BSL-3 Planning, Programming, and Operations Workshop

SAND2008-4268C

BSL3 Design Phase – Laboratory Design

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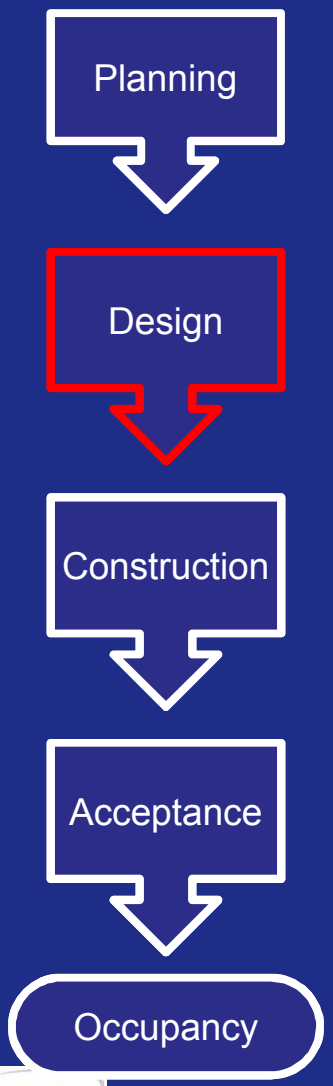
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-9AL85000.

Design Topics



- **Selecting design team with right expertise**
- **Selecting commissioning team with right expertise**
- **Facility type?**
  - Bricks and mortar or modular?
- **Building location**
- **Flows of personnel, materials, and waste**
- **Allocate mechanical space**
- **Address considerations for:**
  - Building control systems
  - Laboratory casework
  - Autoclaves
- **Plan for reviews**
  - Design
  - Peer
  - Value engineering
- **Complete commissioning plan**

Design Participants

- Participants in the Laboratory Planning Process, plus
- Architectural and engineering (A&E) firm, and
- Commissioning consultant

- Also consider hiring a peer review team

- Remember, it's much cheaper to change paper designs than to fix during construction or renovate after occupation

Design Process Overview

- **Schematic Design (Planning document to 20%)**
  - Completed list of laboratory equipment for each space
  - Further develop floor plans
  - Develop personnel, product, and waste flow diagrams
  - Finalize the Biosafety Risk Assessment
  - Finalize the Biosecurity Risk Assessment
  - Review budget (including design contingency, bid contingency, and construction contingency)
  - Coordinate between disciplines (structural, mechanical, electrical, plumbing, etc.)
  - Calculate preliminary heating and cooling loads

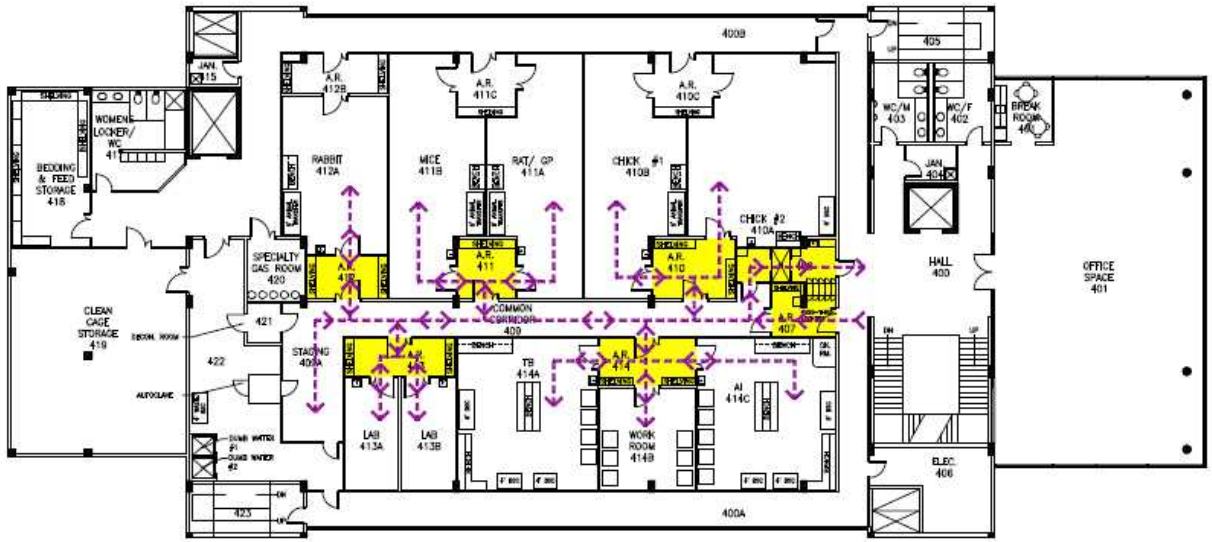
Design Process Overview continued

- **Design Development (20% to 50%)**
  - Finalize floor plans
  - Finalize heating and cooling loads
  - Duct & piping shown, but not sized
  - Develop general specifications
  - Review budget (design contingency should be reduced to half)
  - Coordinate between disciplines

- **Construction Documents (50% to 100%)**
  - Complete floor plans and specifications
  - Review budget (deign contingency should be zero)
  - Coordinate between disciplines

Develop Flow Diagrams for Personnel, Materials, Waste

- **Personnel flow**
  - Determine the path of travel for the laboratory users.
- **Product/material flow**
  - Determine the path of travel for the products used within the laboratory, including live organisms, equipment, animals, supplies, cages, etc.
- **Waste flow**
  - Determine the path of travel for the waste to exit the lab.



LEGEND

Ante Room - PE Don/Doff

Laboratory Personnel Flow

BIOSECURITY ENGAGEMENT PROGRAM

International BIOLOGICAL THREAT REDUCTION

Analysis of Laboratory Flows

- **Identify clean and dirty areas and corridors and grey zones**
  - Explicitly consider procedural controls versus engineering controls (primary and secondary barriers)
- **Make decisions about doors**
  - Where required for pressure differential between spaces
  - Where needed for programmatic reasons (e.g. security, to delineate research spaces, etc)
  - Determine where anterooms are needed
- **Determine space requirements for storage of PPE and supplies**
- **Identify areas for donning and doffing of PPE**
- **Identify BSL2 areas that support the BSL3 areas**

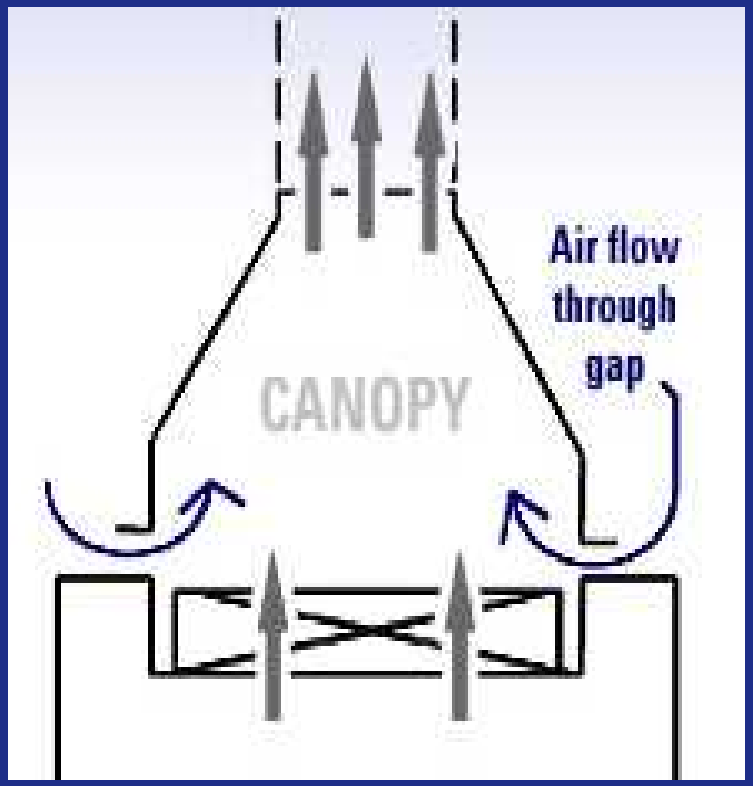
Laboratory Design – Primary Containment

Why does BSC selection matter?

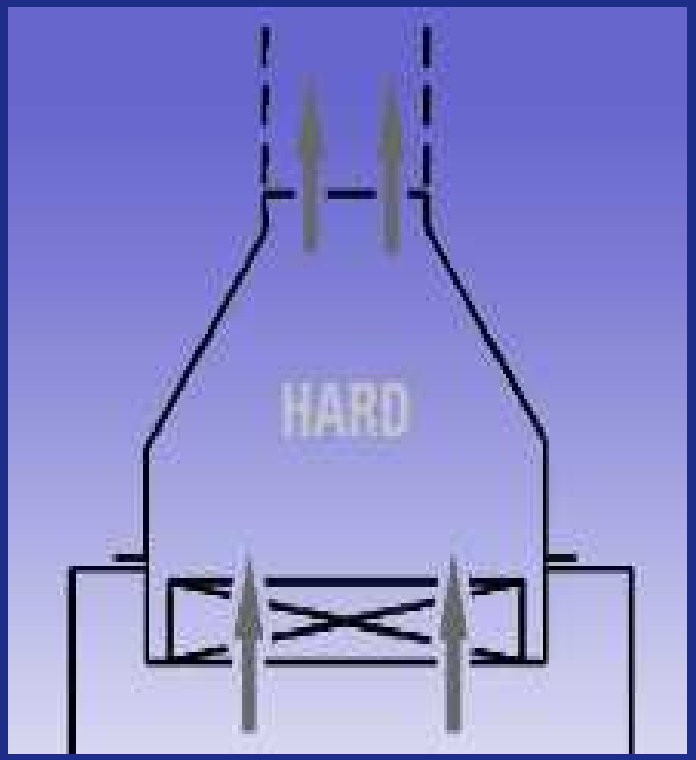
BSC Type	Impact on:		
	ACH	Exhaust System	Exhaust Duct
A2, re-circulating	None	None	None
A2, indirect duct connection	Moderate	Low	Low
B2, total exhaust	High	High	High

Laboratory Design – Primary Containment

Indirect (thimble/canopy) Connection



Direct (hard) Connection



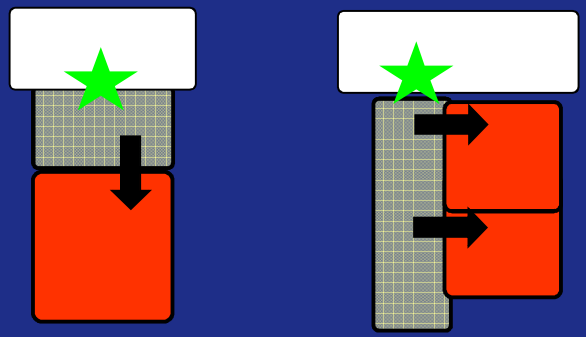
Laboratory Design – Air Changes Per Hour

- **How do I calculate the ACH for my laboratory?**
  - What you need to know:
    - **Exhaust air flow rate**
    - **The interior volume of the laboratory: (length) * (width) * (ceiling height)**
  - Formulas to use:
    - **n = 60 * Q / V (Imperial Units)**
    - **n = 3600 * Q / V (SI Units)**
    - **Where n = ACH, Q = exhaust air flow rate, and V = interior volume**
  - What are typical ACH for laboratories?
    - **10 – 12 ACH for conventional laboratories**
    - **10 – 15 ACH for animal areas**
    - **In excess of 20 ACH can create ambient conditions not conducive to safe BSC operation**

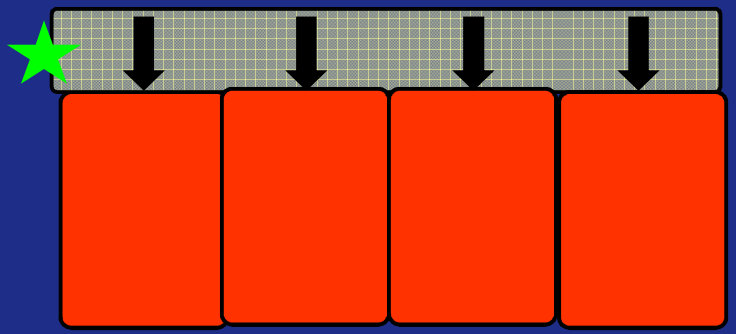
Laboratory Design – Physical Space Recommendations

- 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

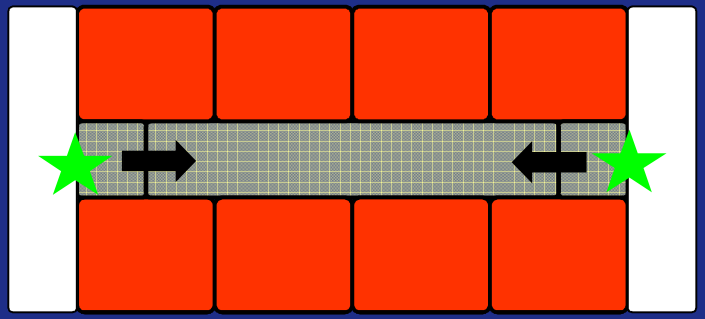
Double Door Entry Options



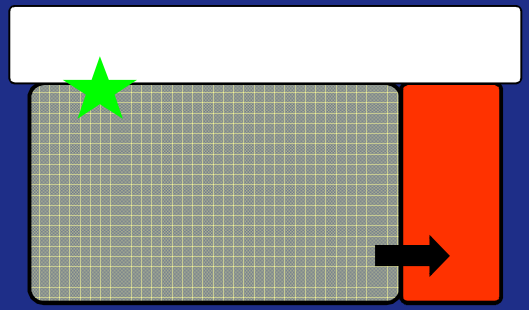
ROOM AS ACCESS ZONE



CORRIDOR AS ACCESS ZONE



SUITE CONCEPT



LAB AS ACCESS ZONE

Laboratory Design – 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

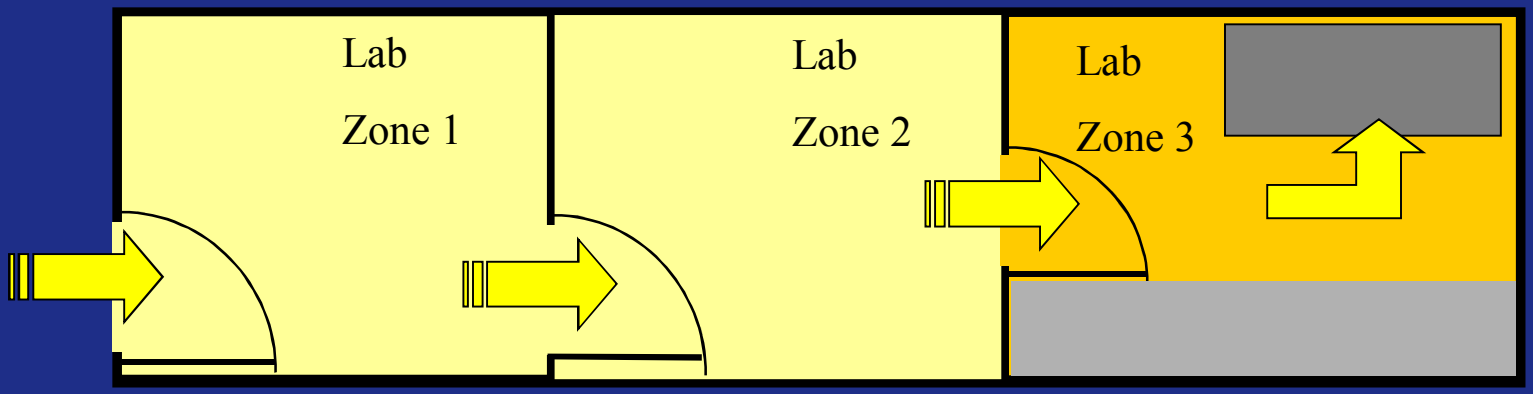
Laboratory Design – Engineering Recommendations

- 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

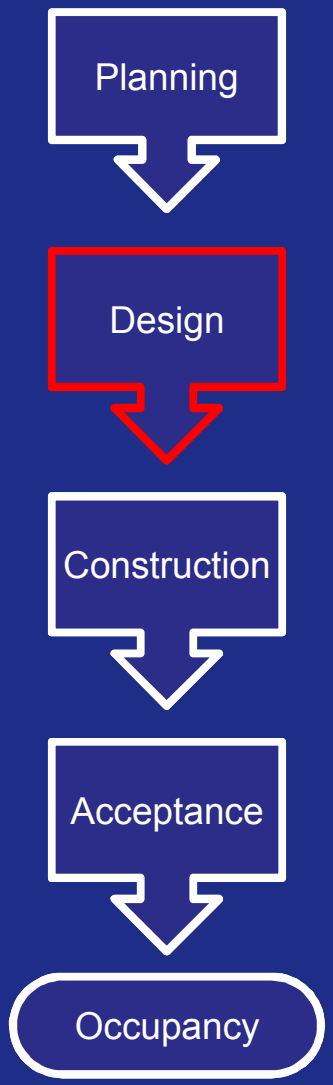
- **When Do You Need Directional Airflow?**
  - All BSL-3 laboratories

- **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

Summary



- **Laboratory personnel develop an accurate and complete laboratory equipment list for each space**
- **Coordination between disciplines**
- **Effort spent in design phase is well-spent**
  - Can help minimize likelihood of costly change orders or post-construction renovations
  - Hire a commissioning consultant early in the design process
  - Hire a peer review team
- **Monitor budget for the facility and construction market costs throughout the entire process**