

## BSL Cleanroom Specifications

*Biotechnology based remedies are rapidly coming to market to address a vast number of rare diseases and common ailments. Biotech innovations have dramatically increased the number of BSL Biosafety Level cleanrooms or BSL zones within larger cleanroom operations. BSL Protocols are put into place to manage risks related to containment, infection, transmissibility, with the Level depending on the nature of the work conducted, origin of the microbe, agent in question, route of exposure.*

Biosafety Level 1 (BSL-1)	Basic level of protection, appropriate for agents that are not known to cause disease in normal, healthy humans.
Biosafety Level 2 (BSL-2)	Level of protection appropriate for handling moderate-risk agents that cause human disease of varying severity by ingestion or through percutaneous or mucous membrane exposure.
Biosafety Level 3 (BSL-3)	Level of protection appropriate for agents of indigenous or exotic origin with a known potential for aerosol transmission that may cause serious and potentially lethal infections after inhalation.
Biosafety Level 4 (BSL-4)	Highest level of protection, appropriate for exotic agents that pose a high individual risk of life-threatening disease by infectious aerosols and for which no treatment is available.

## BSL-1 Cleanroom Design Requirements

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Biotech cleanroom engineering and construction standards to achieve the required ISO Classification for the application, coupled with BSL-1 requirements standard engineering controls for BSL-1 laboratories and cleanrooms include the requirements outlined below.

### Biosafety Level 1: Overview

- Biosafety Level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult's humans and present minimal potential hazard to laboratory personnel and the environment.
- BSL 1 laboratories are not necessarily separated from the general traffic patterns in the building.
- Work is typically conducted on open bench tops using standard microbiological practices.
- Special containment equipment or facility design is not required, but may be used as determined by appropriate risk assessment.
- Personnel must have specific training in the procedures conducted in the laboratory.

### Common BSL-1 Considerations for Architectural Finishes

- Materials of construction and finishes: non-porous, smooth, cleanable, withstand cleaning / sanitization agents, not supporting microbial growth
- Walls: modular construction optional
- Ceilings: suspended lay-in style acoustical tile
- Doors: single & double leaf rapid roll-up seamless door frame
- Floors: troweled self-leveling epoxy flooring
- Exterior glazing: optional but not preferred
- Interior glazing: single or double glaze impact resistant and sealed
- Air Changes Per Hour (ACPH): 15 minimum

## BSL-2 Cleanroom Design Requirements

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Biotech cleanroom engineering and construction standards to achieve the required ISO Classification for the application, coupled with BSL-2 requirements standard engineering controls for BSL-2 laboratories and cleanrooms include the requirements outlined below.

### Biosafety Level 2: Overview

- Biosafety Level 2 standards, protocols, and engineering, design, and construction techniques build upon BSL-1.
- BSL-2 cleanrooms and laboratories commonly handle applications such as equine encephalitis viruses and HIV, as well as *Staphylococcus aureus* (staph infections).
- BSL-2 cleanrooms and laboratories are separated from the general traffic patterns in the building.
- Special containment equipment or facility design is required
- Personnel must have specific training in the procedures conducted in the BSL-2 cleanroom or laboratory. Personnel are trained to handle pathogenic agents and are supervised by those with advanced training.
- Biosafety cabinets or other physical containment for all procedures that can generate infectious aerosols or splashes.
- Autoclave or other method of decontamination for proper disposal of materials or sterilization for re-use.
- Eyewash station or eyewash safety shower
- Interlocking doors, and commonly with badge-controlled facility access
- Extra care is taken to control routes of exposure, including advanced techniques for handling contaminated sharps
- Immunizations are provided to lab personnel when appropriate
- Additional PPE, such as face shields may be necessary
- A lab-specific biosafety manual that outlines the necessary controls and practices for the work performed in that lab is established and well known by the trained team working in the area.

### Common BSL-2 Considerations for Architectural Finishes

- Materials of construction and finishes: non-porous, smooth, cleanable, withstand cleaning / sanitization agents, not supporting microbial growth
- Walls: modular construction
- Ceilings: modular panel system
- Doors: single & double leaf sliding seamless door frame
- Floors: troweled self-leveling epoxy flooring
- Exterior glazing: not recommended, corridor separating exterior from BSL spaces preferred
- Interior glazing: single or double glaze impact resistant and sealed
- Air Changes Per Hour (ACPH): 15 minimum

## BSL-3 Cleanroom Design Requirements

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Biotech cleanroom engineering and construction standards to achieve the required ISO Classification for the application, coupled with BSL-3 requirements standard engineering controls for BSL-3 laboratories and cleanrooms include the requirements outlined below.

### Biosafety Level 3: Overview

- Biosafety Level 3 is applicable to clinical, diagnostic, teaching, research or production facilities where work is performed with indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure
- Personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures
- All procedures involving the manipulation of infectious materials must be conducted within BSCs or other physical containment devices
- These labs must use controlled or directional air flow to ensure additional safety measures
- Other safety features include two self-closing or interlocked doors and sealed windows: ceilings, floors, wall surfaces, and filtered ventilation systems

### Common BSL-3 Considerations for Architectural Finishes

- Materials of construction and finishes: non-porous, smooth, cleanable, withstand cleaning / sanitization agents, not supporting microbial growth
- Walls: seamless hard wallboard
- Ceilings: seamless hard ceiling
- Doors: single & double leaf bubble tight sliding with inflatable seals seamless door frame
- Floors: troweled self-leveling epoxy flooring
- Exterior glazing: not allowed due to hazard
- Interior glazing: single glaze impact resistant and sealed
- Air Changes Per Hour (ACPH): 15 minimum

## BSL-4 Cleanroom Design Requirements

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Biotech cleanroom engineering and construction standards to achieve the required ISO Classification for the application, coupled with BSL-4 requirements standard engineering controls for BSL-4 laboratories and cleanrooms include the requirements outlined below.

### Biosafety Level 4: Overview

- Biosafety Level 4 is required for work with dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections and life-threatening disease that is frequently fatal, for which there are no vaccines or treatments, or a related agent with unknown risk of transmission.
- These labs incorporate all BSL 3 features and occupy safe, isolated zones within a larger building or may be housed in a separate, dedication building.
- Agents with a close or identical antigenic relationship to agents requiring BSL-4 containment must be handled at this level until sufficient data are obtained either to confirm continued work at this level or re-designate the level.
- Staff must have specific and thorough training in handling extremely hazardous infectious agents.
- Two types of BSL-4 Labs:
  1. A Cabinet Laboratory-Manipulation of agents must be performed in a Class III BSC
  2. A Suit Laboratory-Personnel must wear a positive pressure supplied air protective suit
- BSL-4 cabinet and suit laboratories have a special engineering and design features to prevent microorganisms from being disseminated into the environment.

### Common BSL-4 Considerations for Architectural Finishes

- Materials of construction & finishes: non-porous, smooth, cleanable, withstand cleaning/sanitization agents, not supporting microbial growth
- Walls: seamless hard wallboard
- Ceilings: seamless hard ceiling
- Doors: single leaf bubble tight seamless door frame
- Floors: troweled self-leveling epoxy flooring
- Exterior glazing: not allowed due to security, hazard and terrorist threat
- Interior glazing: single glaze impact resistant and sealed, only to monitor staff and operations
- Air Changes Per Hour (ACPH): 15 minimum

## Summary of BSL Typical Requirements<sup>1</sup>

	BSL-1	BSL-2	BSL-3	BSL-4
<b>Overview</b>	Involves handling biological agents that are not known to cause disease in healthy humans and pose minimum hazard to the environment.	Involves handling moderate risk biological agents that cause disease in humans of varying severity and for which treatment and/or vaccines are available.	Involves handling biological agents of indigenous or exotic origin with a known potential for aerosol transmission that may cause serious and potentially lethal diseases in humans after inhalation.	Involves handling biological agents of exotic origin that pose in humans a high risk of life-threatening diseases by infectious aerosols and for which no treatment is available or a related biological agent with unknown risk of transmission.
<b>Procedures</b>	Staff personnel must have specific training on BSL-1 operating procedures with chemicals and biological agents.	Staff personnel must have specific training on BSL-2 operating procedures with chemicals and biological agents and are supervised by those with advanced training.	Staff personnel must have specific training on BSL-3 operating procedures with chemicals and biological agents and are supervised by scientists competent in handling infectious agents.	Staff personnel must have specific training on BSL-4 operating procedures with chemicals and extremely hazardous biological agents. In addition, must understand the primary and secondary containment functions.
<b>Materials of Construction &amp; Finishes</b>	Non-porous, smooth, cleanable, withstand cleaning/sanitization agents, not supporting microbial growth	Non-porous, smooth, cleanable, withstand cleaning/sanitization agents, not supporting microbial growth	Non-porous, smooth, cleanable, withstand cleaning/sanitization agents, not supporting microbial growth	Non-porous, smooth, cleanable, withstand cleaning/sanitization agents, not supporting microbial growth
<b>Walls</b>	Modular construction optional	Modular construction	Seamless hard wallboard	Seamless hard wallboard
<b>Ceilings</b>	Suspended lay-in style acoustical tile	Modular panel system	Seamless hard ceiling	Seamless hard ceiling
<b>Floors</b>	Troweled self-leveling epoxy flooring	Troweled self-leveling epoxy flooring	Troweled self-leveling epoxy flooring	Troweled self-leveling epoxy flooring
<b>Doors</b>	Single & double leaf Rapid roll-up Seamless door frame	Single & double leaf Sliding Seamless door frame	Single & double leaf bubble tight Sliding with inflatable seals Seamless door frame	Single leaf bubble tight Seamless door frame
<b>Exterior Glazing</b>	Optional but not preferred	Not recommended, corridor separating exterior from BSL spaces preferred	Not allowed due to hazard	Not allowed due to security, hazard and terrorist threat
<b>Interior Glazing</b>	Single or double glaze impact resistant and sealed	Single or double glaze impact resistant and sealed	Single glaze impact resistant and sealed	Single glaze impact resistant and sealed, only to monitor staff and operations
<b>Signage</b>	Indicating biohazard level	Indicating biohazard level	Indicating biohazard level	Indicating biohazard level
<b>Air Changes Per Hour<sup>2</sup> (ACPH)</b>	15 min.	15 min.	15 min.	15 min.
<b>Temperature<sup>3</sup></b>	72.0 °F + / - 4.0 °F	68.0 °F + / - 4.0 °F	68.0 °F + / - 4.0 °F	64.0 °F + / - 4.0 °F
<b>Relative Humidity<sup>3</sup></b>	50 + / - 10% RH	45 + / - 5% RH	45 + / - 5% RH	45 + / - 5% RH
<b>Room Differential Pressure<sup>4</sup></b>	+ 0.03 in. WC. min.	Clean side should be positive, + 0.03 in. WC. min. Infected side should be negative, - 0.01 in. WC. min.	Negative, - 0.06 in. WC. min.	Negative, - 0.06 in. WC. min.
<b>Containment Strategy</b>	Typically, special containment is not required but may be used as determined by a biological risk assessment.	Dedicated AHU systems Directional flows Personnel & material airlocks Class I and II biosafety cabinets	Dedicated AHU systems Directional flows Personnel & material airlocks Class II and III biosafety cabinets	Dedicated AHU systems Directional flows Personnel & material airlocks Class III biosafety cabinets
<b>AHU Filtration</b>	30% pre-filter 95% after filter	30% pre-filter 95% after filter	30% pre-filter 95% after filter	30% pre-filter 95% after filter
<b>Terminal Supply Air Filtration</b>	Not required	99.99% HEPA minimum	99.99% HEPA minimum	99.99% HEPA minimum
<b>Return Air Filtration</b>	Not required	99.99% HEPA recommended	N/A, single pass supply air	N/A, single pass supply air
<b>Exhaust Air Filtration</b>	Optional	99.99% HEPA required Bag-in/bag/out optional	99.99% HEPA required Bag-in/bag/out recommended	In series duplex 99.99% HEPA system required Bag-in/bag-out required
<b>Plumbing Facilities</b>	Hand wash sinks and EW/ES	Hand wash sinks and EW/ES, decon shower, effluent treatment system	Hand wash sinks and EW/ES with hands free operation, decon shower, effluent treatment system	Hand wash sinks and EW/ES with hands free operation, decon shower, effluent treatment system
<b>NOTES:</b> <sup>1</sup> Requirements shown are not all inclusive and a biological risk assessment shall be carried out at the beginning of the project. <sup>2</sup> These are minimum and could be higher due to heat loads and/or required clean room classification. <sup>3</sup> Room environmental parameter values could vary depending on clean room classification and process. <sup>4</sup> Pressure relative to outdoors.				