
102. All windows in the laboratory are sealed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
103. Window frames shall be fully welded and sealed. Frames shall be foam filled or otherwise sealed to prevent infiltration. When windows are located in the barrier wall, removable glazing stops shall be located on the non-containment side of the barrier. Glazing shall be tempered safety or laminated glass. **NIH DRM Section 2.6.2.7**
104. Seams, floors, walls, and ceilings surfaces are sealed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
105. All penetrations into and through partitions, floors, and ceilings shall be sealed to enhance sanitation, facilitate gas and vapor decontamination, and resist air infiltration. Piping, ductwork, electrical boxes, and other penetrating items shall be firmly anchored to resist movement that could damage seals. Penetrations shall be visible for inspection and maintenance. **NIH DRM Section 4.9.6**
106. Visual Inspection: Continuous seal between ductwork and room exhaust grille. Verify during initial installation and maintain written/photo documentation for records. **ANSI Z9.14 Section 8.3.4**
107. Seams, floors, walls, and ceiling surfaces should be sealed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
108. Seams between walls, floors, and ceilings and between all dissimilar materials shall be fully sealed. Sealant at movement joints shall be applied after installation of high-performance finishes to resist cracking. **NIH DRM Section 4.9.6**
109. Sealant shall be applied in a uniform, smooth, and continuous manner, resulting in a finish free of voids, pinholes, sharp edges, or excess sealant. Sealant must be compatible with all material that it is in contact with, including other sealant. Sealant must have chemical resistance, flexibility, durability, adherence, and other characteristics appropriate for its use. **NIH DRM Section 4.9.6**

Heating, Ventilation & Air Conditioning

HVAC systems serve core containment functions for ABSL-3 facilities. Systems must provide robust, directional single-pass airflow with HEPA-filtered exhaust. Design considerations must include redundancy, as well as the capability for isolation.

Standard	Explanation	Best Design Practice
1. The laboratory must be designed for ease of maintenance, so that access to critical mechanical equipment is outside containment. [1, 2]	1. N/A	1. Equipment should be accessible for maintenance, repairs and annual verification. • Shutoff valves should be in non-containment spaces. • Mechanical HVAC spaces should be on full size interstitial space/ floor.
2. An ABSL-3 environment must have a minimum of 10 air changes per hourABSL-3.[3,4]	2. The air change rate will be determined by the largest of the following; internal heat gain (cooling load), exhausted equipment (fume hood, glove-box, etc.), or minimum according to this standard.	2. 10-15 air changes per hour. The range of daily temperature fluctuations should be kept to a minimum (+/-2F), and relative humidity should also be controlled (30%-70%) Consult the “Guide for the Care and Use of Laboratory Animals” for appropriate temperature and humidity settings based on species.
3. An ABSL-3 environment must have supply/exhaust fan interlock (communication). [5, 6, 7, 8]	3. Having supply/exhaust interlock will prevent/ minimize airflow reversal in case of exhaust fan(s) failure and prevent/minimize vivarium from going too deep negative during supply fan(s) failure. Physical or soft interlock is acceptable. Interlock monitored by BMS to ensure	3. Consider redundancy by providing both Software and Hardware Interlocks

	maintenance of proper air balance.	
4. Gas tight damper and/or low leakage airflow control valves are required to facilitate isolation of individual laboratory rooms/space based on agent summary statement, risk assessment, or applicable local, state or federal regulations. [9, 10]	4. Gas tight isolation dampers or low leakage airflow control valves allow the facility or laboratory room to become isolated from the rest of the HVAC system without affecting other areas. This feature can be used when performing area decontamination of the room or facility or when removing a large piece of equipment.	4. On supply and exhaust systems (see DRM reference).
5. The A/E shall utilize the latest edition of the following energy codes and standards to design the exterior envelope and select HVAC systems, domestic water heating, electrical distribution and illuminating systems - ASHRAE Standard 90.1, Energy Policy Act 2005, and International Energy Conservation Code. [11]	5. Adherence to the latest version of energy codes will ensure compliance with local, state and federal requirements. • Include local and UC standards	5. Thermostatic controls for each holding space are ideal. Use of zonal control for multiple spaces is discouraged. Provide each space with a dedicated reheat coil. Valves controlling reheat should fail in the closed position, and steam coils should be avoided or equipped with a high-temperature cut-off system to prevent overheating (Guide, 8th ed. p.140).
6. Provide a ducted dedicated, single pass exhaust ventilation system. The exhaust fan system shall be redundant (N+1 minimum) and provide directional airflow, from least hazardous area to most potentially hazardous. [12, 13, 14, 15, 16] • The vivarium exhaust air must not re-circulate to any other area of the building. [30, 31, 32, 33] For BSL-3/ABSL-3 shared facility,	6.	6. Dedicated ventilation system (supply and exhaust) will allow a faster response of the management system by being able to isolate ABSL-3 facility without affecting the rest of the building.

negative directional airflow must be maintained such that ABSL-3 locations are the most negative		
7. Under normal operations, system shall provide directional airflow and shall be exhausted to outside. [17, 18, 19, 20]	7. Maintaining directional airflow from low hazard to high hazard will minimize cross-contamination of spaces. Air shall not be recirculated.	7. N/A
8. 100 CFM doorway infiltration.	8. 100 CFM will maintain an average pressure difference of ~ -0.05 in.w.g. Differential pressure range of -0.04 to -0.15 in.w.g. shall be maintained between each pressure zone. In the event that multiple containment zones exist within a laboratory or laboratory suite, sequentially more negative pressure differentials must be established so that the more contaminated spaces are maintained at a negative pressure with respect to less contaminated areas. • Smoke test to verify directional airflow	8. N/A
9. A N+1 exhaust redundancy is required for High-Containment animal rooms. Capacity and size of the make-up air system serving containment devices/equipment shall correspond to 100% of the programmed containment devices/equipment plus future capacity as defined by the campus personnel. [21, 22]	9. The air-handling unit must provide enough capacity for future upgrades. Capacity of the cooling system shall include the program cooling demand plus an allowance for future expansion of internal heat gain requirements as defined by the campus personnel.	9. A dedicated air handing system is highly recommended. Consider designs with multiple fans, isolation dampers and controls may be designed to satisfy the N+1 requirements. Considerations should be made for design of the HVAC system with regard to constant volume or variable volume.

10. Provide 100% outdoor air supplied to the ABSL-3 laboratory that is then exhausted directly. [23]	10. Providing outside air will minimize cross-contamination between spaces.	10. Provide dedicated supply (air handling unit and ductwork).
11. Provide digital monitor or analog magnehelic gauge at each door leading to a new pressure zone. [24, 25, 26] • "Ball-In-tube" units are not acceptable	11. Pressure monitor must allow laboratory personnel to verify that laboratory is under negative pressure. Alarm shall report to appropriate personnel and Facilities.	11. N/A
12. Provide audible and visual alarms to notify personnel of air flow disruption. [27, 28] **NOTE**: For animal housing rooms, alarm should be visual ONLY.	12. Local alarms shall notify laboratory personnel of issues with the facility.	12. Alarm should report to Facilities personnel and Building Management System (BMS) after the appropriate alarm delay set point.
13. A ABSL-3 environment shall have air pressure differential of -.05" in.w.g. at each barrier door and laboratory.[29]	13. Having a differential pressure of -0.05 in.w.g. provides the containment of pathogens in the case of a release outside the BSC	13. N/A
14. Exhaust air must be HEPA filtered. The Laboratory building exhaust air should be dispersed away from occupied areas and from building air intake locations. [34, 35, 41, 42, 43]	14. HEPA filter sterilizes the air before it is discharged into the environment • Consider other regulatory requirements when volatile chemicals and radioactive materials will be used in B2 cabinets.	14. Air handling intake locations should avoid entrainment of fumes from vehicles, equipment, and system exhaust.
15. Exhaust air systems shall be arranged with single fans or multiple manifolded fans designed to achieve N+1 redundancy and maintain the exhaust air system fully operational, at all times. Each fan shall be designed to	15. N+1 configuration provides redundancy in the system in case of a failure.	15. N/A

be capable of being fully isolated while the overall system remains fully operational. [37, 42]		
16. Provide a dedicated exhaust system with double HEPA filters in series for a Class III BSC. [37,38]	16. Class III BSC are commonly used for aerosol procedures involving biological materials with hazardous chemicals or radioactive materials.	16. N/A
17. Exhaust hoods on the "dirty" side of double door autoclaves shall be connected to the BSL-3 exhaust air system. [39]	17. Connecting exhaust hood to ABSL-3 exhaust system will minimize contamination of non-containment areas in case of failure.	17. N/A
18. HEPA filter housings shall have gas-tight isolation dampers, decontamination ports, and/or bag-in/bag-out (with appropriate decontamination procedures) capability. [46, 47]	18. This allows for HEPA filter housing decontamination before any repairs and/or maintenance is required. • Isolation dampers, decontamination ports and bag in-bag out should be located in areas that are easily accessible with enough room for maintenance/filter change-outs. • HEPA filter housing shall be welded stainless steel construction. • Each HEPA filter shall be capable of in situ decontamination and full face filter scanning.	18. N/A
19. The HEPA filter housing shall allow for leak testing of each filter and assembly. [46, 47, 48]	19. HEPA filters must be checked for leaks on an annual basis.	19. N/A

HVAC References

1. Laboratory is designed, constructed, and maintained to facilitate cleaning, decontamination, and housekeeping. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
2. The interior of walls, floors and ceilings are water resistant so that they can be easily cleaned. **NIH Guidelines Appendix G-II-C-4-b**
3. Ventilation rates in animal facilities are typically 10 to 15 outdoor-air changes per hour (ACH). NIH DRM Section 6.6.4
4. Table 1. Airborne contamination removal and air change rates. **CDC Infection Control. Environmental Infection Control Guidelines. Part IV appendix**
5. A ABSL-3 environment shall have: Supply/Exhaust fan interlock. **NIH DRM Section 7.7.1.B**
6. Ensure that interlock between supply and exhaust is operational. **NIH BSL-3 Certification Section II.6**
7. Verify Control Systems/Fail Safe Operation **ANSI Z9.14 Section 8.3.9**
8. The air handling system shall be designed such that under failure conditions, the airflow will not be reversed and periodic verification. **NIH DNA Guidelines Appendix G-II-C-4-i**
9. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. These laboratory enhancements may include one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas-tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; containment of other piped services; or advanced access control devices, such as biometrics. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
10. Bubble-tight isolation damper shall be provided between the room supply air terminal, the room supply air diffuser, and between the room exhaust grille and room exhaust air terminal. **NIH DMR Section 6.6.9.B**
11. The A/E shall utilize the latest edition of the following energy codes and standards to design the exterior envelope and select HVAC systems, domestic water heating, electrical distribution and illuminating systems - ASHRAE Standard 90.1, Energy Policy Act 2005, and International Energy Conservation Code. **NIH DRM Section 6.1.23.B**
12. A ducted mechanical air ventilation system is required. This system provides sustained directional airflow by drawing air into the laboratory from "clean" areas toward "potentially contaminated" areas. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
13. A BSL-3 environment shall have single pass air directional airflow. **NIH DRM Section 2.5.3.7.E, 6.6.7**
14. Ensure single pass airflow. Directional airflow must be established from clean areas into contaminated areas. In the event that multiple containment zones exist within a laboratory or laboratory suite, sequentially more negative pressure differentials must be established so that the more contaminated spaces are maintained at a negative pressure with respect to less contaminated areas. **NIH BSL-3 Certification Section II.14**
15. The directional airflow shall be verified in normal and failure modes as well as equipment such as BSC's, fume hoods, filtration systems, etc. connected to the ventilation system. **ANSI Z9.14 Section 8.4.1, 8.4.2**
16. A ducted exhaust air ventilation system is provided. The system creates directional airflow that draws air into the laboratory from uncontaminated spaces surrounding the laboratory. **NIH Guidelines Appendix G-II-C-4-i**
17. The laboratory exhaust air is not re-circulated to any other area in the building. **BMBL 6th ed. Appendix A Section VI. Building Exhaust**
18. A BSL-3 environment shall have a supply system independent and separate from the remainder of the building. **NIH DRM Section 6.1.8.1**

19. BSL-3 laboratory spaces shall be provided with dedicated supply air systems, which do not serve any other laboratory spaces outside the containment laboratory. **NIH DRM Section 6.6.2.A**
20. Minimal acceptable conditions for ventilation system performance in BSL-3 facilities include: 1) during normal facility operations, the maintenance of air movement from areas that are not contaminated by any biological hazards towards areas that may be progressively more contaminated inside the laboratory. **ANSI Z9.14 Section 5.2**
21. Air-handling units (AHU) shall be designed to provide N+1 reliability and maintain 100% capacity in the event of a lead component failure. Multiple parallel air-handling units shall be provided to operate simultaneously to meet full load conditions. Each AHU and its related components shall be capable of total isolation by the use of isolation dampers located upstream and downstream of each air-handling unit. **NIH DRM Section 6.1.8.1.B, 6.6.9.A**
22. Capacity and size of the make-up air system to serve containment devices/equipment shall correspond to 120% of the programmed containment devices/equipment. Capacity of the cooling system shall include the program cooling demand plus an allowance for 20% future expansion of internal heat gain requirements. **NIH DRM Section 6.2.1**
23. Use of 100% outdoor air to provide all the room air to be exhausted through laboratory spaces and laboratory containment equipment; (2) Size the exhaust air system to handle the simultaneous operation of all laboratory spaces and all laboratory containment equipment, and (3) Directing airflow from low hazard areas to high hazard areas at all times. Air supplied to the corridor and adjacent clean spaces shall be exhausted through the laboratory to achieve effective negative pressurization. **NIH DRM Section 6.1.13.1.A**
24. A visual monitoring device that confirms directional airflow is provided at the laboratory entry. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
25. A BSL-3 environment shall have pressure differential monitors. **NIH DRM Section 7.7.1.B, 7.7.2.D**
26. Visual Inspection: A means for users to verify airflow direction should be present. Monitor should be provided, both at the outer entry of the BSL-3 suite and at interior doors, based on the risk assessment. **ANSI Z9.14 Section 8.3.3**
27. Audible alarms to notify personnel of airflow disruption are considered. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
28. The BAS shall provide differential pressure monitors on classified spaces to indicate the room differential pressure and shall alarm when the pressure goes beyond adjustable thresholds and time durations. **NIH DRM Section 13.9.4**
29. A BSL-3 environment shall have air pressure differential of -0.05" w.g. at each barrier door and laboratory. **NIH DRM Section 6.1.15.C**
30. The laboratory exhaust air is not re-circulated to any other area in the building. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
31. Laboratory and animal facility air shall not be recirculated to another space or facility to prevent migration of chemical fumes or airborne pathogens and prevent cross-contamination between spaces. **NIH DRM Section 6.1.8**
32. Visual inspection of the exhaust air systems including exhaust stack location and discharge velocities, code distance from exhaust stack and air intakes operable windows, etc., the exhaust stack height, the presence and operation of the interlock between the supply and exhaust, and the exhaust air filtration. **ANSI Z9.14 Section 8.3.4**
33. The exhaust air is not recirculated to any other area of the building, is discharged outside, and is dispersed away from the occupied areas and air intakes. **NIH Guidelines Appendix G-II-C-4-i**
34. The laboratory exhaust air is dispersed away from occupied areas and from building air intake locations or the exhaust air is HEPA filtered. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
35. Construction documents shall include the design of exhaust stack height and discharge air velocity characteristics to overcome the building cavity boundary and avoid re-entrainment of exhaust. Stacks shall be shown as part of the architectural design and the design rationale shall be described in the early design reports. In general, exhaust stacks shall be designed to meet the following requirements - discharge shall be a minimum of 3 m (10 ft.) above the roofline and any roof element within a horizontal distance of a 4 m (13 ft.) radius,

upward velocity shall be a minimum of 15 m/s (3,000 fpm) at the point of discharge. Reentry calculations may dictate higher discharge velocities, safety concerns shall always take precedence over aesthetics, and manifolds for multiple exhaust fans shall have separate exhaust stacks for each fan to avoid having positive pressure ductwork on the discharge side of fans not operating. **NIH DRM Section 6.2.3.C**

36. Exhaust air systems shall be arranged with multiple manifolded fans designed to achieve N+1 redundancy and maintain the exhaust air system fully operational, at all times. Each manifolded fan shall be designed to be fully isolated while the overall system remains fully operational. In the case of single fan systems, in addition to the main fan, a standby fan shall be provided. The A/E shall review redundancy requirements for each particular system with the program user and the NIH/DOHS. **NIH DRM Section 6.1.22.2**
37. Ducted BSCs (Type B) shall be exhausted by dedicated system, which shall be controlled by the BAS. **NIH DRM Section 7.5.15.A**
38. A Class III BSC contains: A HEPA filter on the supply air intake and two HEPA filters in series on the exhaust outlet of the unit. **BMBL 6th ed. Section IV. Biosafety Level 4.C**
39. Exhaust hoods on the "dirty" side of pass-through autoclaves are connected to the BSL-3 exhaust air system. **NIH DRM Section 4.9.10**
40. A BSL-3 environment shall have: Redundant exhaust fans (N+1). **NIH DRM Section 6.6.1.D**
41. The laboratory exhaust air is dispersed away from occupied areas and from building air intake locations or the exhaust air is HEPA filtered. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
42. Exhaust air HEPA filtration is recommended to eliminate the possibility of re-entrainment of ABSL-3 exhaust air into the intake air and to filter highly infectious agents and pathogens that may cause risk to the environment. **NIH DRM Section 6.6.8.B**
43. The exhaust air is not recirculated to any other area of the building, is discharged outside, and is dispersed away from the occupied areas and air intakes. **NIH Guidelines Appendix G-II-C-4-i**
44. When present, HEPA filter housings have gas-tight isolation dampers, decontamination ports, and/or bag-in/bag-out (with appropriate decontamination procedures) capability. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
45. HEPA filter housing shall be welded stainless steel construction. Each HEPA filter shall be capable of in situ decontamination and full-face scanning. **NIH DRM Section 6.6.8.D**
46. The HEPA filter housings allow for leak testing of each filter and assembly. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
47. The housing shall be accessible, and space provided for filter change-outs. **NIH DRM Section 6.6.8.D**
48. HEPA filter installations shall be visually inspected. HEPA filtration shall be tested at least annually. **ANSI Z9.14 Section 8.3.4**

Electrical

Electrical systems should be designed so as to provide sufficient amperage for constant electrical sources (e.g. lighting) and outlets needed for equipment and systems. Wherever feasible, consider dedicated circuits. Design considerations should include the option for expansion based on changing facility needs.

It should also provide backup power for critical infrastructure required to maintain containment and to prevent critical loss. Examples include HVAC systems, containment-specific equipment such as biosafety cabinets, freezers, incubators, auxiliary equipment, building management, and security and A/V systems. Critical infrastructure and equipment not identified in this standard should be evaluated on a case-by-case basis to determine if emergency power is required.

Standard	Explanation	Best Design Practice
1. All electrical penetrations shall be sealed airtight internally at the containment boundary. [1, 2, 3, 4] • Refer to NIH DRM for areas to be sealed and sealant type.	1. Sealed penetrations are required for decontamination and directional airflow • J box is sealed and in wet areas consider using a gasketed outlet cover	1. N/A
2. Electrical faceplates and devices shall be able to withstand routine decontamination, as well as, after spills, splashes, or other potential contamination. [5, 6, 7, 8, 9] • Use of foam and rubber shall be minimized. Open-cell foam is not acceptable. • Wall-mounted electrical receptacles and switches and ceiling-mounted receptacles shall be hinged, self-closing, weatherproof and stainless steel SS-316 with rounded edge cover plates with neoprene closed-cell gasket material for all wall devices.	2. ABSL-3 laboratories must be able to be area decontaminated without affecting the electrical components	2. Utilize stainless steel cover plates for switches and receptacles in rooms that will utilize vaporized paraformaldehyde or chlorine dioxide gaseous decontamination protocols. • Based on decontamination methods, consider providing electric relays for control of power outlets for disinfecting agent generation equipment, mixing equipment, and neutralizing agent generation equipment (if required by disinfecting agent), to be controlled from outside the room(s). Provide power to de-

		humidification equipment if required by disinfection agent protocol.
3. Conduits for all systems - Conduit applications in ABSL-3 facilities are as follows: [10, 11] • Conduit type: use rigid galvanized steel (RGS) conduit with threaded fittings in all ABSL-3 areas • Seal-off: provide seal-off fittings when conduits exit defined ABSL-3 perimeter • SMR: use of surface metal raceway systems (SMRs) is not allowed in ABSL-3 areas	3. Threaded rigid conduit with sealed penetrations at containment barrier provides a long term and durable pathway that meets the airtight containment requirement.	3. N/A
4. ABSL-3 facilities - 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. [12, 13, 14, 15] • All ABSL-3 equipment and controls on backup power shall be supplied backup power through a closed transition transfer switch. BAS controllers and BSCs shall have uninterruptible power supply (UPS) with a run time of at least 120 seconds • UPS shall be installed such that it is easy to monitor and replace on a regular basis. Backup power to the laboratory and associated systems	4. ABSL-3 laboratories shall have emergency power for critical components. UPS shall be provided for primary containment devices such as biosafety cabinets.	4. Emergency Generator - Provide a local generator or equivalent standby power dedicated to the facility to provide emergency/standby power. Consider providing 100% generator backup.

shall be on dedicated circuits from the generator. • All HVAC equipment must be capable of auto-restart after a power failure.		
5. Provide emergency power for the following essential equipment: [16, 17] 1. HVAC 2. Alarms 3. Emergency lighting 4. BSCs 5. Freezers 6. Incubators 7. Animal cage racks • During the design phase, review equipment with facility users to determine emergency power backup needs.	5. Emergency Power shall connect the following loads to the standby electrical systems: • Heating and cooling units provided for critical support function • Receptacles serving selected equipment identified as critical by the program • General lighting in laboratories • Critical control and containment equipment compressed air system	5. As determined per program basis, recommend connecting the following loads to the standby electrical system: • Sterilizers • Cage wash equipment for remote locations • Other loads as required by the program based on risk assessment
6. The emergency power system shall be designed to meet applicable codes and standards. [18, 19, 20]	6. Emergency electrical service size shall be adequate to meet the current and future emergency electrical demand, and applicable codes and standards	6. N/A
7. Life safety loads shall be wired separately from normal powered, legally required and optional standby loads. [21]	7. Life Safety Loads may include all or some of the following: • Emergency egress lighting • Egress signage • Communications systems (including PA systems • Fire alarm and mass notification systems • Self-contained battery-powered lighting at generator set location • Fire-suppression systems (fire	7. N/A

	pumps, jockey pumps, compressors, valves, etc.)	
8. Provide UPS power to all alarms and electronic key access systems. During the design phase, review with facility user's additional equipment that may require UPS power backup. [22, 23, 24] • Biological Safety Cabinets, refrigerators and freezers should be on individual circuits	8. A central UPS system or a number of local UPSs may be required to backup all building wide low voltage systems that are essential for containment operation, safe shutdown of the facility and for critical ABSL-3 specific loads.	8. N/A
9. J boxes shall be cast and/or sealed airtight. [25, 26, 27]	9. Provide cast boxes with external mounting provisions, external hub, and gasketed device cover plates • Sealing: Provide a 25 mm (1 in.) barrier of silicone caulk around the wire within a device box hub. Provide a continuous bead of caulk between the device box and the adjacent surface. Provide a continuous bead of caulk around the device cover plate and the adjacent surface.	9. Consider double gang J boxes • Type and Depth: All boxes should be double gang type; the box depth should be at least the next larger than minimum size required per code.
10. Panel boards must be located outside the contained space. Circuit breakers must be labeled. [28]	10. Electrical equipment that requires service shall not be installed within a containment area.	10. N/A
11. Provide GFCI outlets at sinks for electrically operated pre-mixing valves.	11. N/A	11. N/A
12. Power Wiring Insulation shall be compatible with sealing compound (sealing compound non-deleterious to	12. Verify that manufacturers wiring jacketing is chemically compatible with sealing compounds.	12. N/A

insulation), using THW, THWN, THHN/THWN, or XHHW, with minimum size #12 wire, except #10 wire for special purpose receptacles. The A/E shall coordinate requirements for security wiring, on a per project basis with Facilities and EH&S. [29, 30, 31]		
13. The electrical equipment shall mirror the N+1 configuration of the critical mechanical systems. Where redundant mechanical system components are provided, the electrical system shall be designed to limit the impact of the loss of a single electrical component. (e.g. if 2 fans are provided in a N+1 configuration, each fan should be provided from a separate distribution panels so that the N units of the equipment can continue to operate during failure of any single electrical system component.)[32]	13. The separate distribution panels shall be powered from separate transfer switches. The A/E shall evaluate and minimize single points of failure for all projects.	13. N/A
14. Confirm electrical infrastructure minimum requirements for reliability and redundancy with approving authorities. [33]	14. Redundant electrical services eliminate single points of failure and correspond to critical mechanical system redundancies. Coordinate with campus and utility provider for service infrastructure for high reliability. Review with grant officers, principal investigators, facility operations and authorities having jurisdiction to confirm requirements. • Downstream distribution for BSL-3	14. N/A

	projects from switchgear for critical areas, such as mechanical support rooms with redundant motors in each set, shall consist of pairs of distribution switchboards/ panel boards, each fed from a separate side of the switchgear, to supply approximately half of each set of motors. This would include supplying packaged units with multiple motors with separate feeders for each motor, where possible.	
15. Wall penetrations shall be prepared and sleeved. Wall penetrations through fire rated walls shall be avoided. Where necessary, penetrations shall be in accordance with NFPA and NIH regulations. All fire-rated features of the contract design must be approved by Fire Marshal. [34]	15. Submission and Mock-up - Penetrations into the containment barrier (including mounting of electrical boxes) shall be detailed in the construction documents and require mock-ups to be constructed and tested prior to installation. Penetration details for equipment shall be coordinated with the equipment manufacturer.	15. N/A
16. Provide gasketed, sealed, weather tight surface mounted light fixtures. [34]	16. N/A	16. N/A
17. The BSL-3 lighting systems shall be designed to ensure biohazards are contained within the area. Lighting fixtures shall be easily opened to permit full decontamination. [36, 37]	17. N/A	17. Consider installation of sealed fixtures that can be accessed from the interstitial/mechanical space above the lab for changing light bulbs.
18. Provide emergency lighting in each room of the BSL-3 suite. [38]	18. Emergency lighting installation shall comply with the following requirements:	18. N/A

	• Connect at least 50% of lighting fixtures in the laboratories to the emergency power source. • Provide at least one lighting fixture per room in laboratory areas with self-testing emergency battery ballast. Connect the lighting fixtures with emergency ballasts to unswitched local emergency generator circuits. • • ABSL-3 areas: In addition to the above requirements, battery ballasts shall not be self-testing type.	
19. Lighting levels must be sufficient for tasks.	19. N/A	19. N/A
20. Conventional light switching (voltage toggle) is acceptable. [39]	20. Occupancy sensors may be used in laboratory support and other areas, but not in containment spaces where BSCs are to be located. In addition, specialized lighting controls (such as dimming systems and DC lighting controls) shall be provided per specific program requirements.	20. N/A
21. In ABSL-3 animal holding area, provide a programmable diurnal lighting cycle, which typically provides 12 hours “on” cycle and 12 hours “off” cycle, allowing adjustment of either cycle duration or providing for multiple cycles in a single	21. Programmable diurnal lighting cycle shall: • be programmable, using either the BAS or a stand-alone system, depending on functional needs and	

day at user discretion.

which control method is most cost-effective.

- provide a terminal for user control and adjustment of lighting cycles.
- be provided with necessary integral battery backup (e.g., UPS, etc.)

- provide a local override switch that shall circumvent the programmable lighting panel controls for diurnal cycling to turn lights to “on” cycle for user adjustable period, and then revert back to its normal previously programmed diurnal cycle.

Electrical References

1. The laboratory is designed, constructed, and maintained to facilitate cleaning, decontamination, and housekeeping. Seams, floors, walls, and ceiling surfaces are sealed. Spaces around doors and ventilation openings are capable of being sealed to facilitate space decontamination. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
2. All penetrations shall be durable, sealed, and tested to meet room tightness criteria for ABSL-3 laboratories. **NIH DRM Section 10.8.2.A.2**
3. Inspect and Evaluate – Finishes, penetrations & caulking integrity for architectural elements such as doors, around the ceilings, lighting fixtures, electrical devices, etc. within containment to meet requirements for: Sealed seams and penetrations. **NIH BSL-3 Certification Section I.2**
4. Visual inspection – The integrity of all surfaces, penetrations, and seals on the containment perimeter shall be visually inspected. **ANSI Z9.14 Section 8.3.2**
5. Laboratory equipment is routinely decontaminated after spills, splashes, or other potential contamination, and before repair, maintenance, or removal from the laboratory. **BMBL 6th ed. Section IV. Biosafety Level 3.A**
6. All surface finishes shall be selected to be compatible with the anticipated agents and methods used for cleaning, disinfection, or sterilization and protocols used by program without damage or degradation, including discoloration. **NIH DRM Section 4.4.5**
7. Cover plates for building interior receptacles, switches, and boxes shall be stainless steel, brushed aluminum, or hospital-grade impact resistant nylon. Cover plates for cast boxes shall be gasketed and weatherproof. **NIH DRM Section 10.5.3.8**
8. Provide weatherproof covers for receptacles and switches where they are exposed to water. Utilize stainless steel cover plates for switches and receptacles in rooms that will utilize vaporized paraformaldehyde or chlorine dioxide gaseous decontamination protocols. **NIH DRM Section 10.5.5.H.4**
9. Properly sealed laboratory surfaces (walls, floors, and ceilings) are essential to maintain controlled directional airflow and ventilation system performance. Room leakage or tightness is also critical when gaseous fumigants are used for decontamination. **ANSI Z9.14 Section 8.3.2**
10. Conduits for all systems: Conduit applications in ABSL-3 facilities are as follows: 1) Conduit Type: Use Rigid Galvanized Steel (RGS) conduit with threaded fittings in all ABSL-3 areas. 2)Seal-off: Provide seal-off fittings when conduits exit defined ABSL-3 perimeter. SMR: Use of surface metal raceway systems (SMRs) is not allowed in ABSL-3 areas. **NIH DRM Section 10.8.3.A**
11. Inspect and Evaluate – Finishes, penetrations & caulking integrity for architectural elements such as doors, around the ceilings, lighting fixtures, electrical devices, etc. within containment to meet requirements for: Surface impermeability to liquids; Resistance of surfaces to chemical (organic solvents, acids, alkalis), disinfectants and moderate heat; Gas tightness for decontamination; Pest management requirements. **NIH BSL-3 Certification Section I.2**
12. Develop HVAC system and electrical systems failure tests consistent with laboratory design parameters. Perform tests and record data. To verify correct operations these tests should include at a minimum: 1) Normal operations to emergency power. 2) Emergency power to normal operations **NIH BSL-3 Certification Section II.17**
13. Pneumatic control air system and control power system shall be assessed and verified to be in good operating condition by visual inspection so as to maintain any required critical control or secondary containment features during normal operation and in the event of loss of power, failure of a generator, or failure of primary compressors and equipment. **ANSI Z9.14 Section 8.3.6**
14. Visual inspection of control power system should include control power for all heating, ventilating, and air-conditioning (HVAC) controls should be served by standby power system. **ANSI Z9.14 Section 8.3.6**
15. HVAC systems shall be tested for directional airflow during system failures. During system failures, momentary changes in airflow patterns

can be acceptable based on the facility risk assessment. Failure of the normal/preferred source power supporting supply and exhaust fan components and transition to the emergency or alternate source. The ability to transition from normal to the backup system should be verified. Return from power outage or emergency or alternate power source to normal or preferred power source should be verified. **ANSI Z9.14 Section 8.4.2**

16. Standby Power Requirements: In addition to the loads listed in Section 10.3, Emergency Power, connect the following loads to the standby electrical systems: 1) Heating and cooling units provided for critical support function. 2) Receptacles serving selected equipment identified as critical by the program. 3) General lighting in laboratories. 4) Critical control and containment equipment compressed air systems. **NIH DRM Section 10.8.1.B**
17. As determined per program basis, recommend connecting the following loads to the standby electrical system: 1) Freezers/refrigerators, 2) Sterilizers, 3) Cage wash equipment for remote locations, where there are no other options available to accommodate an extended outage, 4) Other loads as required by the program based on the risk assessment. **NIH DRM Section 10.8.1.B**
18. The emergency distribution panel and all emergency gear up to the load end of the automatic transfer switches shall be located in a separate dedicated electrical room away from the normal power electrical room. **NIH DRM Section 10.3.3**
19. Wiring for the emergency power shall be separate from the normal power. **NIH DRM Section 10.3.4.A**
20. This is to ensure that emergency electrical service will meet current and future demand of the facility. **NIH DRM Section 10.3.1**
21. Life Safety Loads may include all or some of the following: 1) Emergency egress lighting, 2) Egress signage, 3) Communications systems (including PA systems), 4) Fire alarm and mass notification systems, 5) Self-contained battery-powered lighting at generator set location, 6) Fire-suppression systems (fire pumps, jockey pumps, compressors, valves, etc.) **NIH DRM Section 10.3.1.B**
22. A central UPS system or a number of local UPSs may be required to backup all building wide low voltage systems that are essential for containment operation, safe shutdown of the facility and for critical ABSL-3 specific loads. Central UPS shall be of the double-conversion online type; wet cell type batteries are recommended. **NIH DRM Section 10.8.1.C**
23. Develop HVAC system and electrical systems failure tests consistent with laboratory design parameters. Perform tests and record data. To verify correct operations these tests should include at a minimum: 1) If a UPS is installed, verify operation of relays, 2) Provide UPS for BAS, 3) Assess if UPS is operational. **NIH BSL-3 Certification Section II.17**
24. Containment systems should respond in such ways as to avoid operating conditions that present risks to workers and the environment. Electrical systems including backup generators for normal power outages provide effective strategies to maintain containment including minimization of flow reversals. Emergency generators can normally respond within 10-15 seconds to restore power, whereas UPS systems (where installed) provide continuity of power between transitions of normal to emergency power systems. Based on the risk assessment for the facility, each supporting system should have a documented sequence of operation/strategy for power failure and restoration. **ANSI Z9.14 Section 8.4.6**
25. Boxes for All Systems: General requirements of device boxes are as follows: 1) Type and Depth: All boxes shall be double gang type; the box depth shall be at least the next larger than minimum size required per code. 2) Cast Boxes: Provide cast boxes with external mounting provisions, external hub, and gasketed device cover plates. 3) Sealing: Provide a 25 mm (1 in.) barrier of silicone caulk around the wire within a device box hub. Provide a continuous bead of caulk between the device box and the adjacent surface. Provide a continuous bead of caulk around the device cover plate and the adjacent surface. **NIH DRM Section 10.8.3.D**
26. Inspect and Evaluate – Finishes, penetrations & caulking integrity for architectural elements such as doors, around the ceilings, lighting fixtures, electrical devices, etc. within containment to meet requirements for: Sealed seams and penetrations; Surface impermeability to liquids; Resistance of surfaces to chemical (organic solvents, acids, alkalis), disinfectants and moderate heat; Gas tightness for

decontamination; Pest management requirements. **NIH BSL-3 Certification Section I.2**

27. Properly sealed laboratory surfaces (walls, floors, and ceilings) are essential to maintain controlled directional airflow and ventilation system performance. Room leakage or tightness is also critical when gaseous fumigants are used for decontamination. Examples of elements to inspect include piping and electrical wall or ceiling penetrations including fire sprinklers; Seals around light fixtures, receptacles, diffusers, and grilles; Sealing of electrical and communication/data wires within conduit; Components mounted to walls and ceilings. **ANSI Z9.14 Section 8.3.2**
28. Electrical Installation in Containment Areas: Avoid installing electrical equipment which requires service within a containment area. **NIH DRM Section 10.8.2.A**
29. The A/E shall coordinate requirements for security wiring, on a per project basis with the Project Officer and Division of Physical Security Management (DPSM). **NIH DRM Section 10.8.3.C**
30. Inspect and Evaluate – Finishes, penetrations & caulking integrity for architectural elements such as doors, around the ceilings, lighting fixtures, electrical devices, etc. within containment to meet requirements for: Sealed seams and penetrations. **NIH BSL-3 Certification Section I.2**
31. Properly sealed laboratory surfaces (walls, floors, and ceilings) are essential to maintain controlled directional airflow and ventilation system performance. Room leakage or tightness is also critical when gaseous fumigants are used for decontamination. Examples of elements to inspect include: Piping and electrical wall or ceiling penetrations including fire sprinklers; Seals around light fixtures, receptacles, diffusers, and grilles; Sealing of electrical and communication/data wires within conduit; Components mounted to walls and ceilings. **ANSI Z9.14 Section 8.3.2**
32. Facilities shall have a minimum of two dedicated utility services, physically separated in different duct-banks and different manholes. These dedicated services shall be fed by different primary substations or by one double-ended utility substation, which is fed by two dedicated utility service lines. Each required electric service to the facility shall be sized to handle 100% of the design load (i.e., N + 1 redundancy). **NIH DRM Section 10.8.1.A**
33. Evaluate and minimize single points of failure for all systems including power supplies, electrical distribution, grounding, equipment, and controls for all projects. Downstream electrical distribution from switchgear to critical areas, such as mechanical support rooms with redundant motors in each set, shall comprise pairs of distribution switchboards/panel boards, each fed from a separate side of the switchgear, to supply approximately half of each set of motors. Where possible, provide separate feeders to packaged units with multiple motors, i.e., a separate feeder for each motor. **NIH DRM Section 10.8.1.A.6, 10.8.1.A.7**
34. Electrical Installation in Containment Areas: Avoid installing electrical equipment which requires service within a containment area. Electrical systems and equipment not serving the ABSL-3 area shall not be located within the containment area. Containment Barrier Penetrations: Penetrations through the containment barriers shall comply with the following requirements: 1) Penetrations through the containment barriers shall be gas-tight, non-porous, smooth and cleanable; and readily visible for routine inspection, cleaning, and maintenance. Penetrating components shall be sufficiently rigid in construction and adequately braced to structure to maintain the long-term integrity of the penetration. The result shall be free of sharp edges or similar hazards. 2) All penetrations shall be durable, sealed, and tested to meet the room tightness criteria for ABSL-3 laboratories. Submission and Mock-up: Penetrations into the containment barrier (including mounting of electrical boxes) shall be detailed in the construction documents and shall require mock-ups to be constructed and tested prior to installation. Penetration details for equipment shall be coordinated with the equipment manufacturer. **NIH DRM Section 10.8.2.A, 10.8.2.B**
35. Lighting fixture installation shall comply with the following requirements: 1) Fixtures shall be UL listed with a minimum IP65 rating, 2) Lighting fixtures shall allow full decontamination with ease of effort and permit easy re-lamping and access to ballasts. 3) Lighting fixtures shall be

provided with stainless steel housings, glass or heavy duty acrylic prismatic lens, and stainless steel door with tool-less fasteners or captive, flush, stainless steel screws. 4) Use surface mounted, fully sealed, enclosed, and gasketed fluorescent or LED fixtures. Seal surface mounted fixtures with a continuous bead of sealant around its perimeter to seal housing to ceiling. Lighting fixture must have a sealed conduit entrance to housing. Lighting fixtures may be pendant mounted only in an open ceiling. Pendant-mounted lighting fixtures shall be fully sealed and gasketed with same features as those of surface mounted fixtures including both a sealed conduit entrance to housing and a sealed conduit entrance a ceiling canopy. 5) Install fixtures in continuous rows and aligned with edge of laboratory bench in laboratories and laboratory support areas. Install lighting fixtures in a symmetrical pattern. Fixtures mounted in continuous rows should have a minimum of 152 mm (6 in.) between fixtures to allow for disinfection. 6) In specific imaging modalities, such as MRI, incandescent or LED fixtures and conduit shall be made of non-ferrous materials. Utilize EMI filters and DC dimming methods that are compatible with imaging equipment. All special requirements shall be coordinated with the manufacturer of equipment in each modality. **NIH DRM Section 10.8.4.A, 10.8.4.B**

36. The BSL-3 lighting systems shall be designed to ensure biohazards are contained within the area. Lighting fixtures shall be easily opened to permit full decontamination. **NIH DRM Section 10.8.4.A**
37. BSL-3 laboratory lighting fixtures and systems shall be designed with the containment barrier at the outlet box. **NIH DRM Section 10.8.4**
38. Emergency lighting installation shall comply with the following requirements: 1) Connect at least 50% of lighting fixtures in the laboratories to the emergency power source. 2) Provide at least one lighting fixture per room in laboratory areas with self-testing emergency battery ballast. Connect the lighting fixtures with emergency ballasts to unswitched local emergency generator circuits. **NIH DRM Section 10.8.4.C**
39. Laboratories shall utilize line voltage toggle switches. Occupancy sensors may be used in laboratory support and other areas. In addition, specialized lighting controls (such as dimming systems and DC lighting controls) shall be provided per specific program requirements. If occupancy sensors are used, specify infrared sensors with sealed enclosures. **NIH DRM Section 10.8.4.D**

Plumbing

Plumbing systems in an ABSL-3 facility include all services provided via piped supply, including cylinder gases, vacuum, water and waste service. Design considerations must include features to maintain the zone of containment, such as backflow devices, as well as hazardous materials safety such as shutoff valves, safety eyewashes, and fire sprinklers. It is highly recommended that emergency shutoff valves are accessible from outside the zone of containment.

See “Safety and Decontamination” section for details on fire sprinklers.

Effluent Decontamination Systems (EDS) are not an inherent requirement for ABSL-3 facilities, and installation of such systems should be based on the risk assessment.

Standard	Explanation	Best Design Practice
1. Provide labeled shut-off valves to utilities servicing the ABSL-3 area(s) and locate them outside the containment barrier. [1, 2]	1. To maintain the integrity of the containment envelope there should be no access panels in the BSL-3 laboratory. Laboratory Mechanical, Electrical, Plumbing (MEP) items that may need maintenance shall be outside the containment zone.	1. Access to shut-off valves should be restricted to trained individuals whenever possible. • Labels should be understandable to trained individuals, but not compromise security.
2. Cylinder gases shall be piped from adjacent rooms outside the BSL-3 suite, [3]	2. N/A	2. Provide a locked closet for cylinder gases.
3. Provide back-flow prevention devices at each water service. [4, 5] • Provide back-flow prevention devices at each water faucet	3. Backflow device shall be Reduced Pressure Principle type for highest risk level noted in the California Plumbing Code Table 603.2.	3. N/A
4. Minimize surface mounted utilities. [6]	4. Exposed piping shall be chemically compatible, non-porous, smooth, with sanitary surfaces, and shall utilize sanitary type piping clamps and supports.	4. N/A

	Hangers/clamps and all associated attachments shall be corrosion resistant (typically stainless steel with plastic grommets), free of sharps.	
5. Do not provide compressed air to the BSL-3 suite. [7, 8]	5. The use of compressed air increases the risk of aerosolizing microorganisms. Inhalation of infectious aerosols is the primary route of laboratory acquired infections.	5. N/A
6. All piping into the BSL-3 shall be secured to prevent movement that may break the barrier and the outside. [9]	6. N/A	6. N/A

Water Distribution

Standard	Explanation	Best Design Practice
7. The water distribution system shall be designed to provide the required flow and pressure for the most hydraulically demanding fixture/equipment. System must comply with local regulations and industry standards. [10, 11, 12]	7. Pipe mains shall be designed to achieve the maximum calculated flow rate and to provide a 20% allowance for future expansion.	7. N/A
8. Piping systems shall be properly insulated. [13, 14]	8. N/A	8. N/A
9. Comply with all local plumbing codes. [15]	9. N/A	9. N/A
10. If an Effluent Decontamination System (EDS) is provided, plumbing must be installed within the containment zone.	10. The requirement for EDS in the laboratory will be based on a risk assessment	10. N/A

Vacuum Line

Standard	Explanation	Best Design Practice
11. Provide easily replaceable HEPA filters where vacuum lines connect to BSCs. [16, 17, 18, 19, 20, 21] • HEPA filters on the vacuum lines must be easily replaceable and appropriately decontaminated prior to disposal.	11. N/A	11. If a central vacuum system is required, the installed central vacuum systems should be dedicated to the ABSL-3 laboratory, should not serve other areas, and should be located in close proximity to the containment space. Central vacuum pumps should be located in a negatively pressurized room (negative to adjacent spaces). Alternatively, supply portable vacuum pumps for individual lab rooms.
12. Piped veterinary surgical vacuum systems shall not be utilized. Lab vacuum systems shall not be used for anesthetic scavenging. [49, 50]	12. Where vacuum is required, portable point-of-use equipment shall be used. Configurations must comply with the following: • Vacuum terminal connection and point of use autoclavable suction bottle. • Point of use disinfection trap. • In-line sterilizing grade filter with decon and validation ports. [49]	12. It is against best practices to pipe infectious waste and blood out of containment. Filters provided with portable equipment and medical suction cannisters are typically bacterial grade and may be unsuitable for high containment applications. [49]

Sinks

Standard	Explanation	Best Design Practice
13. Provide wall mounted, hands-free type 304 stainless steel (16 gauge) hand wash sink with electrically operated hot/cold premixing valves near main entrance/exit to each room in a laboratory suite. Seal all openings in sink. Sink to have coved backsplash. [22, 23, 24, 25, 26] • Provide hands-free paper towel dispenser and soap dispenser at sink in anteroom	13. N/A	13.N/A
14. Provide hands-free hand wash sink with electrically operated valves at each zone within the BSL-3 laboratory. [27, 28]	14. Provide additional sinks as required by risk assessment. • Risk assessment of agents and laboratory procedures may recommend additional sinks in an effort to minimize exposures.	14. N/A
15. Faucets must be designed such that the splash is minimized during handwashing and other procedures. [29]	15. N/A	15. Faucets within containment should have atmospheric vacuum breaker and laminar flow, non-aerating, non-splash outlet.
16. Flow rates shall be at maximum 1.8 gal/min. [30]	16. Laboratory sinks are not regulated by CalGreen (California code) or LEED. UC Sustainability policy calls for water use reduction in facilities. Adopting this standard would be consistent with UC goals.	16. Suggest that Calgreen kitchen sink requirement be adopted: 1.8 GPM normal maximum with intermittent maximum of 2.2 GPM.
17. Where stainless steel sinks are used, surface undercoating and sound-deadening	17. N/A	17. N/A

pads shall be omitted. [31]

Shower

Standard	Explanation	Best Design Practice
18. Shower out requirements are based on risk assessment. [32, 33, 34, 35, 36] • Hand-held showers shall not be utilized except where specifically required for barrier-free compliance and shall include a vacuum breaker.	18. A shower out requirement will be based on risk assessment. If required, pass-through design shower should be considered to allow traffic in one direction only. Dirty clothing/PPE shall not contaminate the clean area. • Handheld fixtures must have a vacuum breaker and a mount. • Consider EDS for shower out if required by risk assessment.	18. When not required, consideration should be given to the future addition of showers with regards to laboratory design layout and plumbing demands.
19. Fixtures requiring potable supply direct from the domestic potable water system (e.g., emergency eyewash, showers, and toilet room/shower fixtures located in containment) shall be isolated from other functions with an ASSE 1013 backflow preventer. [37, 38]	19. Backflow device shall be Reduced Pressure Principle type for highest risk level noted in the California Plumbing Code Table 603.2	19. N/A

Drains

Standard	Explanation	Best Design Practice
20. If laboratory intends to dispose of contaminated liquid waste down the drains or disposal of such could possibly occur unintentionally, it must be discharged to a dedicated waste system prior to decontamination. [39]	20. Requirement for EDS will be based on a risk assessment and best practices guidelines. • Laboratory personnel may eliminate the need for EDS by decontaminating liquid waste with appropriate disinfectant and contact time prior to disposal.	20. N/A

21. Floor sinks provided for receiving the condensate from the sterilizer chamber shall be on the clean side of the autoclave bioseal. [40, 41]	21. N/A	21. Floor drains/floor sinks should be avoided in containment.
22. Drains pipes must be resistant to liquid decontaminant used in the facility.	22. N/A	22. Metal pipes should be avoided in areas where decontaminated liquid waste will be disposed.

Traps

Standard	Explanation	Best Design Practice
23. 6-inch P traps (minimum) must be provided if significant changes in pressure could occur. • Traps shall be selected to exceed the exhaust fan static pressure to maintain at least a 37-50 mm (1.5 -2 in.) seal depth under HVAC operating and fan failure modes, as well as extra depth as required for control of pressure transients. [42]	23. N/A	23. Deep traps provide safer protection by maintaining trap seal when sudden changes in space pressure occur.
24. Traps shall be resistant to common decontamination agents such as bleach.	24. N/A	24. N/A

Waste Pipe Cleanout

Standard	Explanation	Best Design Practice
25. Provide cleanouts in such a way as to maintain integrity of the containment barrier. [43]	25. N/A	25. Threaded cleanout plugs should be coated with threaded joint sealer for an airtight seal.

Animal Drinking Water Systems

Standard	Explanation	Best Design Practice
26. Animal drinking water serving ABSL-3 shall be completely independent of other spaces. [46]	26. Supply serving and animal drinking water treatment and distribution systems shall be taken directly from building water and supply shall be isolated from other systems with an ASSE 1013 backflow preventer located outside the containment barrier. [46]	26. The use of bottled or prepackaged water versus piped automated drinking water systems shall be evaluated through the risk assessment. [45]
27. Recirculated animal drinking water arrangements and piping in and out of the containment barrier are not used within AABSL-3 facilities due to possible cross-contamination and safety risks. [46, 47]	27. Once distribution systems have entered ABSL-3 facilities, downstream segments of the system shall not be piped back out of containment and shall not have any openings (e.g. drainage points) outside of the containment barrier. [46]	27. Where piped systems are provided only non-circulated systems (automatic flushing-type animal drinking water systems) shall be used, and maintenance of an approved residual disinfectant throughout the system. Flushing lines from the animal drinking water distribution system shall terminate with a fixed air gap to a drain within the containment barrier. [47]
28. Cross contamination protection may be established between spaces or suites working with different agents or programs. [48]	28. ASSE 1015 stainless steel backflow preventers may be used upstream of pressure-reducing/flush stations within the distribution system where required for cross-contamination issues which do not pose a high-risk personnel safety concern. [48]	28. Backflow prevention devices (BFPs) require annual testing. Filters, if used, require replacement at least quarterly, and unnecessary filters require additional maintenance and can compromise water quality. [48]

Veterinary Medical Gas Systems

Standard	Explanation	Best Design Practice
29. Design of Veterinary Medical Gas Systems (VMGS) must comply with the ILAR Guide and the Public Health Service Policy for Humane Care and Use of Laboratory Animals. In cases where euthanasia gases are permitted, refer to PHS Policy and American Veterinary Medical Association Guidelines (AVMA). [51]	29. General design standards for the humane delivery of veterinary medical gasses must be followed. Gases must be clean, uncontaminated, reliable, flexible, and maintained with minimal disruption. [51]	29. Considerations should be made in design plans for capacity, reliability, reserve and backup, and supply continuity. Special considerations should be made for gases which may have elevated demand in ABSL-3 emergency response, such as CO2. [52]
30. VMGS for ABSL-3 areas shall be completely independent of systems from areas outside the containment envelope. [53]** **The use of VMGS may be accommodated by the use of dedicated portable gas cylinders on an as-needed basis. [53, 54]	30. Where piped systems are used, prior to the containment barrier, an upstream sterilizing grade, non-contaminating hydrophobic filter that is clean and approved for oxygen service, USP Class VI, and non-fiber releasing, or a gas-tight check valve that is clean and suitable for oxygen service shall be provided. [53]	30. When piped systems are used, alarm panels shall alert to locations approved by the responsible high containment personnel.

Cage Wash Systems

Standard	Explanation	Best Design Practice
31. Cages are decontaminated prior to removal from the containment barrier and prior to washing in a mechanical cage washer.	31. Cage washers are not appropriate for inside ABSL3 containment.	31. The use of disposable caging systems versus re-useable caging systems shall be evaluated through the risk assessment.

Plumbing References

1. Each pressurized piping penetration from outside the barrier into containment shall be provided with a shut-off valve located outside the containment barrier serving only the ABSL-3 area(s). Each equipment connection shall include dedicated isolation valve. Fire-sprinkler piping need not be provided with a shut-off valve at each penetration; however, the sprinkler zone serving ABSL-3 should be capable of independent isolation. **NIH DRM Section 8.6.1.D**
2. All piping systems shall be identified using system-nomenclature-specific pipe labels. **NIH DRM Section 8.1.3.4.B**
3. Gas cylinders shall not be located inside containment spaces and shut-off valves should be provided for each penetration into containment to permit independent isolation of each service. **NIH DRM Section 8.6.6.B**
4. Water supplies to ABSL-3 spaces shall be isolated from other functions with an approved back-flow preventer (BFP) installed outside containment prior to serving ABSL-3 areas. **NIH DRM Section 8.6.2.A**
5. Each water service shall be provided with a service entrance backflow preventer sized for 100% demand load, ASSE 1013 type for domestic water and ASSE 1015/1048 or ASSE 1013/1047 type for fire service as appropriate. On facilities with single water service is utilized to supply each system, backflow preventers on the individual service shall be arranged in parallel, sized to provide N+1 redundancy. **NIH DRM Section 8.3.2.E**
6. Exposed piping shall be chemically compatible, non-porous, smooth, with sanitary surfaces, and shall utilize sanitary type piping clamps and supports. Hangers/clamps and all associated attachments shall be corrosion resistant (typically stainless steel with plastic grommets), free of sharps, and where applied in ABSL-3 areas exposed piping shall be in conformance with ASME BPE-2002 and properly sealed with an approved sealant. **NIH DRM Section 1.15.4.F**
7. The use of compressed air within a BSC must be carefully considered and controlled to prevent aerosol production and reduce the potential for vessel pressurization. **BMBL 6th ed. Appendix A, Part 6**
8. Pressurized gas systems shall not be connected to primary containment devices, including BSCs... Only where pressurized gas services are necessary for required equipment operation or procedures in primary containment equipment (e.g., aerosol inhalation chambers) may such services be provided… the service line shall have backflow preventer check valve arrangement at the point of use. **NIH DRM Section 8.6.6.C**
9. Each pressurized piping penetration from outside into containment shall be provided with a shutoff valve. Each equipment connection shall include isolation valves. **NIH DRM Section 8.6.1.D**
10. A separate and distinct central laboratory/non-potable water subsystem shall be provided and distributed throughout the building, sourced and isolated from the domestic water system with parallel ASSE 1013 backflow preventers, which have been sized and arranged to N+1 redundancy. **NIH DRM Section 8.3.4.B**
11. The water distribution system shall be designed to provide the required flow and pressure for the most hydraulically demanding fixture/equipment. Systems shall be designed to provide at least 280 kPa (40 psi) residual (flowing) pressure at the most remote outlet on the laboratory water system and not less than 240 kPa (35 psi) residual pressure for the hydraulically remote fixture on the domestic plumbing system. **NIH DRM Section 8.3.4.1.B**
12. A pressure-reducing station shall be provided if required to limit maximum water pressure to 550 kPa (80 psi) at any service outlet. Major pressure reducing station valves shall be of the hydraulically operated pilot-type automatic control valve, municipal grade with stainless steel trim. **NIH DRM Section 8.3.4.1.C**
13. Piping systems shall be properly insulated. **NIH DRM Section 8.3.5.C**

14. Pipe mains shall be designed for the maximum calculated flow at the design stage and to provide a 20% allowance for future expansion. **NIH DRM Section 8.3.5 F**
15. The pipe sizing criteria shall comply with requirements of Table 8.4.5, Minimum Waste Piping Diameters. **NIH DRM Section 8.4.5.B**
16. Vacuum lines in use are protected with liquid disinfectant traps and in-line HEPA filters or their equivalent. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
17. Filters are replaced, as needed, or are on a replacement schedule determined by a risk assessment. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
18. Vacuum lines not protected as described are capped. The placement of an additional HEPA filter immediately prior to a central vacuum pump is considered. **BMBL 6th ed. Section IV. Biosafety Level 3.**
19. Utility services needed within a BSC must be planned carefully. Protection of vacuum systems must be addressed (Figure 12). **BMBL 6th ed. Appendix A**
20. If vacuum lines are used with toxin, they should be protected with a HEPA filter to prevent entry of toxins into the line and include a vacuum flask with decontamination solution between the vacuum source and vacuum line. **BMBL 6th ed. Appendix I**
21. The use of disinfectant traps and hydrophobic filters are required at each point of use, including biological safety cabinets and aerosol chambers. Filters utilized shall be at least HEPA efficiency for liquid and gas streams; and permanent type pipe-line filters should be sterilizing grade for repeated usage. **NIH DRM Section 8.6.5.A**
22. Laboratories have a sink for handwashing. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
23. The sink is hands-free or automatically operated. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
24. Locate sink near the exit door. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
25. All laboratories require a hands-free or automated hand washing sink located near the exit door. **NIH DRM Section 4.9.8.G**
26. Sink faucets shall be hands-free that are either electric sensor operated and hard-wired to AC power, or foot pedal actuated with slow-close off-the-floor mounted valves with flip-up pedals to permit cleaning. Battery actuated faucets and faucets which operate with hands, wrist or elbow are not acceptable. Knee operated valves shall include suitable anchorage or shall be knee-panel type with pneumatic control valves (scrub-sink type). **NIH DRM Section 8.6.11.1.B**
27. If a laboratory suite is segregated into different zones, a sink is also available for handwashing in each zone. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
28. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
29. Faucets within containment shall have gooseneck-type spouts and be fitted with integral ASSE 1001 atmospheric vacuum breaker and laminar flow, non-aerating, non-splash outlet. **NIH DRM Section 8.6.11.1**
30. Flow rates shall be at least 2 gal/min. **NIH DRM Section 8.6.11.1**
31. Where stainless steel sinks are used, surface undercoating and sound-deadening pads shall be omitted. **NIH DRM Section 8.6.11.4.A**
32. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. These laboratory enhancements may include one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas-tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; containment of other piped services; or advanced access control devices, such as biometrics. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
33. Risk assessment may require the use of pass-through showers in the exiting sequence. When not required, consideration should be given

to the addition of showers for future flexibility. **NIH DRM Section 2.5.3.5.C**

34. Maximum outlet temperature at showers shall be limited to 45 degrees C (112 deg. F) at the individual fixture limit stop. **NIH DRM Section 8.2.9.B**
35. Showers shall provide a minimum flow rate of 2.5 gal/min. **NIH DRM Section 8.6.11.2.A**
36. Hand-held shower shall not be utilized except where specifically required for barrier-free compliance and shall include a vacuum breaker. **NIH DRM Section 8.6.11.2.A**
37. Outlets requiring potable supply direct from the domestic potable water system (e.g., emergency eyewash, showers, and toilet room/shower fixtures located in containment) shall be isolated from other functions with an ASSE 1013 backflow preventer. **NIH DRM Section 8.6.2.C**
38. Indirect waste (including but not limited to fire sprinkler drains) shall not terminate into other plumbing fixtures including janitor mop sinks, showers, or other fixtures not dedicated specifically for receipt of indirect waste. **NIH DRM Section 8.4.10.D**
39. All drain inlets within containment shall discharge to the dedicated waste system serving BSL- 3 facilities. **NIH DRM Section 8.6.9.1.D**
40. The sterilized effluent from ABSL-3 autoclave chambers fitted with decontamination of all chamber effluent may discharge through the sanitary system or general building laboratories waste system as an indirect connection through a floor sink. The drain receptor shall be located on the clean (non-contained) side of the bioseal (typically within the clean sterilizer service access area). **NIH DRM Section 8.6.9.1.P**
41. Floor drains/floor sinks shall be avoided in containment. **NIH DRM Section 8.6.9.1.H**
42. Waste systems shall be atmospherically vented to the building exterior and shall include deep seal traps for all drain inlets within containment. **NIH DRM Section 8.6.9.1.A**
43. Waste pipe clean-out access shall be arranged similar to other piping penetrations to maintain integrity of the containment barrier, typically arranged as a threaded capped or plugged pipe extension through a wall. **NIH DRM Section 8.6.9.1.J**
44. The use of bottled or prepackaged water versus piped automated drinking water systems shall be evaluated through the risk assessment and consultation with NIH. **NIH DRM Section 8.6.4.A**
45. Supply serving and animal drinking water treatment and distribution systems shall be taken directly from building water and supply shall be isolated from other systems with an ASSE 1013 backflow preventer located outside the containment barrier. Supply serving and animal drinking water treatment and distribution systems shall be taken directly from building water and supply shall be isolated from other systems with an ASSE 1013 backflow preventer located outside the containment barrier. **NIH DRM Section 8.6.4.B**
46. Where piped systems are provided only non-circulated systems (automatic flushing-type animal drinking water systems) shall be used, and maintenance of an approved residual disinfectant (typically chlorination at up to 4mg/L) throughout the system. **NIH DRM Section 8.6.4.C**
47. Cross contamination protection may be established between spaces or suites working with different agents or programs. ASSE 1015 stainless steel backflow preventers may be used upstream of pressure-reducing/flush stations within the distribution system where required for cross-contamination issues which do not pose a high-risk personnel safety concern. **NIH DRM Section 8.6.4.D**
48. Piped veterinary surgical vacuum systems shall not be utilized. **NIH DRM Section 8.6.7.B**
49. Lab vacuum systems shall not be used for anesthetic scavenging. **NIH DRM Section 8.6.7.C**
50. Design of Veterinary Medical Gas Systems (VMGS) must comply with the ILAR Guide and the Public Health Service Policy for Humane Care and Use of Laboratory Animals. In cases where euthanasia gases are permitted, refer to PHS Policy and American Veterinary Medical Association Guidelines (AVMA). **NIH DRM Section 12.5.2**
51. Loadings for VMGS systems shall consider peak demands and facility emergency response or disaster mitigation plans. **NIH DRM Section 12.5.2.1**
52. VGMS for ABSL-3 areas shall be completely independent of systems from areas outside ABSL-3 containment and protected from

backflow or contamination with point of use filters selected in accordance with the risk assessment. **NIH DRM Section 8.6.7**

53. The alarms for VMGSs alarm panels shall alert to locations approved by the responsible high containment personnel and the location and type of annunciation shall be as approved. **NIH DRM Section 8.6.7.A**
54. Where all required procedures necessitating scavenging cannot be conducted within an approved ducted capture device, active scavenging shall be provided. Suitable disposable filters designed specifically for use with scavenging systems on the passive side of the air brake shall be provided upstream of the air brake (transfer hose side) as approved by the DOHS and the program veterinary anesthetist. Anesthetic gas scavenging shall be either: 1. Air driven autonomous (self-contained) venture type as per Section 12.5 Veterinary Medical Gas Systems for Animal Research Facility. The drive gas shall be located in the anteroom or other approved location as per the risk assessment and shall and shall include an in-line filter or gas-tight check valve prior to entering the containment barrier. Terminal exhaust shall be piped into an approved lab exhaust within the containment envelope, upstream of HVAC HEPA filters. Indirect connection of the exhaust from scavenging to containment ventilation system is not permitted outside containment or outside of the suite where the terminal unit is located. **NIH DRM Section 8.6.7.C.1**
55. The use of self-contained point of use active systems (e.g. self-contained fan powered air brakes or systems with the extractor fan just upstream of the air brake within the same room at the point of use) may be applied for single outlets. The exhaust from such unites shall be piped of approved hard pipe materials with permanently sealed joints to an approved non-recirculating capture device located within the same containment suite in accordance with the risk assessment. **NIH DRM Section 8.6.7.C.2**
56. For applications with halogenated anesthetics only, the use of activated carbon type passive systems may be used with approval of the program veterinarian and DOHS, with autoclaving and disposal after each use. **NIH DRM Section 8.6.7.C.3**

Telecom, Security & Documentation

Telecom

Telecom and security systems should be designed with an eye towards personnel safety, inventory and facility security. Hazard and safety communication (e.g. signage) should be clear, available, and easy to understand. Communication systems should be robust, reliable, and straightforward for use. Best practice design considerations should include an information systems security system.

Standard	Explanation	Best Design Practice
1. Exposed conduit, piping or pathways are to be resistant to decontamination chemicals and easily cleaned behind, if surface mounted.	1. Any material exposed in the ABSL-3 laboratory shall be resistant to decontamination methods.	1. N/A
2. Provision for landline telephone must be made available.	2. Landline makes communication with dispatch easier	2. Provide an intercom or hands-free telephone in each room, including anteroom[1] • System must be connected to a location that has personnel available for emergency response at all times work is being performed in a BSL-3 laboratory.
3. Provide a method for electronic transfer of information to outside of containment (e.g.: scanner, fax, iPad, etc.). [2]	3. Electronic transfer method eliminates the practice of transferring documents from the ABSL-3 to areas outside of containment.	3. An information systems security system should be implemented, to protect networks, computers, programs, equipment, and data from unwanted and deliberate intrusions. • If remote access systems are in place, they should have controls that admit only authorized and authenticated

		users. • Design considerations should include any network-connected laboratory equipment (e.g. real-time cell imagers).
Security		
Standard	**Explanation**	**Best Design Practice**
4. Anteroom doors must be self-closing and interlocked. Mechanically interlocked doors must have an emergency override. Interlocking doors must meet campus fire marshal requirements.[3, 4,]	4. Self-closing doors are required to both maintain the pressure differential and the security of the space. Locks are required to prevent unauthorized access to the containment facility.	4. N/A
5. Electronic access control is required at Anteroom for access to BSL-3 suite. System must provide access history. [5, 6, 7,]	5. Due to the use of biohazardous materials, access to the biocontainment facility must be strictly limited to trained authorized personnel. • Provide card key, biometric, or PIN security access. Link system to EH&S and/or building/campus security.	• Video surveillance cameras should be installed to provide live and recorded video activity outside of the secured space, in interior activity spaces, and covering materials of interest. Camera should be capable of wireless power and have sufficient resolution and light capability to view and accurately assess observed activities. The access control and video surveillance system devices should be coordinated to allow for recording and monitoring of entry and exit events. Due to the sensitivity of research, the physical

		security systems should be integrated to provide for real time monitoring and post evening auditing of the video surveillance and electronic access control systems. Please utilize any existing enterprise systems in coordination with the Campus Police Department. • Emergency/duress notification systems should be installed in the laboratory spaces where work is being performed. A two way, single button push emergency phone with direct connection to the Campus Police Department should be installed in a highly visible and easily accessible location in the laboratory. Please utilize any existing enterprise systems in coordination with the Campus Police Department.
6. Access to mechanical and support spaces must be designed to limit unauthorized users.	6. N/A	6. Consider a method for maintaining an access control record for mechanical/support spaces.

Signage

Standard	Explanation	Best Design Practice
7. Provide space on or near the anteroom door for appropriate signage, coordinated with EH&S and the Fire Marshal.	7. Accurate signage information is important for many reasons, including health and safety. Conversely, for security reasons detailed signage may be a concern. To determine actual signage requirements, the design team should meet with the University's EH&S and the Fire Marshal.	7. N/A

Enhanced Facilities

Standard	Explanation	Best Design Practice
8. Enhanced facility requirements shall be determined by risk assessment study. Enhancements may be required for facility and security based on Select Agent Requirements. Example includes shower-out capabilities for projects involving work with Highly Pathogenic Avian Influenza. [8, 9]	8. In some cases, risk assessment may call for facility designs that exceed those recommended in the BMBL BSL-3 guidelines. This may be due to the agents and/or volumes in use, the experimental procedures or other guidelines that may be followed. The enhancements noted have all been noted in other parts of this document and may be required to further protect the users and environment, to better be able to decontaminate the facility or to provide better security. • Laboratory effluent decontamination	8. N/A

Verification & Documentation

Standard	Explanation	Best Design Practice
9. The BSL-3 facility design, operational parameters, and procedures must be verified and documented prior to operation. Facilities must be re-verified and documented at least annually. [10]	9. BSL-3 facilities are some of the most complicated facilities to design, construct and operate. The complex systems must be thoroughly documented and facilities personnel should be trained to maintain the various systems.	9. N/A
10. An independent third-party commissioning agent (CA) is required for design consultation and certification of the BSL-3 Facility. The Biosafety Officer and High-Containment Director must be included in the BSL-3 facility design and certification. BSL-3 laboratories must be certified by an experienced team of engineers and biosafety professionals before initial operation. [11, 12] • Certification must be done in the presence of the Biosafety officer and/or High-Containment Director. • The facility must be tested and verified at least annually in coordination with the HCLD to provide assurance that the facility is in proper operational condition.	10. Documentation of initial testing must be provided and must comply with ANSI Z9.14 standards.	10. Commissioning agent should be involved from the beginning of the project.

Seismic

Standard	Explanation	Best Design Practice
11. All tall (over 42 inches) and/or heavy equipment must be provided with seismic restraints designed to withstand shaking equivalent to 7.0 on the Richter scale. [13]	11. This is to prevent damage of equipment in the event of an earthquake.	11. N/A
12. Tall and/or movable cabinets must be seismically anchored. Anchor points that penetrate the containment barrier must be properly sealed.	12. Penetrations made to the containment envelop need to be sealed to maintain proper directions airflow.	12. N/A

Telecom, Security & Documentation References

1. Evaluate availability of emergency two-way communication system. **NIH BSL-3 Certification Section I.3**
2. Evaluate availability of system provided for electronic transfer of information to outside of containment. **NIH ABSL-3 Certification Section I.3**
3. Laboratory doors are lockable in accordance with institutional policies. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
4. Physical separation of the high containment laboratory from access corridors or other laboratories or activities may be provided by double-door clothes change room (showers may be included), airlock, or other access facility which requires passage through two sets of doors before entering the laboratory. **NIH Guidelines Appendix G-II-C-4-a**
5. Laboratory access is restricted. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
6. At ABSL-3, more emphasis is placed on primary and secondary barriers to protect personnel, the surrounding community, and the environment from exposure to potentially infectious aerosols. **BMBL 6th ed. Section III. Principles of Biosafety. Biosafety Levels**
7. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. These laboratory enhancements may include one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas-tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; containment of other piped services; or advanced access control devices, such as biometrics**. BMBL 6th ed. Section IV. Biosafety Level 3.D**
8. Biosafety Level 3 Enhanced for Research Involving Risk Group 3 Influenza Viruses. (See Appendices G-II-C-2-n, G-II-C-2-r, and G-II-C-4-i for additional guidance for facilities, waste handling, and serum collection for research involving mammalian transmissible HPAI H5N1 virus. **NIH Guidelines Appendix G-II-C-5**
9. Enhanced environmental and personal protection may be necessary based on risk assessment and applicable local, state, or federal regulations. These laboratory enhancements may include one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas-tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; containment of other piped services; or advanced access control devices, such as biometrics. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
10. The BSL-3 facility design, operational parameters, and procedures are verified and documented prior to operation. Facilities are tested annually or after significant modification to ensure operational parameters are met. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
11. An independent third-party commissioning agent (CA) is required. **NIH DRM Section 1.10.1.E**
12. Personnel shall verify that the direction of the airflow (into the laboratory) is proper. The exhaust air from the laboratory room may be discharged to the outside without being filtered or otherwise treated unless research is being conducted with mammalian transmissible HPAI H5N1 virus. For research with mammalian transmissible HPAI H5N1 virus, exhaust air must be HEPA filtered and there must be sealed ductwork from the containment barrier to the filter. In addition, the air handling system shall be designed such that under failure conditions, the airflow will not be reversed and periodic verification, with annual verification of the HEPA filters, shall be performed. **NIH Guidelines Appendix G-II-C-4-i**
13. Any equipment, including but not limited to, appliances and shelving to be installed by the contractor, which is 42 inches or higher and has the potential for falling over during an earthquake, or moving and blocking corridors or doors, shall be permanently braced or anchored to wall-studs, structural columns and/or the floor. **UC Laboratory Design Manual, Seismic Hazard Abatement #3.**

Safety and Decontamination

Safety

Safety equipment and the associated storage space for it, should be provided within the zone of containment. Decontamination infrastructure should be based on the risk assessment.

Standard	Explanation	Best Design Practice
1. Provide adequate storage for safety equipment and supplies in the BSL-3 suite, including biological and chemical spill kits. [1]	1. Readily available safety equipment will facilitate response in an emergency.	1. N/A
2. Provide binocular, hands-free eyewash. [2, 3, 4]	2. N/A	2. Provide binocular, hands-free eyewash in each room of an ABSL-3 that complies with current ANSI eyewash standard (Z358.1).
3. Provide a combination emergency shower and eyewash unit. Coordinate exact location(s) with EH&S. Locate unit in a central location within the ABSL-3 laboratory/suite. Emergency shower/eyewash unit location must be compliant with ANSI 358.1-2014 and Cal-OSHA regulations. [5, 6]	3. N/A	3. Flow alarms should be provided on emergency showers in lab spaces to notify the staff of possible issue(s).
4. Provide mounted type ABC fire extinguisher at contained side of anteroom door. Risk assessment and Fire Marshal requirements shall determine need for additional fire	4. Provide type ABC fire extinguisher at contained side of anteroom door. Risk assessment and Fire Marshal requirements shall determine need for additional fire extinguishers.	4. Provide in gasket, recessed cabinet.

extinguishers. The maximum travel distance to an extinguisher shall be 15 m (50 ft.). For open labs, the fire extinguisher shall be located as closely as possible to the exit access doors.[7, 8]		
5. BSL-3 facilities shall be fully protected with an automatic sprinkler system based on local regulations. Fire sprinkler heads, if in canopy hoods, should be rated higher than the steam temperature. [9]	5. N/A	5. Fire sprinkler sensors for placement near autoclaves or other high heat/steam generating equipment should be designed to prevent nuisance triggering and floods
6. Sprinkler heads shall be pendent type and not be recessed or concealed. The piping drop shall extend through the penetration sufficient to allow for application of a visible seal. Escutcheons shall not be provided. A flat solid stainless steel plate or washer that is tight fitting against the pipe may be utilized bedded in sealant and sealed to the pipe circumference. Pipes shall be braced to prevent movement that may damage the barrier seal. [10]	6. N/A	6. N/A
7. Provide space in anteroom for storage of clean PPE. Provide areas for laundry and/or waste bin for disposal of dirty PPE as necessary**.** Provide space and outlets for PAPR charging station and adequate space for donning/doffing procedures.	7. N/A	7. Considerations for privacy and changing areas should be made

8. Provide local audible and visual alarms for the following: [11] • Fire hazard • HVAC failure • Differential pressure at any door out of range • Switch to emergency power • Alarms must be clearly audible above ambient noise levels and audible and visible throughout the laboratory. • NOTE: Alarms for animal housing locations should be visual ONLY (NO AUDIO).	8. N/A	8. Consider also reporting alarm to PI, facilities or campus security/police, as appropriate for a given alarm condition. • Freezer and incubator alarms should be considered. Supply utilities for such alarms • Security alarms at appropriate points (e.g., doors, windows, other)
9. Alarms must be on UPS power. [12]	9. N/A	9. Alarms should be differentiated from each other (in the BMS) so that each can be easily identified.

Decontamination

Standard	Explanation	Best Design Practice
10. Provide pass-through autoclave in the BSL-3 suite [13, 14, 15, 16] • Provide exhaust hoods on the clean and dirty sides of double door autoclaves. The dirty side canopy hood must connect to the BSL-3 exhaust. The clean side canopy hood is connected to the general lab exhaust. • Provide space adjacent to the autoclave on the dirty and clean side of pass-through autoclave for waste collection and disposal.	10. N/A	10. N/A

11. Rooms shall be capable of being sealed for protocols that require gaseous and/or vapor decontamination. [17, 18, 19]	11. The facility should be capable of being fully sealed for decontamination purposes.	11. Consider placement of decontamination ports that are accessible from the outside of the facility. Decontamination corridor integrated into the design for decontamination of large pieces of equipment. Facility should be designed to allow for individual rooms or zones to be isolated for decontamination.
12. Liquid effluent from ABSL-3 autoclaves may be discharged to sanitary sewer or reclaimed as appropriate. [20]	12. Based on risk assessment, liquid from the ABSL-3 autoclave may need to be treated prior to disposal to municipal sewer.	12. N/A
13. Air evacuated from the autoclave chamber prior to decontamination cycle shall be considered potentially contaminated and requires HEPA filtration or other validated method.	13. Provide HEPA filter at the autoclave vacuum system to minimize release of infectious material during purging phase.	13. N/A
14. Class II Biological Safety Cabinets must meet the NSF/ANSI 49 standard. [21, 22, 23] • Class III BSC may be required based on a risk assessment.	14. Primary containment is required for manipulations of infectious materials	14. N/A

Safety and Decontamination References

1. Evaluate availability of emergency equipment. **NIH BSL-3 Certification Section I.3**
2. An eyewash station is readily available in the laboratory. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
3. A BSL-3 environment shall have: Hands free hand washing sink with eyewash. **NIH DRM 8.2.10.1**
4. Available hands-free sink near laboratory exit. **NIH BSL-3 Certification Section I.3**
5. In spaces where a significant hazard exists and it is likely a user may be present without supervision, a flow alarm shall be provided to indicate emergency shower operation. The alarm shall provide local audible alert and remote alert. **NIH DRM Section 8.2.10.D**
6. Validate availability of emergency shower. **NIH BSL-3 Certification Section II.13**
7. All fire extinguisher cabinets shall be sized to contain the approved fire extinguisher. Cabinet doors shall not have locks. The maximum travel distance to an extinguisher shall be 15 m (50 ft.). For open labs, the fire extinguisher shall be located as closely as possible to the exit access doors. **NIH DRM Section 9.4.4**
8. Evaluate availability of working fire extinguisher. **NIH BSL-3 Certification Section I.3**
9. BSL-3 facilities shall be full protected with an automatic sprinkler system. **NIH DRM Section 9.5.1.1.A**
10. Sprinkler heads shall be pendent type and not be recessed or concealed. The piping drop shall extend through the penetration sufficient to allow for application of a visible seal. Escutcheons shall not be provided. A flat solid stainless steel plate or washer that is tight fitting against the pipe may be utilized bedded in sealant and sealed to the pipe circumference. Brace pipes to prevent movement that may damage the barrier seal. **NIH DRM Section 9.5.1.1.B, 9.5.1.1.D**
11. In the event of loss of directional airflow, personnel in the containment space shall be notified of such condition via audible and/or visual alarms. Alarm indication should be located inside the laboratory space(s), at the entrance of the BSL-3. **ANSI Z9.14 Section 8.3.3**
12. Power to BMS and other control systems for monitoring, controlling, and alarming HVAC normal and failure modes should be on UPS. **ANSI Z9.14 Sec. 8.4.6**
13. A method for decontaminating all laboratory waste is available in the facility, preferably within the laboratory (e.g., autoclave, chemical disinfection, or other validated decontamination method). **BMBL 6th ed. Section IV. Biosafety Level 3.D**
14. Provide stainless steel exhaust canopy hoods over door to capture steam (both sides). “Dirty” side canopy exhaust should be tied into contaminant exhaust. “Clean” side canopy exhaust may be tied into non-contaminant exhaust. **NIH DRM Section 6.6.10.A**
15. Autoclave for decontaminating laboratory wastes is available. **NIH Guidelines Appendix G-II-C-4-h**
16. Equipment that penetrates secondary barrier shall be provided with a manufacturer-supplied bioseal. Bioseal shall form a continuous, airtight seal. **NIH DRM Section 4.9.11.B**
17. Facility is constructed to allow decontamination of the entire laboratory when there has been gross contamination of the space, significant changes in usage, major renovations, or maintenance shutdowns. Selection of the appropriate materials and methods used to decontaminate the laboratory is based on the risk assessment. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
18. All penetrations into and through partitions, floors, and ceilings shall be sealed to enhance sanitation, facilitate gas and vapor decontamination, and resist air infiltration. **NIH DRM Section 2.6.2.5.**

19. Gas tightness for decontamination **NIH BSL-3 Certification Section I.2**
20. The sterilized effluent from BSL-3 autoclaves may discharge through sanitary system or general building laboratory waste system as an indirect connection through a floor sink. The drain receptor shall be located on the clean side of the bioseal (including with the clean utility access area.) **NIH DRM Section 8.6.9.P**
21. All procedures involving the manipulation of infectious materials are conducted within a BSC or other physical containment device, when possible. No work with open vessels is conducted on the bench. If it is not possible to perform a procedure within a BSC or other physical containment device, a combination of personal protective equipment and other administrative and/or engineering controls, such as centrifuge safety cups or sealed rotors, are used, based on a risk assessment. **BMBL 6th ed. Section IV. Biosafety Level 3.B**
22. Refer to Appendix F "Biological Safety Cabinet (BSC) Placement Requirements for New Buildings and Renovations" for BSC placement guidelines. **NIH DRM Appendix F**
23. Verify correct placement of biological safety cabinets with respect to supply and exhaust diffusers, doors and traffic patterns. **NIH BSL-3 Certification Section II.6**

ABSL-3 Standard Equipment

Autoclaves

Included facility equipment should be determined on a case-by-case basis, but standard examples are provided below. Design considerations should include infrastructure to support equipment (e.g., biosafety cabinet to contain a cell sorter), equipment footprint, amperage, and changing facility needs. Workflow considerations may aid in selection, and best practices may include an eye towards streamlining facility operations to reduce personnel hours required at higher biosafety levels.

Minimum Standards	Explanation	Best Design Practice
1. Provide a pass-through autoclave within the laboratory. [1, 2, 3]	1. N/A	1. Provide a pass-through autoclave opening to a secure room outside the ABSL-3 suite. • Pass through autoclaves penetrating the BSL-3 barrier should have an approved bioseal. The body of the autoclave should be on the outside of the containment barrier. [4, 5, 6] • Autoclave doors should be interlocked. [7] • Floor sink for the autoclave should be on the outside of the containment barrier. [9, 10] • Clean side autoclave doors should not open directly onto a public corridor but should open into a vestibule with doors separating it from the public corridor. [11, 12] • Provide exhaust hoods on the clean and dirty sides of double door autoclaves. The dirty side canopy hood should connect

		to the BSL-3 exhaust. The clean side canopy hood can be connected to the general lab exhaust. [13, 14] • Provide emergency power to ensure completion of autoclave cycle and ability to unload/open autoclave door during power failures. • Provide space adjacent to the dirty side of the autoclave for waste collection. [15, 16]
2. Autoclave size, accessories and decontamination cycles shall be determined during the design phase in coordination with EH&S. [16]	2. Consideration should be made for accommodating load sizes that will include animal cages.	2. N/A

Biosafety Cabinets

Minimum Standards	Explanation	Best Design Practice
3. BSCs must meet the NSF/ANSI 49 standard. Include space for seismic bracing. [17, 18, 19]	3. Locate BSCs to minimize air current effects of passing traffic and door openings.	3. BSCs should be placed according to the NIH DRM Appendix A. Adhere to any UC ergonomics policies, including installing a BSC with the user ability to adjust height. • Perform a risk assessment to determine if the BSCs can be safely exhausted back into the room or if they require a thimble or hard connection. Hard ducted cabinets (B1 or B2) cannot be installed without consultation with

EH&S.

4. For labs that will be performing aerosol challenges, consideration must be given to Class III BSC with enhancements (e.g. double door sterilizer or dunk tank) or other primary containment devices. Work with HCLD and EH&S for risk assessment of specific aerosol challenges. [20, 21, 22] • Provide HEPA filtration for supply and exhaust of Class III BSCs. • Class III BSCs must be directly (hard) connected up through the second exhaust HEPA filter of the cabinet. Supply air must be provided in such a manner that prevents positive pressurization of the cabinet.	4. Aerosol challenges shall be conducted within a class III biological safety cabinet, other primary containment device, or other approved inhalation - exposure system capable of withstanding rigorous decontamination by disinfectants required by the program.	4. N/A

Flow Cytometry

Minimum Standards	Explanation	Best Design Practice
5. If flow cytometers are used in a BSL-3 facility, they must be installed within a biological safety cabinet or other primary containment device specifically designed for the purpose of containing any aerosols produced. [23, 24]	5. N/A	5. N/A

Centrifuge

Minimum Standards	Explanation	Best Design Practice
6. Centrifuges shall be equipped with gasketed safety cups, sealed rotors or operated only within a BSC. [25, 26, 27]	6. N/A	6. N/A

ABSL-3 Standard Equipment References

1. A method for decontaminating all laboratory waste is available in the facility, preferably within the laboratory (e.g., autoclave, chemical disinfection, or other validated decontamination method). **BMBL 6th ed. Section IV. Biosafety Level 3.B.9, Section IV. Biosafety Level 3.D**
2. Solid waste shall be decontaminated by use of an autoclave. Autoclaves with a double door pass through function are preferable, but single door autoclaves are acceptable. **NIH DRM Section 4.9.10**
3. An autoclave for decontaminating laboratory wastes is available preferably within the laboratory. **NIH Guidelines Appendix G-II-C-4-h**
4. All equipment integral to the containment barrier requires a manufacturer supplied biological seal in the containment wall. The biological seal shall be a structural stable, mechanically fastened gasketed seal capable of containing decontaminating gas and allowing for differential movement and remaining intact for gaseous decontamination protocols. **NIH DRM Section 2.6.2.5**
5. Design documents shall include large scale penetration details for each type of barrier wall, floor and ceiling penetration including bioseals. **NIH DRM Section 2.6.4.1**
6. Penetration seals shall be readily visible (when applicable) for inspection, cleaning, and maintenance. **ANSI Z9.14 Section 8.3.2**
7. Pass through autoclaves shall not permit door opening on the clean side prior to completion of a validated decontamination cycle. **NIH DRM Section 4.9.10**
8. Interlocks shall be connected to the Building Automation System. **NIH DRM Section 4.9.3.2**
9. A sink shall be located in the clean side of autoclaves for disposal of sterilized liquid waste. **NIH DRM Section 4.9.10**
10. The floor sink for receiving the sterilized chamber condensate shall be located on the clean side of the bioseal, typically in the utility service access space. **NIH DRM Section 4.9.10**
11. A pass-through autoclave from containment to an anteroom outside of the containment barrier eliminates the need for transport of contaminated material outside of containment **NIH DRM Section 2.5.4.2**
12. Clean side autoclave doors shall not open directly onto a public corridor but shall open into a vestibule with doors separating it from the laboratory. **NIH DRM Section 4.9.10**
13. The room shall have adequate exhaust capacity to remove heat, steam, and odors generated by the use of the autoclave. **NIH DRM Section 4.6.1.12.C**
14. A canopy exhaust hood shall be provided above the autoclave door to capture steam and odors. In two-door pass through configurations, a canopy hood is required above the non-containment side door. A second exhaust hood may be required over the containment side door if the program calls for autoclaving materials into the containment barrier. Canopy hoods on the containment side shall be connected to the HEPA-filtered containment zone exhaust system. Canopy hoods on the non-containment side shall be connected to the non- containment exhaust system. **NIH DRM Section 4.9.10**
15. Each laboratory area shall be provided with designated space for the safe storage of biological. **NIH DRM Section 2.1.3.7.4**
16. Laboratories shall be designed with a room for temporary storage of hazardous waste. **NIH DRM Section 1.11.3.4**
17. Risk Assessment, Systems Failure & Disaster Mitigation **NIH DRM Section 1.15.6**
18. All procedures involving the manipulation of infectious materials are conducted within a BSC or other physical containment device, when possible. **BMBL 6th ed. Section IV. Biosafety Level 3. B**
19. Placement of fume hoods and BSCs in laboratories shall be in accordance with the Biological Safety Cabinet Placement Guide. **NIH DRM**

20. BSCs are located away from doors, heavily traveled laboratory areas, and other possible airflow disruptions. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
21. Class III BSCs are provided supply air in such a manner that prevents positive pressurization of the cabinet or the room. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
22. BSCs can be connected to the laboratory exhaust system by either a canopy connection (Class IIA only) or directly exhausted to the outside through a hard connection (Class IIB, IIC, or III). **BMBL 6th ed. –Section IV. Biosafety Level 3.D**
23. Aerosol challenges shall be conducted within a class III biological safety cabinet or other approved inhalation- exposure equipment capable of withstanding rigorous decontamination using chemicals required by the program. All materials in the containment cabinet shall be decontaminated prior to exiting the cabinet. An in-line double-door sterilizer and a dunk tank or fumigation integral to the BSC may be required based on risk assessment and program requirements. **NIH DRM Section 4.9.11.C**
24. Equipment that may produce infectious aerosols is used within primary barrier devices that exhaust air through HEPA filtration or other equivalent technology before being discharged into the laboratory. These HEPA filters are tested annually and replaced as needed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
25. Ensure that continuous flow centrifuges or other equipment that may produce aerosols are contained in devices that exhaust air through HEPA filters before discharge into the laboratory. **NIH BSL-3 Certification Section II-10**
26. Equipment that may produce infectious aerosols is used within primary barrier devices that exhaust air through HEPA filtration or other equivalent technology before being discharged into the laboratory. These HEPA filters are tested annually and replaced as needed. **BMBL 6th ed. Section IV. Biosafety Level 3.D**
27. Equipment used for handling and analyzing infectious agents in laboratories, such as pipettes, blenders, centrifuges, sonicators, vortex mixers, cell sorters, and matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) mass spectrometers are potential sources of aerosols. **BMBL 6th ed. Section II. Biological Risk Assessment**

Appendix I

UC ABSL3 Design Standards Deviation Request Form

To initiate a deviation request, present this completed form to your campus High Containment Laboratory Oversight Group (HCLOG) for review. As part of the HCLOG review, ensure approval by your campus AHJ. Once approved by the campus HCLOG, the request will be provided to the systemwide High Containment Laboratory Oversight Committee (HCLOC) for final review.

As part of the review process, the HCLOC Chair will select a subcommittee of five designated reviewers. One member shall be an HCLOG chair from a location other than the submitting campus, one member shall be the HCLD from the submitting campus, and the remaining three members will be chosen by the HCLOC Chair or Vice Chair. The subcommittee will strive to provide the submitting campus a decision within 10 working days of receiving all the necessary information.

Please note financial restrictions do not outweigh safety requirements. Requests for deviations cannot be based solely on financial constraint.

Campus:

High Containment Lab Director:

Campus ABSL3 Building Location Details (see request for relevant documentation below)**:**

Principle Investigator(s):

Date: Click or tap to enter a date.

UC ABSL3 Design Standard – provide the standard section or sections you are seeking to deviate from

Section:

Number:

State the standard:

Justification for Deviation

Explain why you are unable to adhere to the standard:

Discuss any alternate plans for mitigation:

Discuss any possible risks associated with the deviation:

Proposed research

Overview of research projects to be conducted in the facility:

List proposed agents/toxins in use:

Select Agents:

Select Toxins:

Tier 1 Select Agents/Toxins:

List any other applicable Federal Agency Requirements:

List experimental procedures:

Describe standard laboratory procedures:

Describe any proposed high-risk procedures:

Discuss any future projects or plans for this facility:

Personnel

How many ABSL3 users:

Support staff:

Facility Layout – provide a full description of the space

Describe the laboratory space:

Is there an anteroom:

Will there be ABSL3 space:

Relevant documentation – attach the following:

1. Laboratory Floor Plans
2. Building Floor Plans
3. Facility Specifications
4. Mechanical Plans
5. Approved BUAs or Research Summaries

Submitting Campus Signatures:
HCLOG Chair
HCLD
HCLOG Review Date: Click or tap to enter a date.

HCLOC Review Notes:
Date Received: Click or tap to enter a date.
HCLOC review notes and decision:
Date Returned to submitting campus: Click or tap to enter a date.