A/BSL3 Laboratory Design

Laboratory Biosecurity for BSL3 Laboratories
Nashville, TN
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www.biosecurity.sandia.gov

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Laboratory Design and Commissioning

Cancer Research Center,
Medical College of Georgia

The Laboratory Design Process

- **1. Planning**
  - Define project / team
  - Budget
  - Schedule
  - Owner requirements
    - **Goals**
    - **Functional requirements**
    - **Preliminary biosecurity and biosafety risk assessment**
    - **Codes, Standards, Guidelines**
- **2. Design**
  - Budget
  - Schedule
  - Finalized biosecurity and biosafety risk assessment
  - Design stages
  - Construction documents – drawing and specifications
- **3. Construction**
  - Procurement
  - Budget
  - Construction schedule
  - Build
    - **Installation and Inspections**
    - **Startup and testing**
    - **Commissioning**
    - **Primary containment certification**
    - **Training**
  - Turnover
- **4. Occupancy**
  - Move in
  - Training
  - Go hot
  - Periodic testing, commissioning, and certification

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The Laboratory Design Participants

- Architects/Engineers
- Biosafety Personnel
- Biosecurity Personnel
- Building Maintenance Personnel
- Principal Investigator(s)
- Animal Care Personnel
- Facility Upper Management
- Commissioning Consultant
- Security Personnel

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Design Considerations for BSL-3 Laboratories

BSL-3 Physical Space Recommendations

- Builds upon recommendations for BSL-1 and BSL-2
- Biohazard warning sign posted at the entrance
- Separated from other areas with restricted access
- Double door entry through self closing and interlocked doors
- Ante room with clear delineation between clean and dirty
- Adequate storage space for street clothes
- Adequate space for PPE storage, electrical outlets for PAPRs, if required.
- Walls, floors, and ceilings smooth and easy to clean
- Envelope penetrations sealed to facilitate decontamination
- Windows closed, sealed, break resistant
- Hand washing station with hands-free operation
- Autoclave available in containment area
- Personnel Shower, if identified by RA
- Sustainability and maintainability are key

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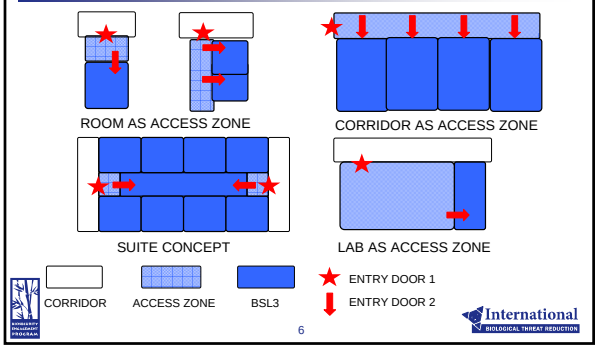
Double Door Entry Necessary for BSL3 Laboratories



BSL-3 Engineering Recommendations

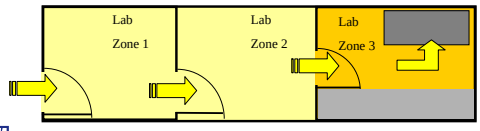
- Ducting systems designed to facilitate gaseous decontamination
- One-pass directional airflow with visual indicator
- Differential pressure vs. volumetric offset
- Controls to prevent sustained positive pressurization
- Monitored HVAC system
- HVAC control sequences for power interruption/failure and power restoration
- Interlock supply and exhaust
- Exhaust discharged away from occupied buildings and air intakes
- Exhaust HEPA filters, if identified by RA
- Interlock supply and exhaust equipment
- BSC's located away from lab traffic, doors, and room supply and exhaust

BSL-3Engineering Recommendations, Cont.

- N+1 exhaust system, N+1 for supply system, if feasible
- Emergency power for HVAC systems and critical lab equipment
- Typical ventilation rate, 10 ACH
- Future flexibility
- Laminar (surgery room) diffusers
- Backflow prevention for water supply
- Vacuum breakers at each laboratory sink
- Vacuum lines protected with traps and HEPA filters
- Sprinkler heads, if required, pendant mounted
- Surface mounted light fixtures
- Emergency lighting
- Access to equipment provided outside containment envelope
- Liquid effluent decontamination system, if identified by the RA
- Lab gases stored outside the containment zone.

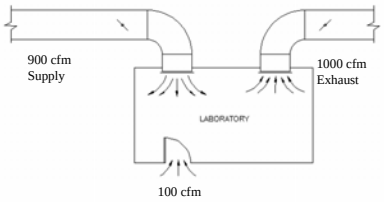
Directional Airflow

- **When Do You Need Directional Airflow?**
- **Airflow Offset Control**
  - Cascading airflow from lower levels of containment to higher levels
  - Relies on differential air pressure achieved by volumetric offset between supply and exhaust
  - Inflow of airflow through doors
  - Provides "Zone Control" of hazards and odors



Airflow

Volumetric Airflow Offset Control



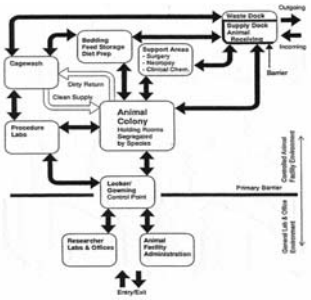
BSL-3 Air Balance Schematic

Design Considerations for ABSL-3 Laboratories

ABSL-3 Physical Space Recommendations

- Builds upon recommendations for ABSL-1, ABSL-2, and BSL-3
- Hand-washing facilities provided in anteroom.
- Personnel shower(s) provided in anteroom.
- An incinerator should be readily available.
- Careful attention paid to personnel, product, and waste flow.
- Adequate storage for feed, bedding, and pharmaceuticals.
- Adequate space for washing and sterilization equipment
- Adequate storage for clean (sterilized) cages.
- Locate vivarium support equipment away from breeding areas
- Adequate space for surgery and/or necropsy
- Adequate cold storage space for carcasses
- Adequate space for animal support personnel
- Adequate space for processing newly arrived animals
- Wall and door bumpers

Typical Vivarium Flow Diagram

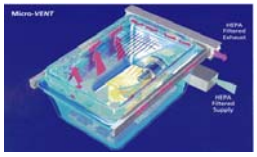


Whole Building Design Guide
www.wbdg.org/images

ABSL-3 Engineering Recommendations

- Diurnal lighting cycle
- Exhaust HEPA filters
- Typical ventilation rate, 15 ACH
- Temperature and humidity control varies, dependant on species
- Provisions to maintain temperature in the event of power or equipment failure
- Noise control, 85 db
- Drain pipes, 4” minimum
- Fire alarm: visual vs. audible
- Individual ventilated and open caging systems
- Floor drains filled with disinfectant
- Odor control measures
- Animal watering systems

Individually Ventilated Cage (IVC) Systems



Commissioning

- **Definition: "A quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria." ASHRAE Guideline 0**
- **Benefits:**
  - **Early detection of potential problems**
  - **Fewer change orders during construction**
  - **Verify performance and increase efficiency**
  - **Better facility documentation**
  - **Shortened occupancy transition period**
  - **Additional training for O&M staff**
  - **3rd party verification**
- **Goals:**
  - **Define and document requirements clearly at the outset of each phase and update throughout the process**
  - **Verify and document compliance at each completion level**
  - **Establish and document commissioning process tasks for subsequent phase delivery team members**
  - **Deliver buildings and construction projects that meet the owner's needs, at the time of completion**
  - **Verify that operation and maintenance personnel and occupants are properly trained**
  - **Maintain facility performance across its life cycle**
- **When: Throughout process – planning, design, construction, occupancy**

Commissioning Responsibilities Throughout the Development of a New LAB

- **Planning Phase**
  - Establish commissioning team
  - Review owner requirements
  - Scope and budget for commissioning
  - Develop plan for commissioning
- **Design Phase**
  - Develop commissioning specifications
    - **Process**
    - **Component verification checklists**
    - **Systems test forms**
    - **Integrated systems forms**
    - **Training**
    - **Documentation**

Commissioning Responsibilities Throughout the Development of a New LAB

- **Construction Phase**
  - Commissioning schedule
  - Complete component verification checklists
  - Develop test procedures
  - Test
  - Oversee resolution of issues
  - Training
- **Occupancy Phase**
  - Warranty review
  - Seasonal testing
  - Oversee resolution of issues
  - Document baseline

Commissioning Test Process

- **Pre-functional test**
  - Verification that component meets design intent and technical requirements
  - Verification that component is installed with adequate maintenance access
- **Functional test**
  - Testing to ensure fully functional system under all operational parameters
- **Integrated system test**
  - Interdependency of systems and final facility validation
- **Planted failure test**
  - Failures created by the commissioning team to test the ability of the maintenance team/users to respond, report, and correct problems

Summary

- **Biosafety and biosecurity risk assessment should be a central factor when developing the facility design**
- **Biocontainment can be achieved through a variety of strategies**
  - Balance of primary barriers, secondary barriers, and procedures and practices
- **Every lab is unique – need to ensure lab will work as intended**
  - Commissioning
- **Designing and building a lab is only the start**
  - Must plan for maintenance and long-term sustainability