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Pitfalls of Biocontainment Facility Projects and How to Avoid Them

Expert Says More Than Half of all Biocontainment Labs are Incorrectly Constructed

Too many multimillion-dollar biocontainment facilities built around the world are not immediately usable due to faulty design and construction. Tony Della-Porta, managing director of Biosecurity & Biocontainment International Consultants, suggests that the best way to succeed in building a safe, functional, easily serviced facility is to include lab users, along with building management and maintenance staff, as part of the design team. The team must work together to supervise the construction and purchase proper biocontaining equipment.

“More than 50 percent of the labs I have inspected are incorrectly constructed,” says Della-Porta. “There are serious problems associated with these facilities, including design pitfalls, non-compliance with regulations, incorrect biocontainment requirements, and poorly supervised construction.”

Knowing how and for what purpose the facility will be used enables the design team to seek out and adhere to the proper regulations. Determining potential risks prevents them from happening.

“If you don’t identify the hazards, then you can’t design systems to make sure you protect against them,” says Della-Porta.

Workflow analysis can help ensure that worker needs will be met. Keep in mind that animal research facilities have additional requirements.

“You need to know how you get the staff, equipment, and materials in and out. If you don’t work that out at the beginning, you will find that the facility won’t work,” he points out.

Equipment should be suitable for biocontainment purposes and easy to access, service, and remove for decontamination. Decontamination chambers are recommended for BSL-3 facilities containing more than one laboratory, so that equipment can be decontaminated across the containment barrier for servicing and to allow for entry of new equipment and large items. Autoclaves must be serviceable from the outside, rather than from the secure side. Ultracentrifuges should have a HEPA filter between the chamber and the vacuum pump. The plant must not be built in a secure area. Costly cleanroom-designed equipment should not be selected because it does not fulfill biocontainment requirements. Place as much serviceable equipment outside of the secure area as possible to help cut back on potential contamination and unnecessary personnel entrances.

“The more equipment outside the contained area, the better,” says Della-Porta. “This allows the engineering staff to service the equipment without going into the facility.”

Rooms must be properly sealed with coving, and designs should take into account changeable and/or extreme climates. During design and after construction, workers should be instructed in proper use of the facilities. Airlocks are not for storage. Hands-free sinks must be truly hands-free and used after every use of the biological safety cabinet and every time the laboratory is exited.

Photo Gallery

This report will illustrate and examine instances of pitfall occurrences and suggest how to prevent against them.

Description: This large airlock at the University of Hong Kong features air inflatable door seals that are flush with the floor.
Pitfalls: If the door seal is not flush with the floor (such as with pressure seal doors of the submarine type) then equipment has to be rolled over the lips, damaging the bottom of the door and risking employee back injury.
Suggested precautions: Design with ergonomics in mind. Use doors that are flush with the floor, consider optimal durability, and be certain that doors meet regulatory and containment requirements.

Description: Hands-free sinks are required at the exit of the laboratory.
Pitfalls: Handles do not make these sinks truly hands-free. Sinks placed inside the airlock can contaminate the airlock; sinks placed outside of the laboratory can spread contamination. Lab coats are not suitable for BSL-3 facilities because they form a risk of contamination of the wearer if there is a spill of infectious material.

Suggested precautions: Use hands-free sinks that are truly hands-free. Don't locate sinks in airlocks or outside of laboratories. A hands-free sink needs to be at the exit of each laboratory and its water supply, which is part of the potable water supply, must be separated from the laboratory water. Provide users with back fronted lab gowns with long sleeves, elasticized cuffs, and gloves that overlap the top of the cuffs.

Description: This ceiling is collapsing due to higher negative air pressures than the materials can resist.
Pitfalls: Walls and ceilings that are not designed to withstand positive pressure leak tests or negative room pressures, such as dry plaster board construction, can move or collapse breaking the secure barrier.
Suggested precaution: Select materials and construction with positive pressure leak test and negative room pressures in mind, such as sandwich panel construction as used in cleanrooms or cold rooms.

Description: Terminal HEPA filters.
Pitfalls: These filters, based on a cleanroom design, draw potentially contaminated air across the worker and are difficult to decontaminate and test.
Suggested precautions: Mount HEPA filter canisters on the floor above, with ducts entering from the ceiling. Locate the supply vent near the entry door and the exhaust vent on the other side of the room to ensure directional airflow away from the door. The HEPA filter canister should contain the HEPA filter, a pre-filter, access for scanning the filter, bubble tight dampers at each end, and ports for decontamination of the HEPA filter without having to also decontaminate the laboratory.

Description: Exhaust HEPA filters are mounted just above the floor underneath a biological safety cabinet.
Pitfalls: HEPA filters cannot be decontaminated without shutting down the whole facility and circulating air through the air handling system. Filters cannot be tested or removed and handled safely.
Suggested precaution: Use HEPA filter canisters.

Description: This boiler is mounted too high, with a burst disk near the top.
Pitfalls: When the boiler is mounted too high, it is extremely difficult to service. Lag spots are present, and temperature probe testing reveals poor circulation.
Suggested precaution: Mount boilers where they will be easy to monitor and service.

Description: Room humidity and cool air temperature causes condensation of water on non-stainless-steel pipes, causing rust.
Pitfalls: Inferior materials were used, instead of stainless steel and the plant room was not conditioned to remove humid air, which condenses on the cold air ducts.
Suggested precaution: Use stainless steel and condition the plant room.

Description: This laboratory is properly designed.
Key elements: Moduline ducting carries power and communication cables around the walls, which prevents unsealed penetrations and allows additional communication points to be added later without breaking the facility's air seals. Normal outlets can then be used instead of airtight outlets, which can be up to 40 to 50 times more expensive. Ergonomically designed biological safety cabinets should sit low enough to allow the user's feet to rest on the ground thus supporting the back and shoulders and reducing over-use syndrome injuries caused from stretching into the safety cabinet to work. The system should allow users to be able to see the pressure gauge (Magnehelic gauge recommended) so that they are aware of what pressure alarms mean in their laboratory. Power outlets that are switchable outside the facility should allow the decontamination process to be turned on and off.

Description: Unsealed floor without coving.
Pitfalls: Visible holes reveal non-waterproof outlets that are not airtight, preventing hosing down. Improperly sealed retrofitting is another common problem.
Suggested precaution: Properly seal walls, floors, and equipment. Extend floor covering at least six inches up the walls (coving).

Description: Properly sealed double-ended bioseal autoclave.
Key elements: Maintain a barrier to seal the autoclave. Install a vent filter on the vacuum and contain condensate. Ultracentrifuges require a HEPA filter between the chamber and the vacuum pump to contain infectious material in case of an accident.

Summary
"You need to get the design right," emphasizes Della-Porta. "It needs to fit the purpose for which the staff are working."

The purpose can often change as the animals, equipment, and staff in a facility change. It is important to determine the anticipated hours of use per week of a facility before building. A facility that operates 24/7 cannot be fumigated entirely. Compartments must be created in which systematic fumigation can then occur. Decontamination facilitates the safe removal of equipment without the need to close down the facility.

Engineers and architects must work closely with project managers and other staff during planning and construction to prevent the common pitfalls of building a biocontainment facility. One facility that already passed its containment tests required the installation of exit signs as noted by the safety committee. Without the proper supervision and adherence to quality finishes, exit signs were mounted in the walls breaking the containment barrier, costing the facility its containment status.

"It is absolutely critical to get these things right," stresses Della-Porta. "If the changes are not implemented properly the facility no longer works as it was designed."

Biography: **Tony Della-Porta** worked more than 30 years for Australia's Commonwealth Scientific and Industrial Research Organization in the fields of virology, infectious diseases of livestock, biocontainment, and biological safety. He served as program manager and deputy head of the Animal Health Laboratory in Geelong. He is now the managing director of Biosecurity & Biocontainment International Consultants.

This report is based on a presentation given by Della-Porta at the Tradeline *2007 International Conference on Biocontainment Facilities* held in March.

For more information:
Tony Della-Porta, FASM, BSc, PhD, FASM GAICD
Managing Director
Biosecurity & Biocontainment International Consultants
PO Box 531
Geelong, Victoria 3220
Australia
61-3-5222-7228
tony.della-porta@bio2ic.com