

**Plumbing for High Containment
(Part 1)**
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Disclaimer

- The information provided is for aiding the engineer or designer in the design of plumbing systems for High Containment. The information provided does not address all the possible specifics of each project. It is the engineer or designer's responsibility to apply this information to the specifics of the facility being designed.

Learning objectives will address the following:

1. Learn what guidelines and standards apply to high containment facilities design.
2. Develop an understanding of the biosafety levels and the impacts they have on the design of systems.
3. Understand what systems may be required for BSL-3's and higher levels of containment.
4. Understand the importance of isolation of systems and containment & treatment of wastes.
5. Understand the importance of reliability, redundancy and maintainability of the systems for these areas.
6. Lessons learned.

Introduction:

THE 3 W's

Why

1. Since 2001 a major increase in the funding for research in biomedicine has occurred. A large part of this funding has been used for the construction of BSL-3 and BSL-4 high containment facilities.
2. This increase is intended in developing new countermeasure to protect the public from the threat against bio-terrorism (i.e. infectious diseases and biological agents) and to accelerate the development of diagnostics, vaccines and therapies to combat these new threats.
3. To provide individual state(s) response to bio-terrorist threats.

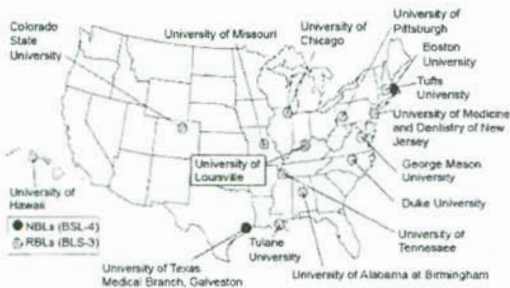
Who

- As of October 2007 no single government agency is responsible to track how many facilities exist in the US.
- 2005 NIH survey estimates at present time there are approximately 275 BSL-3 laboratories in the US.
- 2005 survey by Department of Homeland Security (DHS) and Department of Health and Human Services (HHS) estimates there are approximately 600 BSL-3 laboratories in the US.
- The General Accounting Office (GAO) October 2007 report based upon CDC & USDA information estimates the number of BSL-3 laboratories at 1356 within the US.

- The same GAO report estimates the number of BSL-4 laboratories since 2001 has increase from 5 to 15 within the US.
- Primarily funded by National Institute of Allergy and Infectious Diseases (NIAID) and the National Institutes of Health (NIH).
- NIAID has provided funding for 13 new Regional Bio-Containment Laboratories (RBL's) and 2 National Bio-Containment Laboratories (NBL's).

Current/Under Construction National Biocontainment Laboratories (NBL) and Regional Biocontainment Laboratories (RBL)

Source NIAID



Existing BSL-4 Facilities in North America

- Canadian Science Center – Winnipeg, Canada
- Center for Disease Control & Prevention – Atlanta, GA
- Georgia State University – Atlanta, GA
- National Institutes of Health – Bethesda, MD
- Southwest Research Institute – San Antonio, TX
- USAMRIID Fort Detrick – Frederick, MD

What - Not in my back yard?

(High Profile, Highly Publicized and Very Sensitive)

1. What is a Bio-safety Laboratory?
2. What will be studied?
3. Why in my back yard?
4. How would the community benefit from the facility?
5. What is the safety record of existing facilities?
6. How will the agents be transported?
7. Who will provide oversight & inspection of these facilities?
8. What bio-safety measures will be incorporated?
9. Safety protocols
10. Will bio-weapons be developed?
11. Will background verification of personnel be done?
12. How will the community be notified in the event of an emergency or evacuation?
13. Community awareness
14. What are public concerns and protests.
15. Location – densely populated versus not densely populated areas.

Areas within BSL-3 and BSL-4 High Containment Facilities

- Animal/Ante/Procedure rooms
 - Small Animals (mice, rats, guinea pigs, rabbits, cats)
 - Medium Size Animals (dogs, goats, pigs, primates)
- Laboratory Suites
- Equipment/Support Laboratories
- Surgery/Necropsy Suites
- Rack Sterilizer rooms
- Inner/Outer Changing areas
- Imaging
- Airlocks
- Fumigation rooms
- Chemical Showers
- Specimen Processing room
- Suit rooms
- Aerosol Challenge
- Insect Holding rooms
- Animal Transfer rooms
- Toilet rooms
- Microbiology rooms
- Viral rooms

Make sure you understand the containment levels of your project.



Risk Assessment



risk =
probability x
consequence

Biological Risk Assessment (BMBL)

- Risk assessment is a process used to identify the hazardous characteristics of a known infectious or potentially infectious agent or material, the activities that can result in a person's exposure to an agent, the likelihood that such exposure will cause a laboratory-associated infection, and the probable consequences of such an infection.

Biological Risk Mitigation (BMBL)

- The information identified by risk assessment will provide a guide for the selection of appropriate biosafety levels and microbiological practices, safety equipment, and facility safeguards (through Standard Operating procedures- S.O.P."s) that can prevent laboratory associated infections.

Biosafety



Mad Cow!

Avian Flu!

BSL-1

- Work involving well characterized agents, not known to cause disease in healthy adults.
- Minimum potential hazard to laboratory personnel and to the environment.
- Examples bacteria and viruses including hepatitis, chicken pox & non-infectious bacteria.
- Level of precautions is at a minimum.
- Gloves & eye/face protection.
- Laboratory is not necessarily separated from general traffic patterns.
- Work is conducted on open bench top.
- Washing hands with antibacterial soap.
- Washing exposed surfaces with disinfectant.
- Material used for cell and bacteria culture are decontaminated via autoclave.





BSL-2

- Work involving agents of moderate potential hazard to laboratory personnel and to the environment.
- Examples are bacteria and viruses that cause only mild disease to humans or are difficult to contract via aerosol, including Lyme disease, influenza A, mumps, measles & etc.
- Level of precautions is moderate.
- Gloves & eye/face protection.
- Very careful handling of sharp objects like needles, syringes & scalpels.
- Laboratory personnel are specifically trained in handling pathogens & agents (specific SOPs).
- Access to laboratory is limited and clear of general traffic patterns.
- Work is conducted in bio-safety cabinets or other containment equipment.
- Specific procedures for handling aerosols and splashes, work within bio-safety cabinets or other containment equipment.
- Airflow to/from lab rooms is once through (100% outside air, no recirc.)
- Airflow is balanced to each space to have airflow into highest containment level to ensure capture of agents.







BSL-3

- Work involving agents of high potential hazard to laboratory personnel and to the environment.
- Examples are bacteria and viruses that cause severe to fatal disease to humans for which vaccines or other treatment exist, including anthrax, West Nile virus, Sars, yellow fever, tuberculosis & etc.
- Level of precautions is high.
- Gloves, full face protection, respirator & protective clothing.
- Very careful handling of sharp objects like needles, syringes & scalpels.
- Laboratory personnel are specifically trained in handling pathogens & potentially lethal agents (specific SOPs).
- These areas are considered a neutral or warm zone.
- Access to laboratory is restricted by airlock thru doors in series.
- All work involving infectious material are conducted in bio-safety cabinets or other containment equipment.

BSL-3 (cont'd)

- Specific procedures for handling aerosols and splashes, work within bio-safety cabinets or other containment equipment.
- Class II bio-safety Cabinets with HEPA filtration.
- All penetrations must be well sealed.
- Shower-in/shower-out procedure
- Autoclave incoming and out going materials.
- Airflow to/from lab rooms is once through.
- Airflow is balanced to each space to have airflow into highest containment level to ensure capture of agents.
- HVAC exhaust HEPA filtration recommended.
- Liquid Effluent Decontamination recommended.
- Local vacuum HEPA filtration with disinfectant traps.
- Plumbing vent HEPA filtration recommended.

BSL-3 Lab

Empty box for BSL-3 Lab notes.

BSL-3 Corridor



Floor Sleeve Penetrations

BSL-3E (Enhanced) (Owner's EH&S Directed)

- BSL-3E refers to the protective enhancements corresponding with the risk assessment of the pathogens and requirements for additional protection.
- Generally it is used to identify high containment spaces which have more protective features than a standard BSL-3, but not all those features of a full BSL-3Ag or BSL-4 areas.

BSL-3Ag

- BSL-3Ag refers to research involving large agricultural animals and foreign and emerging pathogens that may cause serious consequences in livestock but that are not harmful to humans because protective measures are available.
- In agriculture, the research involving high consequence livestock pathogens in animal species or other research where rooms/suites provided the primary containment (USDA).
- BSL-3Ag facilities design requirements are similar to most of all the features ordinarily used for BSL-4 facilities as enhancements. All BSL-3Ag must be designed, constructed and certified as primary containment barriers.
- More that often these type of rooms are isolated zones within a lower bio-safety level facility. Zones are strictly controlled access with physical security measures and functions as a box within a box concept.
- Liquid Effluent Decontamination required.
- HEPA filtration – HVAC/Plumbing.

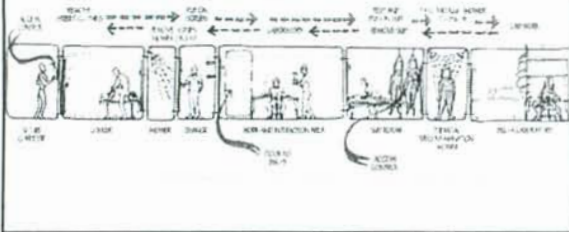
BSL-4

- Work involving the most dangerous, lethal and exotic agents that possess high risk of aerosol transmission. Also agents that cause fatal disease in humans where vaccines or other treatment are not available.
- Examples are Ebola virus, Marburg virus, Lassa fever & smallpox.
- Level of precautions is extremely high.
- Full protection via breathing air supplied chlorinated polyethylene containment suit.
- Mandatory multiple showers-in & shower-out procedures.
- Vacuum room/Ultraviolet light room.
- Access to laboratory is restricted by multiple airlocks thru doors in series.
- Highest security level.
- Laboratory personnel are specifically trained in handling pathogens & potentially lethal agents (specific SOPs).
- Liquid Effluent Decontamination required.
- Work involving agents within class II or III bio-safety cabinets or other containment equipment.

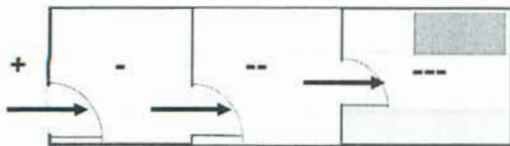
BSL-4 (cont'd)

- Specific procedures (SOPs) and extensive training for dealing with extremely hazardous infectious agents (training labs).
- Understanding of primary and secondary functions of the facility, including equipment and design criteria.
- All penetrations are well sealed with piping welded to imbedded plates.
- All air & water services going to and coming from requires treatment.
- Autoclave incoming and out going materials.
- Main objective to destroy all traces of the Bio-hazard.
- Airflow to/from lab rooms is once through.
- Airflow is balanced to each space to have airflow into highest containment level to ensure capture of agents.
- Other design issues, totally separated building or controlled areas within a building.
- Provide engineering systems to prevent micro-organisms from being released into the environment.
- HEPA filtration – HVAC/Plumbing – required.

Typical progression to & from BSL-4 Containment Area.



HVAC pressurization for BSL-4 containment area.



BSL-4 Containment Labs

- For more details see:

<http://www3.niaid.nih.gov/topics/BiodefenseRelated/Biodefense/PublicMedia/>





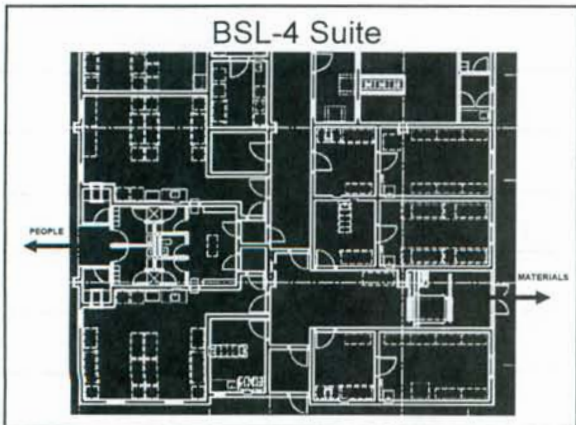
BSL-4 Chemical Shower



BSL-4



BSL-4 Suite



BSL-4 Under Construction

BSL-4 Construction



Floor Sleeve Penetrations

What Codes and Standards Apply?

Practically everything!
Legally - locally adopted codes.
Association Guidelines

Codes
(basic)

- Building Code
- Plumbing Code
- Mechanical Code
- Fire Code
- When Codes or Standards are in Conflict -
Most Stringent Requirements Apply

Codes and Standards Organizations

- NFPA – National Fire Protection Association
- ANSI – American National Standards Institute
- ASME – American Society of Mechanical Engineers
- ASSE – American Society of Sanitary Engineering
- ASTM – American Society of Testing and Materials
- AWS – American Welding Society
- AWWA – American Water Works Association
- CSA – Canadian Standards Association
- CGA – Compressed Gas Association
- CFR – Code of Federal Regulations
- 3-A Standards
- NSF – National Sanitation Foundation International
- EPA – Environmental Protection Agency
- OSHA – Occupational Safety and Health Administration
- AAALAC – Association for Assessment and Accreditation Laboratory Animal Care
- CDC – Centers for Disease Control and Prevention
- NIH – National Institutes of Health

Guidelines and Standards to Consider

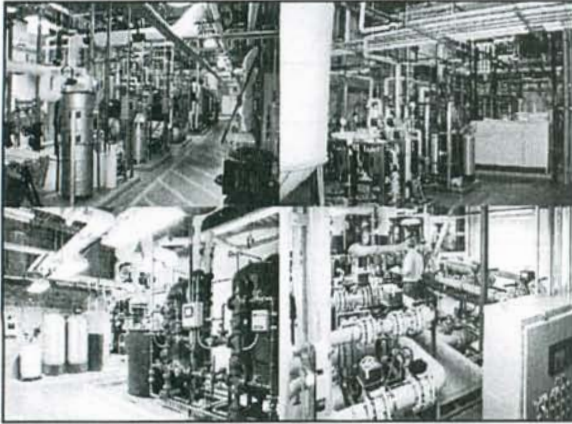
- Guide for the Care and Use of Laboratory Animals
 - by American Association for Laboratory Animal Science
- Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (Ag Guide)
- Bio-safety in Microbiological and Biomedical Laboratories
 - 5th Edition, by the Centers for Disease Control and National Institutes of Health
 - Online at: <http://www.cdc.gov/od/ohs/biosfty/bmb15/bmb15toc.htm>
- Planning and Designing Research Animal Facilities
 - by the American College of Laboratory Animal Medicine (Nov 2008 release date)
- Design Guidelines for the National Institutes of Health

Reference NFPA Standards to Consider

- NFPA 30 - Flammable and Combustible Liquids Code
- NFPA 45 - Standard on Fire Protection for Laboratories Using Chemicals
- NFPA 54 – ANSI Z223.1 National Fuel Gas Code
- NFPA 70 - National Electric Code
- NFPA 99 - Standard for Health Care Facilities

Mechanical Room Equipment

- Locate equipment room towards middle of building footprint to minimize pipe runs and sizes.
- Interstitial Floors.
- Mechanical/Plumbing Rooms.
- Penthouse Mechanical Rooms.
- Layout equipment in a logical order following flow of utility. For Example: Incoming Water Service to Booster Pumps to Water Softeners to Heaters.
- Make sure there is sufficient clearance around and above equipment for service and maintenance.
- Allow main aisles for circulation and equipment replacement.
- Consider doors or removable wall panel to outside to remove large equipment like effluent decontamination tanks.

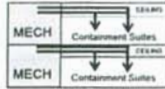


Utility Distribution Considerations

- Horizontal Distribution of Utilities.
- Vertical Distribution of Utilities.
- Service Closets.
- Consider space and/or capacity for future Utilities.
- Locate valves in readily assessable locations. (No ladders)
- Provide sectional valves to minimize disturbances to others.
- Provide gauges & valves to allow for troubleshooting of system during startup.

Utility Distribution Strategies

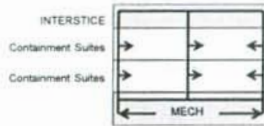
Horizontal
Distribution



- PRO
- LOWER BUILDING HEIGHT
 - MINIMAL SHAFTS
 - HIGH FLOOR PLATE EFFICIENCY
- CON
- LARGE % OF MECHANICAL ROOM
 - PIPING LESS ACCESSIBLE

Utility Distribution Strategies

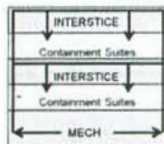
Vertical
Distribution



- PRO
- PIPING & EQUIPMENT ACCESSIBLE IN MECH ROOMS OR CHASES
- CON
- MAY NOT BE PRACTICAL FOR ACCESSIBILITY IN CONTAINMENT AREA
 - VERTICAL SHAFTS REQUIRED
 - LOW FLOOR PLATE EFFICIENCY

Utility Distribution Strategies

Interstitial
Distribution



- PRO
- HIGH FLEXIBILITY
 - MOST ACCESSIBLE EQUIPMENT & PIPING
- CON
- HIGHEST BUILDING HEIGHT
 - HIGHER BUILDING COST

What are the Maintenance and Safety considerations?

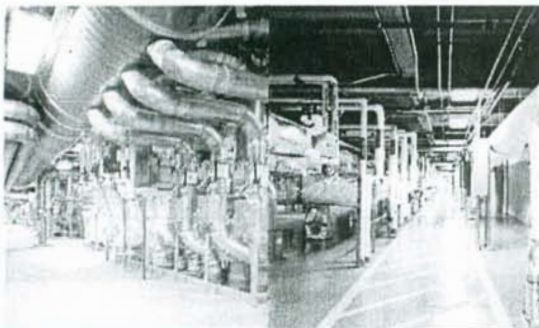
- Get input from Owner's environmental health & safety, facilities operations and maintenance groups.
- They can tell you what equipment and accessories work and do not work for them.
- Get list of preferred vendors to enable bulk buying of maintenance and repair parts. Preferred vendors also allow for less maintenance training and better pricing for service contracts.
- Think about ways to minimize human factor. Humans can make mistakes. Labor is more costly than materials in most cases. Worker injuries are becoming major concern due to lost time and high cost of insurance and healthcare.
- Central supply or collection systems for specialty utilities (gases or liquids) cut down on handling of cylinders or containers throughout facility.

Maintenance and Safety Considerations (cont'd)

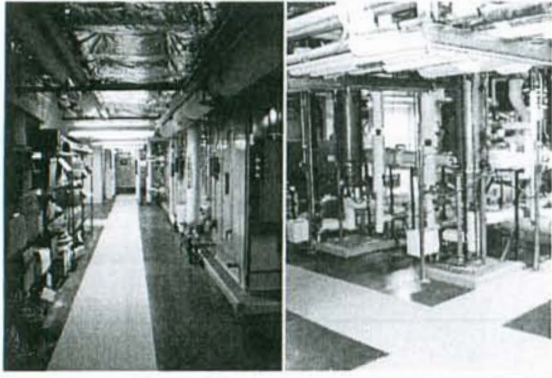
- Locate valves and items requiring service in readily accessible locations. Ideally located from standing level on the floor. Adds to worker safety and less strain and possible injury. Will encourage normal maintenance if it is easy.
- Plumbing closets with risers and valves. Ensures quick and easy access during an emergency. (Required by NFPA 45.)
- Possibly provide service catwalks or mezzanines. (Cost Impact)



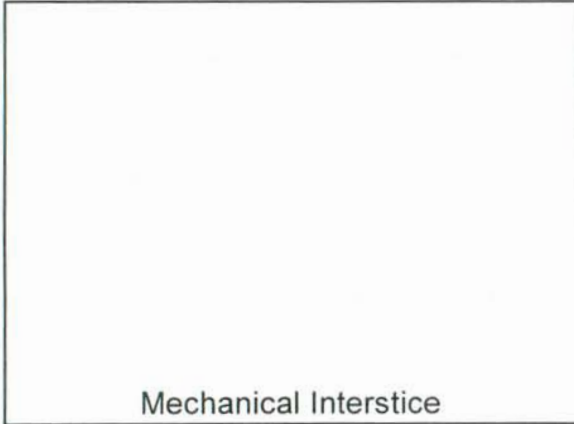
Mechanical Penthouse or Interstice



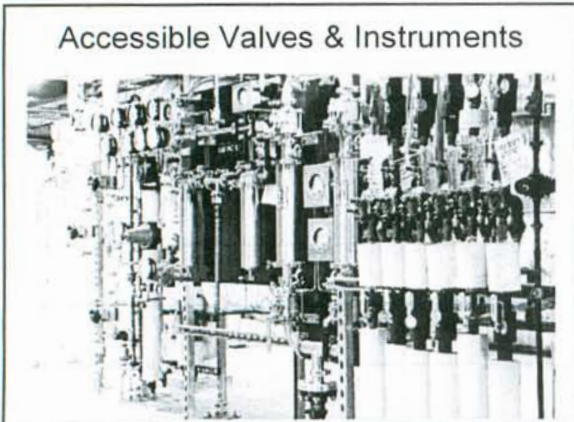
Mechanical Interstice



Mechanical Interstice



Accessible Valves & Instruments



Accessible Valves & Instruments

Any Questions?

Thank You
for your time and
attention.
