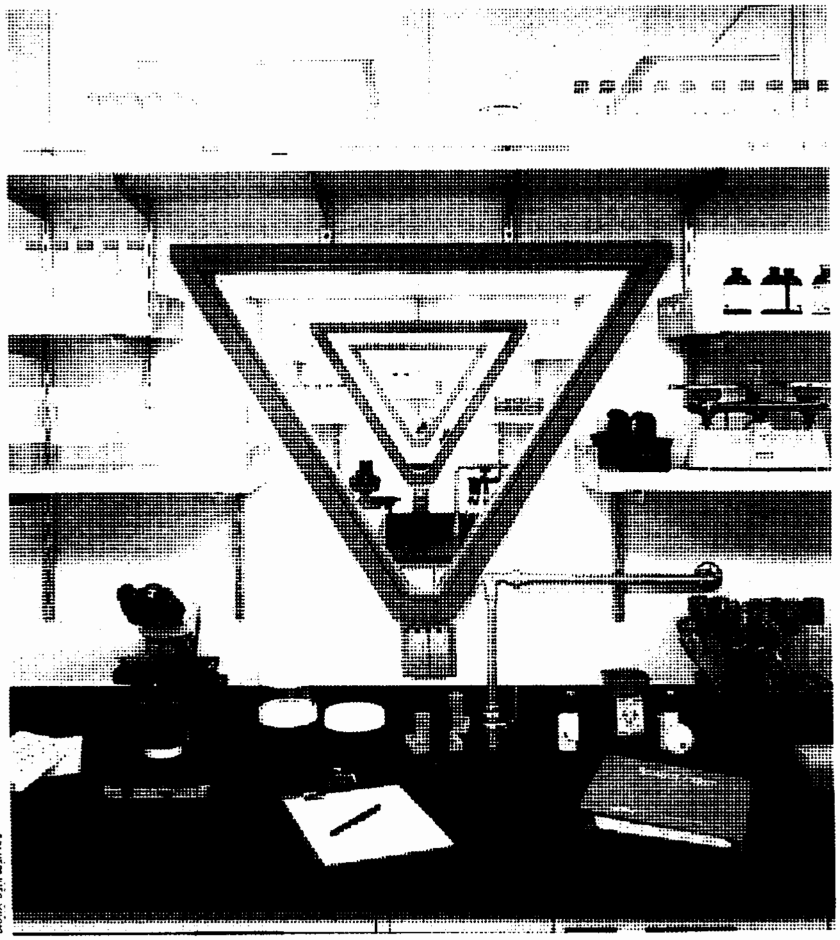
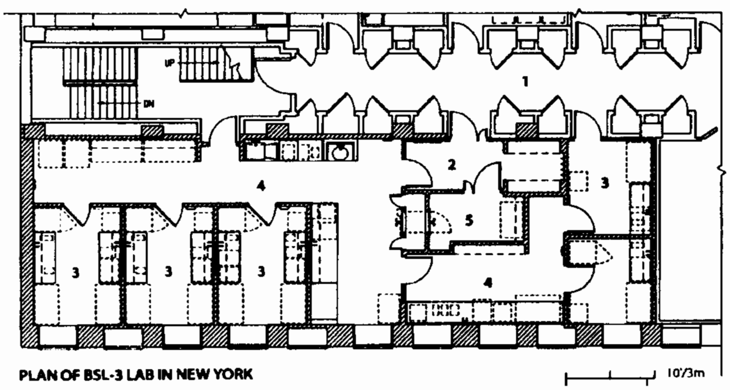
Form Follows Safety

Biosafety labs are in demand by today's researchers. Here's a checklist of design issues that architects should keep in mind.

by William N. Bernstein



VIEW THROUGH RESEARCH MODULES OF BSL-3 LAB IN NEW YORK (WILLIAM N. BERNSTEIN & ASSOCIATES ARCHITECTS).



1 CORRIDOR
2 VESTIBULE
3 RESEARCH MODULE
4 COMMON WORK AREA
5 AUTOCLAVE ROOM

PLAN OF BSL-3 LAB IN NEW YORK

With a growing awareness of the dangers of working with infectious agents such as AIDS and TB in research, architects are taking a more active role in the integration of basic biosafety principles into laboratory design.

The first or "primary containment" of infectious agents involves the safe operation of the laboratory, including the use of containment equipment such as biosafety cabinets within the laboratory. This initial layer of containment protects the laboratory workers and the internal laboratory environment from exposure to infectious agents, an exposure that can occur either through physical contact or through the air. The "secondary containment" entails protecting those outside of the laboratory from exposure to infectious agents.

The Centers for Disease Control and National Institute of Health (CDC/NIH) have jointly established four levels of biosafety guidelines for the design and operation of labs: Biosafety Level-1 ("basic"); BSL-2 ("basic" lab, but with more stringent requirements than BSL-1); BSL-3 ("containment"); and BSL-4 ("maximum containment"). BSL-3 labs are receiving the greatest attention now as the research community seeks a level of protection commensurate with the level of risk associated with highly infectious agents.

Design Guidelines

Whether a single lab or a suite of laboratories, BSL-3 facilities share common attributes, as prescribed by the CDC/NIH:

1. Plans should incorporate a vestibule, with two sets of entry doors, through which all users of the lab must pass when entering the lab from corridors or other public spaces.

2. All wall, ceiling, and floor finishes should be monolithic and sealed (or capable of being sealed) to prevent accidental air leakage out of the space, as well as to allow cleaning and/or decontamination of the space. Typically, finishes include concrete block or gypsum wallboard with an epoxy finish for walls, gypsum wallboard with an epoxy finish

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for ceilings, and sheet vinyl with an integral, coved base and heat-welded seams for the floor. An additional advantage of monolithic finishes is that when the laboratory requires decontamination, a small number of remaining open joints (for example, between door and floor) can be simply and temporarily sealed during the decontamination process.

3. Bench tops should be waterproof as well as resistant to acids, alkalis, organic solvents, and moderate heat.

4. Spaces between casework and equipment should be accessible for cleaning.

5. A sink that is foot- or elbow-operated should be located near the entrance to the laboratory. A High Efficiency Particulate Air (HEPA) filter also should be located at each vacuum outlet in the laboratory with an additional HEPA filter for the entire system of vacuum outlets. Special filtering for acid waste should also be provided. As a matter of safe practice, all liquid mediums containing infectious agents are decontaminated before being placed in a drain.

6. All windows in the laboratory should be closed and sealed to prevent air leakage. While the concept of containment motivates sealed barriers between the BSL-3 lab and the rest of the building, as well as between spaces within the BSL-3 facility, safety of the occupants within the facility argues for maximum visibility from one part of the lab to the next. Therefore, the location of piping runs and equipment should be planned to allow for glazed openings between all spaces, ideally aligned to provide visibility through several spaces. Safety glass is recommended for all glazed openings in a BSL-3 lab to minimize the danger of airborne shards of glass from an explosion.

7. Doors into laboratory and/or into containment modules should be provided with closers.

8. An autoclave should be provided within the laboratory for decontamination of waste.

9. The HVAC system should be carefully designed to create a directional airflow from the cleanest area, which should be at the highest positive pressure, to the most contaminated area, which should be at the lowest positive pressure. In a facility where both the BSL-3 lab and surrounding corridors are new, it is desirable to design the air system so that the air flows from the access corridor (which is the cleanest space, ideally at the highest pressure), through the vestibule, through the common working area, and finally into the labs (the most contaminated spaces, ideally at the lowest pressure).

In existing installations where, for example, the approach to the BSL-3 is from an existing corridor, it may be either too difficult or too costly to positively pressurize the corridor, so it may be necessary to positively pressurize the lab vestibule to prevent air flow from traveling from the lab to the corridor. In addition, exhaust air from the laboratory cannot be recirculated and must be exhausted directly out of the building. Although the CDC/NIH guidelines note that this laboratory exhaust air does not need to be filtered or treated before being discharged to the outside, this should be checked against local codes; in New York exhaust air must be filtered before being discharged outside.

10. There are two possible approaches to the treatment of exhaust air from the biological safety cabinets. If the cabinets are tested and certified at least once a year, then the guidelines permit the cabinet exhaust air to be recirculated within the laboratory. However, for safety reasons, it is best to exhaust the air from the biosafety cabinets out of the building and not to recirculate it within the room. If this route is chosen, the guidelines recommend the use of a "thimble connection" between the biosafety cabinet exhaust and the exhaust duct. This thimble connection, which fits over the cabinet exhaust but maintains an air gap between cabinet exhaust and the exhaust duct, avoids the potential interference with the air balance of the room or cabinet exhaust that would occur if a direct or "hard" connection were made between the cabinet exhaust and the exhaust duct.

11. Electrical requirements include sealing all penetrations through walls and ceilings, including all lighting fixtures and conduits. An intercom system should provide communication among various parts of the facility, and a card-key access system should be designed to record identity of visitors, including entry and exit times.

Before Commissioning

As a final step before the facility opens, the BSL-3 lab should be independently evaluated and commissioned. Commissioning procedures should be developed in conjunction with the institution's department of environmental health and safety, and should include pressure tests of the architectural envelope, pipes, and ductwork, and tests of the HVAC system, including all monitoring and fail-safe procedures.

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Recommended Reading

Biosafety in Microbiological and Biomedical Laboratories, 3rd Edition, (HHS Publication No. (CDC) 93-8395), published jointly by the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Institutes of Health, 1993.

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