Optimizing HVAC Performance and Biosafety in an Operational BSL-3 Lab:

The SEBLAB Renovation Success Story

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UAB The University of Alabama at Birmingham.

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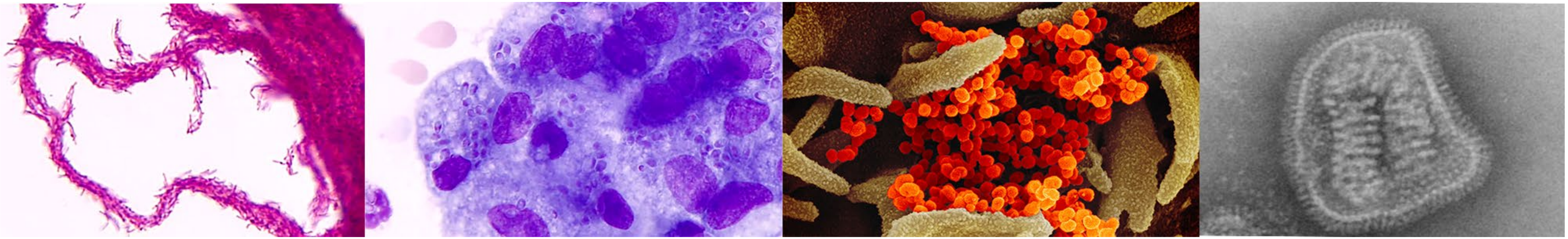
Presenter



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LEARNING OBJECTIVES

1. Understand Biosafety Levels BSL-1 through BSL-3.

2. Grasp infrastructure and safety requirements for BSL-3

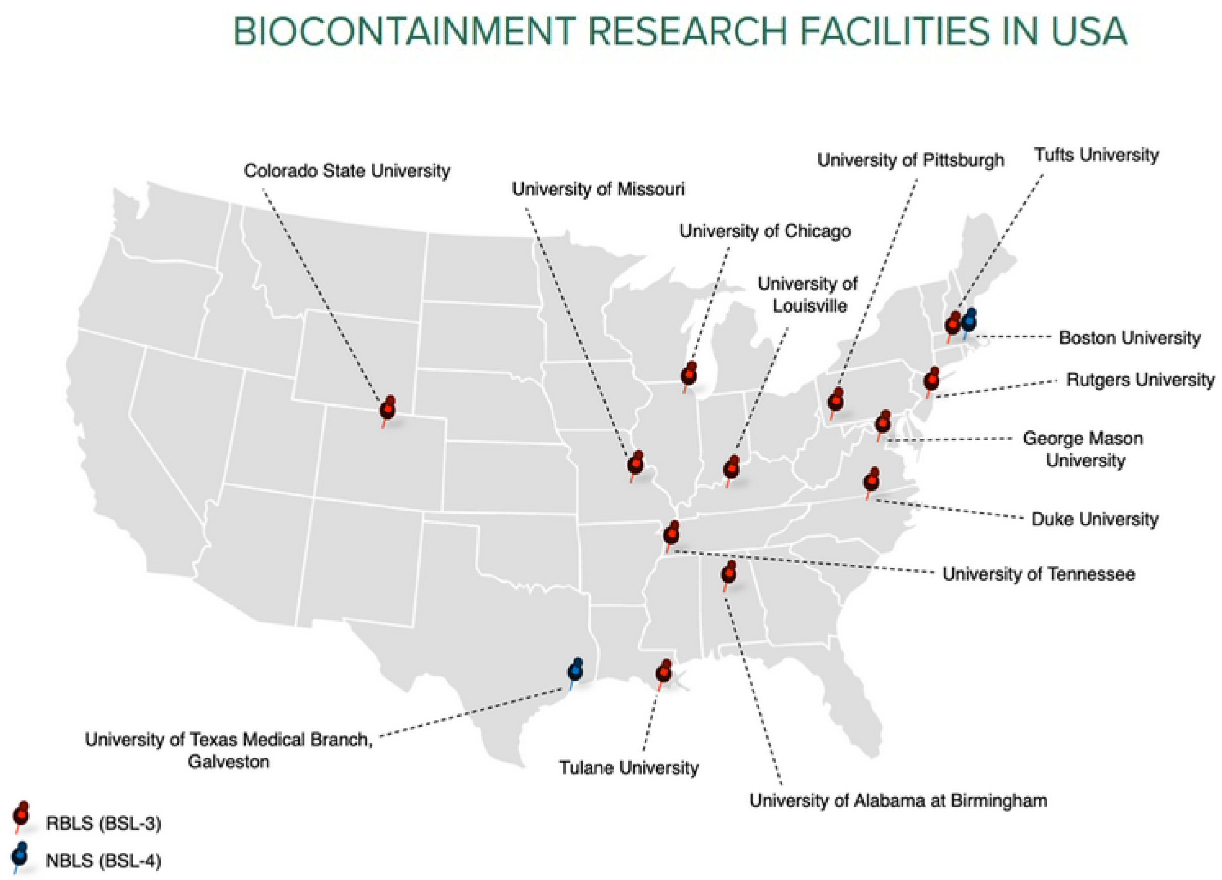
3. Recognize the importance of collaboration in operational BSL-3 laboratory upgrades

4. Learn laboratory style exhaust control strategies for energy conservation and resiliency.

5. Identify common startup and commissioning pitfalls

What is Biosafety

Safety precautions to limit exposure to infectious agents and protect the lab and community.



NATIONAL BIOCONTAINMENT LABORATORIES (NBLs)

- Boston University
- University of Texas

REGIONAL BIOCONTAINMENT LABORATORIES (RBLs)

- Colorado State University
- Duke University
- George Mason University
- Rutgers University
- Tufts University
- Tulane University
- **University of Alabama at Birmingham**
- University of Chicago
- University of Louisville
- University of Missouri
- University of Pittsburgh
- University of Tennessee

Biosafety Level 1 (BSL-1)

- Low-risk microbes (non-disease causing).
- Example: Non-pathogenic *E. coli*.

Requirements:

- Standard lab practices
- PPE as needed
- Open bench work permitted

Biosafety Level 2 (BSL-2)

- Moderate-risk microbes
- Example: *Staphylococcus aureus*

Requirements:

- Everything from BSL-1 **PLUS**
- Restricted access
- PPE (gloves, eye protection, face shields)
- Biosafety cabinets for aerosol-generating procedures
- Decontamination (e.g., autoclave)

Biosafety Level 3 (BSL-3)

- High-risk, airborne transmission
- Example: *Mycobacterium tuberculosis*

Requirements:

- Everything from BSL-2 PLUS
- All work in biosafety cabinets
- Restricted access at all times
- Anteroom entry
- Full PPE, including respirators

SEBLAB HVAC Renovation Project Goals

Implement the 2021 infrastructure grant involving upgrading aging 2009 systems to Improve safety, resiliency, and energy efficiency

Scope:

- Retrofitting AHU supply fans
- Replacing high-plume exhaust fans
- Pneumatic to DDC control upgrades
- HEPA exhaust system modifications

BSL-3 HVAC Infrastructure Requirements

Original construction requires system verification

- No airflow reversal upon failure
- HEPA-filtered exhaust
- N+1 Redundancy for main equipment

System Re-verification required after:

- Major equipment replacement (fans, valves, BAS)
- Control system changes

Project Planning & Collaboration

- Multi-stakeholder coordination:
    - Facilities, EH&S, Researchers, Security
- Key questions addressed:
    - Can labs stay operational?
    - What work can be preformed while labs are operational.
    - Contractor access protocols
    - Pre-implementation planning critical to avoid poor outcomes during construction

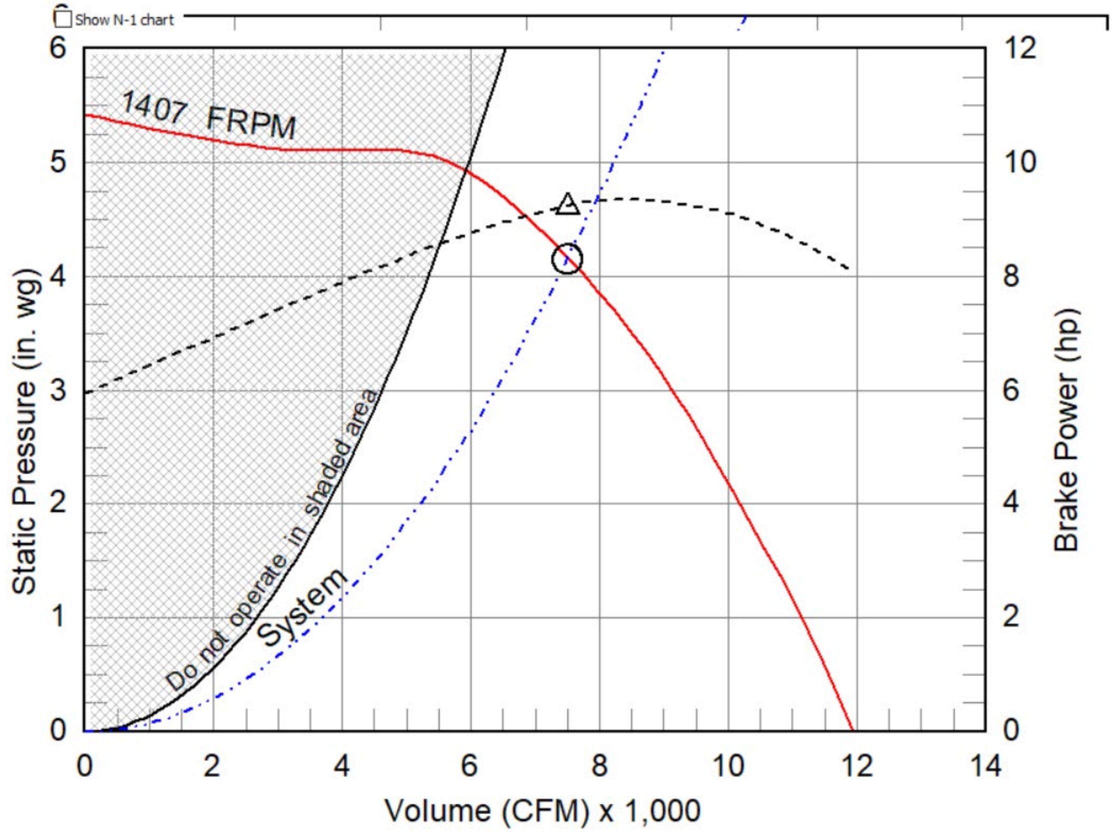
Typical Mixed Flow Exhaust System with Bypass Damper

- Typically, one exhaust fan operates continuously at 100% speed while bypass dampers modulate to control duct pressure
- Typical Selection 3000 to 5000 fpm exhaust velocity at design
- As system airflow reduces or required duct pressure is less than design Exhaust velocity increases as bypass damper opens

Fan Selection & Redundancy

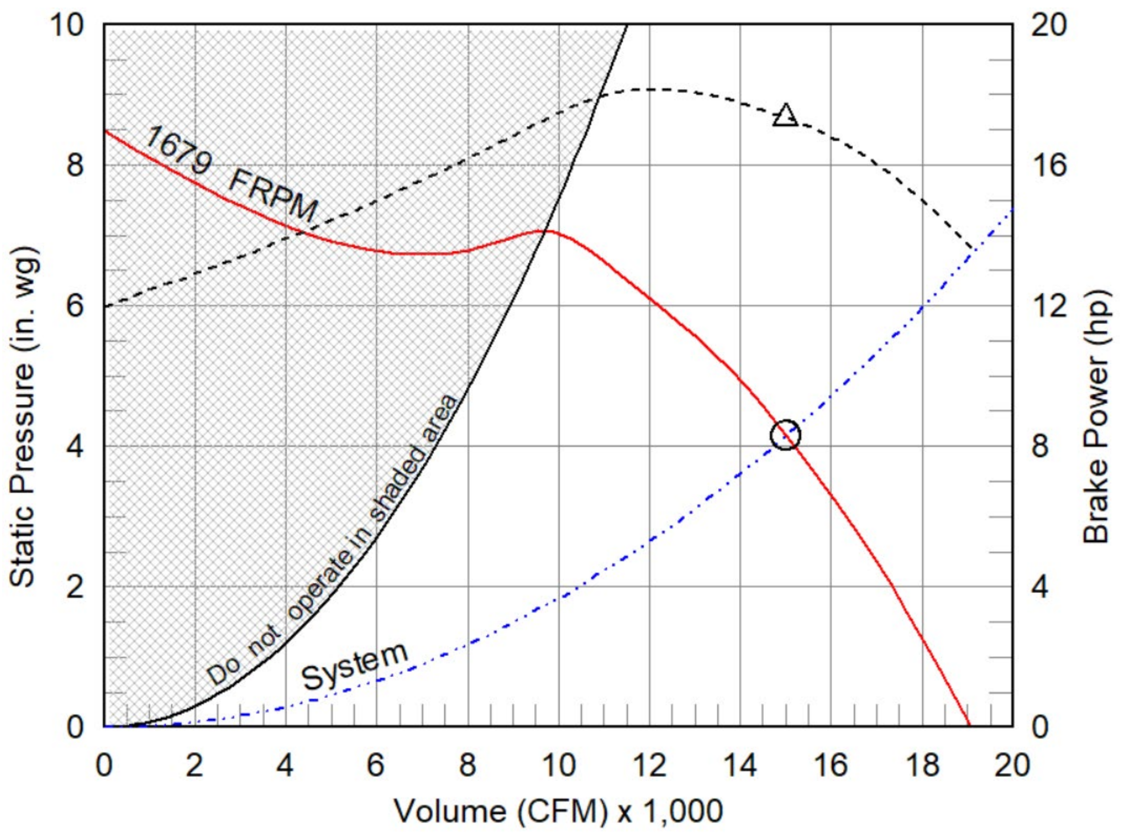
- AHU supply Fan Array designs often utilize selections with one failed fan and parallel operation
- Exhaust system was also selected for parallel operation for resilient system operation with the VFD for controlling duct static pressure for.
- Careful selection is required to operate in both modes parallel and failure condition (N-1).

Parallel Exhaust Fan Selection & Real world BSL-3 Comparison



- Airflow station and bypass can be utilized for stack velocity control.
- To operate without airflow stations parallel operation requires a faster than typical discharge under “failure” condition
- This parallel operation selection is 3800 fpm exhaust velocity no bypass airflow
- 9.22 hp *2 fans = 18.44hp
- Failure condition one fan 28.29hp

Parallel Exhaust Fan Comparison



- Real world typically selected BSL-3 exhaust fan example Selection N+1 operation 3500 fpm ~17.5 hp
- Parallel fan operation has comparable hp requirements while providing additional system resiliency
- Fan laws state HP decreases by the cube of speed.
- VFD fan speed reduction provides energy savings when the system is not at design.

Increased Energy Efficiency Variable Flow Heat Recovery and Two-Way Valves

- Fieldwork revealed 3-way valves on the AHU heat recovery coils.
- The bypass flow around the AHU coils reduced the effectiveness of the heat recovery system = lower energy demand.
- After conversations with the owner, pump VFDs and minor sequence changes increased heat recovery.
- **Result:** Enhanced performance & reduced energy use

Implementation, Commissioning & Verification

- Project Schedule updated each construction meeting.
- Shutdowns were carefully planned and coordinated to reduce risk to manageable levels
- Building wide exhaust shutdown was scheduled to allow a research to reach a stopping point
- Entire ABSL-3 suite was decontaminated to allow work to progress.
- Startup and Commissioning activities occurred off-hours to mediate risk

Implementation Lessons Learned: VFD Damper Permissive Overview

- Modified damper permissive sequence allows a fan to start into a live system without spinning backwards.
- The sequence requires VFD to start at minimum speed before commanding damper Open
- Once damper end switch communicates the damper is open VFD speed is released
- Some VFD manufactures include this logic while other manufactures require an additional Relay
- System failed first commissioning test even after coordination of drawings, submittals, and pre-shutdown meetings

Implementation Lessons Learned: Ductwork Testing

- BSL-3 requires duct pressure testing of stainless steel ductwork.
- Project required ductwork pressure testing of all new work
- Leaks were found in previously hidden existing ductwork which required sealing

Implementation Lessons Learned: Actuator Speed

- The project included changing pneumatic dampers actuators to DDC.
- During startup testing AHUs were alarming because the controls timers were not updated for the slower damper actuators.
- Pneumatic actuators are much faster than typical 60 to 90s electronic actuators.
- Fast acting actuators have limited in-lbs. not conductive to large AHU dampers.

Implementation Lessons Learned: Fan Direction

- A fan running backwards will still produces airflow
- Reduced performance can mask configuration issues
- The first AHU startup had 3 of the 4 fans spinning in the wrong direction.
- Each fan required bumping to determine direction
- Redundant VFD or bypass also requires direction verification, can change directions.

Key Takeaways

- **Safety:** BSL-3 containment imperative for design and implementation
- **Resiliency:** Redundant systems, improved controls
- **Efficiency:** Energy savings through recovery & controls
- **Collaboration:** Essential across all stakeholder groups
- **SEBLAB:** Now a model for future BSL-3 HVAC upgrades

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Questions ?

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