

Biological Safety Levels: BSL-1, BSL-2, BSL-3, BSL-4

Protecting personnel from infectious agents

What is BSL?

Biological Safety Level (BSL) is a biocontainment designation system with requirements intended to protect personnel from potentially harmful pathogenic exposure in a research or manufacturing environment.

What are the differences among the BSL designations?

The Centers for Disease Control (CDC) specifies four broad Biological Safety Levels, each of which corresponds to a level of exposure danger and a set of design features and operational protocol. Each increasing level builds on the previous level(s):

- **BSL-1:** Required in the presence of microbes that do not consistently cause disease, such as *E. coli*. Work can be done on an open bench, and minimal Personnel Protective Equipment (PPE) is required. Doors separate the BSL-1 lab from the rest of the facility.
- **BSL-2:** Required in the presence of moderately hazardous microbes, such as *Staphylococcus aureus*. The lab is restricted behind self-closing doors. Personnel wear minimal PPE plus face shields; many operations are performed within biological safety cabinets (BSCs – see explanation below). Negative-pressure containment is generally advised, and exhausted air may require filtration.
- **BSL-3:** Required in the presence of potentially lethal, often “exotic” airborne microbes, such as tuberculosis. The lab is restricted behind two sets of doors. Workers may require immunizations, and PPE plus respirators are advised. All work is performed within a BSC. Filtered room air must be exhausted.
- **BSL-4:** Required in the presence of high risk of airborne transmission; infections are frequently fatal, as from Ebola. Decontaminate all material before exiting lab; shower after exiting. Full body, positive-pressure cleanroom suit. All work performed in Class III BSC. Lab is in a separate building.

All BSL facilities require that personnel follow “standard microbial practices”: no food or drink; no cosmetics; hands and gloves are frequently washed and surfaces routinely decontaminated. Sterilization and entry/exit protocol vary by BSL level.

Get complete BSL information from the [Centers for Disease Control](#).

How do BSL designations correlate to cleanroom levels (e.g, ISO 5 or ISO 6)?

There is no necessary correlation between a BSL and an ISO cleanliness level since they correspond to two different sets of concerns: protection of personnel and the environment from biological exposure vs. protection of a sensitive sample from contaminant exposure.

Any BSL environment can require any ISO cleanliness standard, depending on the sensitivity of the process to airborne particulates (including aerosols and germs). BSL applications that involve storage or handling of packaged pathogens may tolerate a relatively “dirty” environment, such as ISO 8, whereas processing unpackaged pathogens susceptible to contamination by airborne particles might require an ISO 5 environment.

As a practical concern, the most challenging applications involve hazardous microbes (BSL-2 or higher) that are also highly sensitive to particulate contamination (requiring ISO 5 or cleaner). These situations require a high volume of micro-filtered air passing through the enclosure to guarantee cleanliness, and therefore also a high volume of exhausted air to ensure negative-pressure containment. Such systems typically incorporate high-capacity exhaust fans and ductwork, often with system redundancy, and sophisticated airflow monitoring systems.

How do BSL designations correlate to Biosafety Cabinet (BSC) Classes?

Biosafety Cabinets are designed to provide a primary, localized protection within a larger cleanroom or laboratory. Typically, they protect personnel and the environment from a potentially harmful biological sample; many BSC designations provide additional product protection from environmental contaminants.

Generally, a BSL application should incorporate a BSC with a comparable application recommendation. BSC types and application recommendations are specified by the CDC as follows:

Class I: Protects personnel but not product. These hoods draw air within the enclosure away from the operator and into an exhaust system for external treatment and release, typically with UV-C disinfection and exit HEPA filtration.

Class II: Protects personnel, environment and product using negative-pressure plenums and HEPA filters to provide sterile, particle-free make-up air to the work area. They are subdivided into four divisions of protection by the National Science Foundation (NSF):

Class II, Type A1 – maintain a minimum inflow velocity of 75 ft/minute; 70% of air is recirculated and 30% is exhausted through an exhaust HEPA filter. Suitable for use with low- to moderate-risk biological agents in the absence of volatile toxic chemicals and radionuclides.

Class II, Type A2 – maintain a minimum inflow velocity of 100 ft/minute; negative air pressure plenum surrounds all contaminated plenums under positive pressure. Applications are similar to Type A1, but a minute amount of volatile chemicals and/or radionuclides is acceptable. Not recommended for use with hazardous chemicals except when ducted.

Sample products: [Radiopharmacy Isolators Purifier Logic+ Class II, Type A2 BSC](#)

Class II, Type B1 – maintain a minimum inflow velocity of 100 ft/minute; must be hard-ducted to an exhaust system. Circulates 30% - 40% of air and exhausts 60% – 70% of air outside lab. Suitable for work with moderate risk biological agents and a minute amount of volatile toxic chemicals and/or radionuclides

Class II, Type B2 – maintain a minimum inflow velocity of 100 ft/minute, with 100% exhaust of air to ducting system. Used in facilities when use of small amounts of hazardous chemicals is critical, as in toxicology labs.

Sample Products: [Purifier Logic+ Class II, Type B2 BSC](#)

Class III: These glovebox enclosures provide maximum containment for working with highest-risk pathogens and/or small amounts of volatile toxic chemicals or radionuclides. The viewing window is sealed shut to form a gas-tight enclosure; processes are manipulated via glove ports. HEPA filters required for exhaust and make-up air.

Sample Products: [SEA III Gloveboxes](#)

Can Terra Provide a BSL Cleanroom?

Yes, but it depends on your specific application.

Modular cleanrooms are rarely appropriate for BSL-3 and BSL-4 applications, which typically require sophisticated facility integration involving air handling systems and environmental monitoring equipment.

Terra provides BSL-2 modular cleanrooms, but how a given BSL specification affects cleanroom design and construction is not always clear. Some operations that fall under BSL-2 may require single-pass air that is filtered before being exhausted to the outside; others may allow recirculation of air and release of unfiltered exhaust air.

For this reason, Terra requests that any BSL application receive careful review by the appropriate process validation expert, who can translate the process and BSL requirement into specific environmental design specifications involving ISO cleanliness level, pressure levels, air change rates, air circulation, and exhaust air treatment, among other factors.

Once these issues are clear, Terra can propose the most economical way to address your BSL application.