Division of Technical Resources
Office of Research Facilities
The National Institutes of Health Vol. 01, No. 46
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News to Use
Design Requirements Manual
The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial p}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho\overline{U_i U_j})=-\frac{\partial \overline{p}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U_i}}{\partial x_j}-\rho\overline{u_i u_j}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_j}(\rho\overline{U_i H})=\frac{\partial}{\partial x_j}\left(\lambda\frac{\partial \overline{T}}{\partial x_j}-\rho\overline{u_j h}\right)$ biomedical research facilities.

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Please address questions or comments to: shawm@mail.nih.gov

Environmental Management

Environmental management is very important to the NIH ensuring the health and well-being of NIH employees, visitors, and neighbors. Federal laws applicable to environmental management on the NIH campus include: Clean Air Act, Clean Water Act, Hazardous Materials Transportation Act, National Environmental Policy Act, Resource Conservation and Recovery Act, Safe Drinking Water Act, Toxic Substances Control Act and Worker Safety Requirements.

National Environmental Policy Act (NEPA) applies to all construction projects regardless of the size. The project officer, Division of Environmental Protection (DEP) and Division of Facilities Planning work together to determine actions required for the project. All NIH facilities shall be designed to minimize the use of hazardous substances. The use of alternative non-hazardous or nontoxic materials is required in all new construction and renovations. The A/E shall develop a plan for eliminating the use of hazardous substances and where hazardous substance use is unavoidable; the A/E shall demonstrate that alternate non-hazardous substances are not available. Examples of hazardous substances that shall be avoided include, but are not limited to: oil-based paints and sealants; hazardous cleaning, surface preparation, and paint-stripping solvents; and petroleum-based contact adhesives.

Receiving Areas:

Hazardous substances used in a laboratory delivered directly to the end-user laboratory from the loading dock do not require staging and temporary storage areas.

Materials used in support of a facility such as chemicals used for washing glassware, cage washing, or neutralizing wastewater discharges, must be placed in a hazardous-substance storage area. Buildings utilizing these hazardous substances shall be designed with a receiving and storage area located at or near the point of use of the materials and shall be used for long term storage of hazardous materials.

Storage and Staging Areas:

Hazardous-substance storage areas shall be out of the normal flow of personnel traffic and shall be located near the loading dock for easy access to the trucks used to transport the waste for processing. Convenient access from the storage room to the freight elevator shall be provided without having to traverse heavily used corridors so as to minimize the risks to the building occupants during the transport of the waste.

The storage and staging area shall be large enough to store the hazardous substances and provide room for loading and unloading the drums or containers. If multiple substances are stored, the design shall allow incompatible materials to remain segregated while in storage.

Spill containment in each section of the storage room shall be designed to contain any spills of hazardous waste resulting from mishandling the waste materials. Some options for spill containment within the storage room include a spill-containment curb around the room, secondary containment bins, shelving designed to contain spills, or a combination thereof. Any curb used for containment spills shall be designed to allow convenient ingress/egress using a drum trolley. Each section of the storage area shall be designed to contain a spill of a minimum of 4 L of liquid. The configuration of the storage area shall be designed to facilitate spill cleanup. Interior surfaces of the storage area shall be cleanable, corrosion resistant, and non-reactive.

A chemical-resistant coating shall be applied to the walls and floor in this area to contain spills and to facilitate cleanup. These areas shall be thoroughly sealed to minimize pest harborage and exclude pests.

Safety equipment including emergency eyewash, emergency shower, and a telephone shall be provided for each storage room and staging area. The telephone to contact emergency response personnel shall be located either in the room or within 10 m of the room. Fire protection design requirements shall apply if flammable materials are stored.

Hazardous Waste Storage and Handling at On-Campus Buildings:

Laboratory and animal research facility buildings on the NIH campus shall be designed with a room for temporary storage of hazardous waste and radioactive wastes. Mixed waste (hazardous waste that is also radioactive) shall be treated as radioactive waste in this temporary storage area. Hazardous waste is generally stored in this room for several hours or overnight.

Layout and Size:

The storage room shall be large enough with two sections (one for hazardous waste and one for radioactive waste) to provide for temporary storage of the hazardous waste and radioactive waste, and for storage of specialized carts to transport the hazardous waste from the laboratories. The hazardous waste storage section shall be 2.5 m x 3.5 m minimum. The radioactive waste storage section shall be 0.75 m x 1.5 m minimum.

Storage Cabinets:

A minimum of three 2 m-high storage cabinets shall be provided in each room to provide segregated storage of incompatible materials. Open floor space in the storage room shall accommodate one 1 m-long waste cart and allow access to the storage cabinets and shelving.

Ventilation System:

A separate ventilation system shall be installed for the storage room. Exhaust shall be directed away from the building and surrounding buildings' air intakes. This ventilation system shall be connected to the building's emergency power system.

Fire Protection:

Sprinkler protection in the room shall be designed to meet the requirements for Ordinary Hazard Group 2.

Design Review and Approval:

The Division of Radiation Safety and DEP shall review all designs for hazardous waste storage rooms and shall provide the final approval of the design.

Hazardous Substances Storage and Handling within Laboratories:

Laboratory Modules: All laboratory modules shall be designed for the safe storage of hazardous substances while discouraging the storage of excessive amounts of hazardous substances. All wet laboratories shall contain an approved ventilated acid (corrosive) cabinet and an approved flammable materials storage cabinet. The sizes of these cabinets shall be based on the volume of corrosive and flammable materials used in the laboratory. The location of radioactive storage cabinets shall be standardized in the laboratories to assist emergency response personnel, optimally located near the laboratory door for convenient access by the technician collecting the hazardous waste.

For laboratory modules with a service corridor, the storage area shall be located near the service entrance rather than the hall entrance, avoiding the transport of hazardous waste through the main corridors of the laboratory building. There shall be no flammable storage cabinets located under fume hoods. Acid storage cabinets shall be ventilated and are typically located beneath fume hoods. If no fume hood is present, exhaust ventilation must be provided to these cabinets. Acid cabinets and flammable material storage cabinets shall be located diametrically opposed from each other and towards the back of the laboratory away from the laboratory entrance.

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BSL-3 Planning Part 1: The Barrier

The BMBL states that Biosafety level 3 practices, safety equipment and facility design and construction are applicable to…facilities in which work is done with indigenous or exotic agents with a potential for respiratory transmission, and which may cause serious and potentially lethal infection.[1]

The first step in planning a BSL-3 facility is defining the barriers that are fundamental to the safety and function of the facility. Barriers are required to contain the infectious agents and protect the people who are working directly with them. Barriers also protect occupants in the building outside of the BSL-3 laboratory and people and animals in the larger community. Barrier protection is accomplished as a two-layer approach, consisting of primary and secondary barriers.

Primary Barriers are items within the BSL-3 laboratory which isolate and contain the infectious agents, and physically separate them from the personnel manipulating them. The use and function of primary barriers are determined by a laboratory's standard operating procedures (SOPs), risk assessment based on the agents to be used and the activities to be performed. It is important that the SOPs be established early in the planning process, and that the design professionals have access to them, so that the equipment and procedures associated with primary barriers can be understood and accommodated in the design. Primary barriers include:

1) Biological safety cabinet (BSC): BSC uses directional air flow and HEPA filtration to contain infectious material within the cabinet enclosure and protect the user. BSCs are available in a range of sizes and types, and must be selected to meet the requirements of the particular lab.[2] BSCs must be placed with adequate clearance to ensure their optimal operation.[3] All manipulation of infectious agents should occur in a BSC.

2) Lab containers (including centrifuge cups and waste containers): When out of the BSC, lab containers encapsulate the infectious material and prevent spills and aerosolization.

3) Personnel protective equipment (PPE): PPE requirements depend on the specific (SOPs) of a lab, but generally include gloves, gowns and shoe covers, and may include eye or face protection, hair covers, respirators and other items.

Secondary Barriers consist of the physical enclosure of the BSL-3 laboratory. The secondary barrier protects people and animals outside of the BSL-3 laboratory from agents that are inside of the lab, but outside of the primary barriers. Secondary barriers include:

1) Architectural Enclosure: The perimeter walls, floor, ceiling, doors, windows and other elements that surround and contain the BSL-3 lab must be constructed, finished and sealed sufficiently to prevent leakage and infiltration. Windows must be sealed, and entrances and exits must be minimized. Required entrances and exits must be configured in vestibules with interlocking doors and directional airflow to maintain the integrity of the barrier.

2) Heating, Ventilation and Air Conditioning (HVAC) Systems: The HVAC systems treat, control and exhaust the air in the BSL-3 lab, and ultimately releases the filtered air to the atmosphere. The HVAC system must be configured to prevent the release of unfiltered air and maintain directional airflow (generally from the least-hazardous to the most-hazardous areas), during normal operation, emergency and failure scenarios.

3) Waste Treatment: Waste must be sterilized as it exits the BSL-3 laboratory. Most waste is autoclaved. Liquid sterilized autoclaved waste may discharge through the sanitary or general BSL-2 lab waste. Effluent decontamination systems are only required where approved risk assessment validates the need. PPE, equipment and all other materials leaving the BSL-3 lab must be considered potentially hazardous waste and handled and treated accordingly.

The barriers dictate the general functional layout of the lab (see Figure 1: BSL-3 Barriers). Entry is from a low hazard area (generally a BSL-2 laboratory) through the secondary barrier at a vestibule. The laboratory is arranged so that people and processes proceed to increasingly hazardous areas, with the BSC s and other primary barrier components at the end of the process. The process is reversed, from the most hazardous to the least hazardous, for exiting.

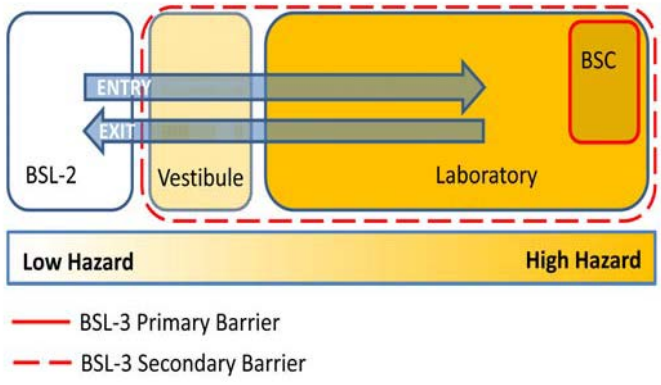

Figure 1: BSL-3 Barriers

References:

[1]Biosafety in Microbiological and Biomedical Laboratories (BMBL), 5th Edition, December 2009
[2]Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets, BMBL, Appendix A
[3]BSC Placement Requirements for All New Buildings and Renovations, NIH DRM 2008, Appendix I

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualpdf.aspx
DRM Chapter 2, Section 2-5 BSL3 Containment Laboratories at the BSL3 Level

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BSL-3 Planning Part 2: The Barrier

As outlined in the previous News to Use[1], the first step in planning a BSL-3 facility is defining the barriers that are fundamental to the safety and function of the facility. Primary barriers are the devices that contain the infectious agents; the secondary barrier is the physical enclosure of the laboratory.

The integrity of the secondary barriers must be maintained, which is challenging because of the openings through which people, material, utilities and air must constantly pass. Smooth and quick passage through the barrier is desirable for the efficient operation of the facility; however this must be weighed against procedures that are required to maintain the integrity of the barrier. In all cases, the locations of entry and exit points must be limited, and standard operating procedures (SOPs) must be set and followed.

Exit and entry points can be classified as follows:

Personnel People pass through the secondary barrier at an entry vestibule. The first vestibule door is a security point, with appropriate security devices. The purpose of the vestibule is to create containment via differential pressure, which must be maintained by door interlock mechanism or by SOPs. The differential pressure must be monitored, and there may be an alarm to notify of an unacceptable drop of pressure. The vestibule must have adequate accommodations for donning the appropriate personal protective equipment (PPE). Changing rooms and showers may be provided, in accordance with SOP requirements. In smaller facilities, the entry vestibule may also be used for exiting. In larger facilities unidirectional flow may be required, and separate entry and exit vestibules may be provided.

Equipment An equipment vestibule shall be provided if large equipment or bulk materials are expected to be entering or exiting the facility during operation. Vestibule doors and differential pressure are similar to the personnel vestibule. An equipment vestibule must be large enough to accommodate wipe-down, packaging and other required procedures.

Materials Small quantities of materials may be carried by people through the entry vestibule. Alternately, a pass-through box with interlocked doors may be provided. Large or bulk materials shall pass through an equipment vestibule. All material leaving the facility must be sterilized, and is generally autoclaved. Any material that cannot be autoclaved must be sterilized and packaged following SOPs and exit the facility via the personnel vestibule, pass-through box or equipment vestibule.

Utilities Pipes and conduits penetrations must be sealed to maintain the integrity of the secondary barrier. All items must be anchored to prevent movement, and flanges or escutcheons must be provided and sealed. The interior of conduits and junction boxes must be sealed following DRM requirements[2] to eliminate open pathways. Penetrations with porous thermal or fire safing insulation are not acceptable unless augmented with flanges or escutcheons and properly sealed.

Air The heating, ventilation and air conditioning (HVAC) systems treat, control and exhaust the air, ultimately releasing the filtered air to the atmosphere. Air devices must be sealed to wall and ceiling surfaces to maintain the secondary barrier, and all exhaust components shall be welded stainless steel to provide an air-tight system up to the point of exhaust, which must be HEPA filtered. The HVAC design, including redundancy and controls, shall maintain directional airflow and pressurization during normal operations, emergency operations and failure scenarios.

Waste All waste, including liquid waste, exiting the facility must be sterilized, usually by autoclaving. Autoclaves must be sized to accommodate the expected quantities, and consideration should be given to providing redundant autoclaves for continuous operation during maintenance. Autoclaves must be installed with manufacturer-provided bioseals forming part of secondary barrier, and configured so that components requiring service and maintenance are outside of the barrier. On the sterilized side a vestibule or room shall be provided so that the autoclaved material is not deposited directly into a corridor. A canopy hood shall be provided to capture steam and heat. Adequate space shall be provided for carts and staging.

Thoughtful planning, along with SOPs, can provide required entry and exit while maintain the integrity of the secondary barrier.

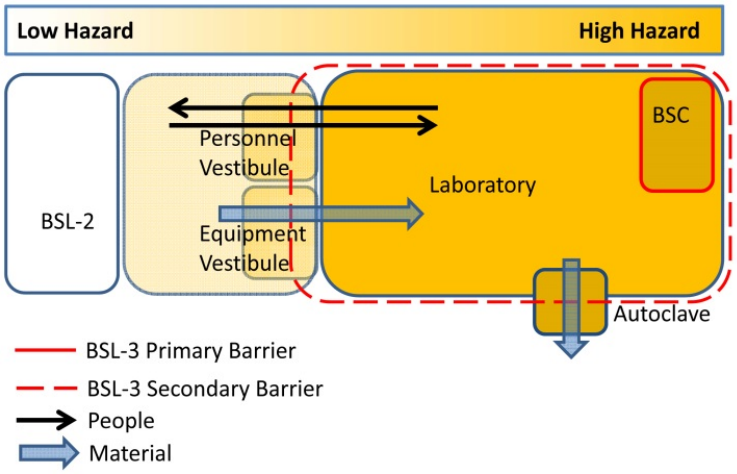

Figure 1: BSL-3 Vestibules and Autoclave

References:

[1]February 2014 News to Use, http://orf.od.nih.gov/POLICIESANDGUIDELINES/Pages/DRM_News_to_Use.aspx

[2]DRM Sealant Table, Exhibit X4-2-A http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DRMHTMLver/Chapter4/Pages/Section_4-2_Exterior_Achitectural_Elements.aspx

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BSL-3 Planning Part 3: Autoclave Fundamentals

As outlined in the previous two issues of News to Use[1], defining the barriers is fundamental to the planning of a safe and functional BSL-3 facility. Primary barriers are the biological safety cabinets and other devices in which infectious agents are manipulated; the secondary barrier is the physical enclosure of the laboratory.

The autoclave is an essential component of the secondary barrier. It allows waste and other material to safety leave the containment environment, and maintains the physical enclosure that constitutes the secondary barrier.

Autoclave Function and Types

Autoclaves use steam to kill infectious agents, and render hazardous material safe for ordinary handling and disposal. Saturated water vapor is a very dependable method of sterilization, and is faster and more effective than dry heat, ultraviolet or ionizing radiation or other common methods. Autoclaves are pressure vessels, inside of which material is subject to steam at a predetermined pressure and temperature and prescribed time duration to ensure sterility. Due of the high temperature some plastics, sealed vessels and other items cannot be autoclaved and must be sterilized by an alternate method.

Autoclaves are available as steam and electric. Steam autoclaves operate using a central steam source. Electric autoclaves produce steam using an integral steam generator. Steam autoclaves are preferable, if central steam is available, because of reduced cycle times, maintenance and operating cost. Clean steam is generally not required.

There are three basic types of autoclaves. The primary differences are the way air is removed from the sterilization chamber:

- **Gravity Displacement:** Steam is introduced into the chamber as it is produced, which displaces air by gravity until the sterilization process begins. Some air remains in the chamber, which defines the cycle times.

- **Positive Pressure Displacement:** Steam is held in a separate chamber. When sufficient steam has been accumulated it is released into the main chamber in a pressurized burst, beginning the sterilization process. This process removes more air and decreases cycle times.

- **Negative Pressure Displacement:** Air is removed from the chamber using a vacuum pump prior to the introduction of steam. This process removes the most air and further reduces cycle times.

Note that all air exhausted from the chamber prior to the completion of the sterilization cycle must be HEPA filtered or otherwise decontaminated. Autoclaves should be selected with cycles for dry goods, liquids and other functions required by the lab. Color-changing autoclave tape is used to confirm the efficacy of cycles, and records must be kept of cycles, maintenance and testing.

Autoclave Planning

Autoclaves used in BSL-3 labs generally are double-door pass-through units, installed as part of the secondary barrier. This eliminates the need to wrap or protect items to be autoclaved. Doors are interlocked and programmed to the completion of the sterilization cycle, thereby maintaining the integrity of the barrier. The size of the autoclave should be determined based on anticipated throughput, considering such factors as load capacity and cycle duration. Redundant autoclaves or alternate sterilization methods may be considered to maintain operations during maintenance and other outages.

Autoclaves are both large and heavy. Clear paths have to be identified for the installation and replacement of units. Paths must include height, width, turning radii and vertical components from the loading dock to the final location. Weight should be confirmed for both the final location and the installation/replacement path. Weight calculations must consider that units may be required to undergo periodic hydrostatic testing, where all chambers are filled with water.

Autoclaves are generally installed with only the door section protruding into the BSL-3 lab, enabling most mechanical components and maintenance tasks to be performed outside of the secondary barrier. The junction between the unit and the barrier shall be a bioseal. The bioseal is usually stainless steel, fully welded to the outer steam jacket and sealed to the wall surfaces comprising the secondary barrier. The seal incorporates a flexible component at the wall designed to maintain integrity through differential movement and expansion. Adequate space must be provided for all mechanical components, including sufficient space for access and service activities.

A room or alcove shall be provided at the unloading side of the autoclave so that materials are not unloaded directly into a corridor. This space shall have a sink for the disposal of liquid, and space for carts, waste receptacles and other required items. A canopy-type steam capture hood shall be installed above each door. Exhaust air shall be at a minimum rate of 0.254 m/s (50 fpm) capture velocity, and a drip edge provided to collect steam condensate, and the condensate must be drained to a drain or receptor on the same side of containment as the respective hood. Consideration should be given to how steam and heat may affect smoke and heat detectors. The area immediately around the autoclave shall have finishes resistant to heat and humidity, and must have lighting which is sealed, gasketed and with a minimum UL damp rating.

The sterilized effluent from the BSL-3 autoclave may discharge through the sanitary waste or lab waste system as indirect connection through a floor sink, located within the service area on the non-containment side.

References:

[1]Februaryand March 2014 News to Use, POLICIESANDGUIDELINES/Pages/DRM_News_to_Use

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BSL-3/ABSL-3 Electrical Requirements

High containment (BSL-3/ABSL-3) facility electrical design should consider various factors such as reliability, redundancy and decontamination.

Electrical Service, Distribution and Feeders: For new facilities, to ensure reliability of electric service, a minimum of two dedicated utility services, physically separated in different ductbanks and different manholes should be considered. These dedicated services shall be fed by different primary substations or by one double-ended utility substation, which is fed by two dedicated utility service lines. Each required electric service to the facility shall be sized to handle 100% of the design load (i.e., 2N redundancy). The preferred method of installation for the electric utility services is underground; overhead lines may be used only within the secured perimeter of the facility. Locate distribution equipment, such as medium voltage switches and transformers, in a secured location. Downstream electrical distribution from switchgear to critical areas, such as mechanical support rooms with redundant motors in each set, shall comprise pairs of distribution switchboards / panelboards, each fed from a separate side of the switchgear, to supply approximately one-half of each set of motors.

Emergency Generator: Provide a local generator dedicated to the facility to provide emergency/standby power; however, a remote generator farm (with redundant feeders) may also be acceptable.

Consider providing 100% generator backup for facilities where the loads mandated to be connected to a generator comprise the majority of the load of the facility. Consider the loss of redundancy in emergency operation of the facilities with 100% generator backup and update operational procedure during emergency operation. Provide a load bank (including a connection point suitable for use for a portable generator) for periodic testing of the generator.

Electrical Installation in Containment Areas: Avoid installing electrical equipment which requires service within a containment area. Electrical systems and equipment not serving the BSL3/ABSL3 area shall not be located within the containment area.

Containment Barrier Penetrations: Penetrations through the containment barriers shall comply with the following requirements:

- Penetrations through the containment barriers shall be gas tight, nonporous, smooth and cleanable; and readily visible for routine inspection, cleaning, and maintenance. Penetrating components shall be sufficiently rigid in construction and adequately braced to structure to maintain the long term integrity of the penetration. The result shall be free of sharp edges or similar hazards.
- All penetration shall be durable, sealed, and tested to meet the room tightness criteria for BSL3/ABSL3 laboratories.
- Submission and Mock-up: Penetrations into the containment barrier (including mounting of electrical boxes) shall be detailed in the construction documents and shall require mock-ups to be constructed and tested prior to installation.

Sealing Requirements: Provide silicon-based caulk in all areas in accordance with Sealant matrix provided in Exhibit X4-2-A.

Conduits for All Systems: Conduit applications in BSL3/ABSL3 facilities are as follows:

- Conduit Type: Use RGS conduit with threaded fittings in all BSL3 areas.
- Seal-off: Provide seal-off fittings when conduits exit defined BSL3/ABSL3 perimeter.
- SMR: Use of surface metal raceway systems is not allowed in BSL3/ABSL3 areas.

Power Wiring: Insulation shall be compatible with sealing compound (sealing compound non-deleterious to insulation), using THW, THWN, THHN/THWN, or XHHW.

Other System Wiring: Voice/data, fire alarm, control, and security system wiring shall follow the same sealing requirements as that of the power wiring. Cable types shall be determined by NIH Information Technology and manufacturer's recommendations for voice/data wiring and by respective system manufacturers for other systems. The A/E shall coordinate exact requirements for security wiring with the Division of Physical Security Management (DPSM) for projects within NIH, Bethesda campus.

Boxes for All Systems: General requirements of device boxes are as follows:

Type and Depth: All boxes shall be double gang type; the box depth shall be at least the next size larger than the minimum size required per code.

Cast Boxes: Provide cast boxes with external mounting provisions, external hub, and gasketed device cover plates.

Sealing: Provide a 25 mm (1 in.) barrier of silicone caulk around the wire within a device box hub. Provide a continuous bead of caulk between the device box and the adjacent surface. Provide a continuous bead of caulk around the device cover plate and the adjacent surface.

Lighting Fixtures: Lighting fixture installation shall comply with the following requirements:

- Fixtures shall be UL listed for damp location. Lighting fixtures shall allow full decontamination with ease of effort, and permit easy re-lamping and access to ballasts. Lighting fixtures shall be provided with stainless steel housings, glass or heavy duty acrylic prismatic lens, and stainless steel door with tool-less fasteners.
- Use surface mounted, fully sealed, enclosed, and gasketed fluorescent fixtures. Seal surface mounted fixtures with a continuous bead of sealant around its perimeter to seal housing to ceiling. Lighting fixtures may be pendant mounted only in an open ceiling. Pendant-mounted lighting fixtures shall be fully sealed and gasketed with same features as those of surface mounted fixtures.
- Connect 50% of light fixtures in the laboratories to the emergency power source. Provide at least one lighting fixture per room laboratory areas with self-testing emergency battery ballast connected to unswitched local emergency generator circuits.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx
DRM Chapter 10, Section 10-9: BSL3 & ABSL3 Biocontainment

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The formulae $\frac{\partial \rho U_i}{\partial t} + \frac{\partial}{\partial x_j}(\rho U_j U_i) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\mu \frac{\partial U_i}{\partial x_j}\right) + g_i(\rho - \rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho \overline{U_i U_j}) = -\frac{\partial \overline{P}}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\mu \frac{\partial \overline{U_i}}{\partial x_j} - \rho \overline{u_i u_j}\right) + g_i(\rho - \rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho U_i H) = \frac{\partial}{\partial x_i}\left(\lambda \frac{\partial T}{\partial x_i} - \rho \overline{u_i h}\right)$ biomedical research facilities.

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BSL-3 and ABSL-3 HVAC System Requirements - Part I

HVAC systems play a critical role in control of hazards in a bio-containment facility. Biosafety Laboratories (BSL)-3 and Animal Biosafety Laboratories (ABSL)-3 animal facilities shall comply with all requirements for BSL-2 laboratories and ABSL-2 animal facilities as described in the DRM Chapter 6 Mechanical Systems Design. This article includes additional requirements to be included in level-3 bio-containment laboratories and bio-containment animal facilities. Design of BSL-3 and ABSL-3 laboratories shall be reviewed and approved by NIH Division of Technical Resources (DTR) and NIH Division of Occupational Health and Safety (DOHS). This article is based on DRM Section 6.6 Biosafety Level-3 and Animal Biosafety Level-3 Bio-containment. Part 1 covers the contents up to DRM 6.6.9 Air Filtration. Part 2 will cover the remaining subjects in DRM Section 6.6.

Supply Air Systems in BSL-3/ ABSL-3 Laboratories

(1) Dedicated Supply Air Systems: To provide protection against cross-contamination to spaces outside of containment, BSL-3 and ABSL-3 laboratory spaces shall be provided with dedicated supply air systems, which do not serve any other laboratory spaces outside the containment laboratory. BSL-3 and ABSL-3 supply air systems may not be combined to a common system. Refer to DRM Chapter 7 Building Automation Systems for detailed control requirements and pressure control requirements.

(2) Independent Supply Air Terminal: In as much as possible, each room shall be served by an independent supply air terminal. This is to maintain pressure differential and isolate rooms during decontamination.

Ventilation Rates in BSL-3 Laboratories

BSL-3 laboratories shall be provided with a minimum of 6 air changes per hour (ACH). Ventilation rates in animal facilities are typically 10 to 15 outdoor ACH. This minimum air flow shall be maintained at all times, including unoccupied periods. Ventilation systems shall be designed to remove all heat dissipated by all equipment within the lab space and provide all exhaust air requirements from fume hoods, BSCs, sterilizers, etc. These ventilation rates have been established to not only provide for the safe and effective removal of potential airborne contaminants from the laboratory air space, but also for odor control and removal of animal dander.

Relative Room Pressurization

Airflow in bio-containment facilities BSL-3 and ABSL-3 shall be designed to move from "clean" areas toward the bio-containment space. The system shall be designed to maintain a negative pressure differential of 12.5 Pa (0.05 in. w.g.) between each pressure zone. Where multiple containment zones exist within the suite, sequentially more negative pressure must be established so that more contaminated rooms are placed at greater negative pressure to less contaminated rooms. Monitoring and control devices shall be provided to ensure that the pressure differential is maintained. Visual readout devices and alarm devices shall be provided at the entry to the containment space, in anterooms, and at entry to the individual rooms within the containment suite.

Anterooms

Anterooms shall be located between the BSL-3 and ABSL-3 and the clean corridor outside the bio-containment space. An anteroom provides a dedicated entry and exit for the laboratory, a gowning area, storage of supplies, etc. These anterooms are typically negative to the clean corridor and positive to the BSL-3 and ABSL-3 spaces keeping the contents in the bio-containment room from leaving that room. That is, the BSL-3 and ABSL-3 room is negative to the anteroom. The use of anterooms needs to be reviewed with DTR and DOHS.

Exhaust Air Systems

(1) Dedicated Exhaust Air Systems: BSL-3 spaces shall be provided with dedicated exhaust air systems. BSL-3 and ABSL-3 may not be combined to a common system or any other system serving spaces outside the bio-containment space. This dedicated exhaust air system shall include pressure-independent constant-volume air terminal units, roof-mounted exhaust fans (number of fans to provide N + 1 redundancy), variable frequency drives (VFD) for filter loading and/or for multiple room applications, exhaust stacks, etc.

(2) Exhaust Ductwork Materials: All exhaust ductwork shall be welded stainless steel and gastight to allow for decontamination.

(3) Independent Exhaust Air Terminal: In as much as possible, each room shall be served by an independent exhaust air terminal.

Air Filtration

(1) Supply Air: Supply air serving BSL-3 laboratories and ABSL-3 animal facilities is not required to be high efficiency particulate air (HEPA) filtered, unless specifically required per the program. If HEPA filtration is requested on supply air, it shall be reviewed by DTR and DOHS.

(2) Exhaust Air HEPA Filtration: Exhaust air HEPA filtration is recommended and each particular system/application shall be reviewed with the user, DTR, and DOHS. If HEPA filtration is not required, the exhaust air system shall be designed with provisions for adding HEPA filtration in the future.

(3) HEPA Filter Location: HEPA filters shall be located as close as possible to the containment barrier penetration. HEPA filters shall be rated for 99.99% efficiency at 0.3 microns. These filters shall include provisions for bag-in/bag-out filter replacement. HEPA filters shall be located with consideration to replacement and testing procedures. HEPA filters shall be zoned so that shut downs can be coordinated. Provide redundant filter banks to allow replacement of filters during operation.

(4) HEPA Filter Housings/Dampers: The HEPA filter housings shall be welded stainless steel construction. Each HEPA filter shall be capable of in situ decontamination and full face scanning. Bubble-tight dampers with end switches shall be used for HEPA filter isolation. Bubble-tight dampers shall be of the positive seal type with zero leakage and rated for the pressure classification of the system.

(5) HEPA filters and Specialized Equipment: Certain equipment such as a continuous flow centrifuge that gives out aerosolized air shall be protected with HEPA filters before discharging the air into the room.

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BSL-3 and ABSL-3 HVAC System Requirements – Part II

Isolation Dampers

(1) Isolation Damper Locations: Bubble-tight (no-leakage) isolation damper shall be provided between the room supply air terminal and the room supply air diffuser and between the room exhaust grille and room exhaust air terminal.
(2) Access to Dampers: Access to the bubble-tight dampers shall be from outside the laboratory suite.

Autoclaves

(1) Exhaust Canopy Hoods: Autoclaves serving BSL-3 and ABSL-3 shall be provided with stainless steel exhaust canopy hoods over the door to capture steam and aerosols from the autoclave. In the case of double-sided autoclaves, stainless steel canopy hoods shall be provided over both the "dirty" (loading) side and the "clean" exit side door.
(2) Need for HEPA Filtration: The need for HEPA filtration of the exhaust air from the canopy serving the dirty side of the autoclave shall be reviewed by NIH Division of Technical Resources (DTR) and NIH Division of Occupational Health and Safety (DOHS).
(3) Autoclave Service: A steam isolation valve shall be located outside the containment barrier. To the extent possible, service to the autoclave shall be performed from outside the containment.

Service Access Panels and Mechanical spaces

Access panels through the containment barrier walls or ceilings shall be avoided. To the extent possible, piping, valves, dampers, air terminals, shall be located outside the containment barrier. Alternatively, the use of full stainless steel access cabinets with closed back and sides, gaskets, and stainless steel pipe inserts weld-sealed to the box can be utilized to provide a sealed box arrangement.

Major equipment serving the containment spaces shall be located in interstitial spaces or mechanical galleries or corridor.

Variable Frequency Drives (VFD)

Following a power outage and the initiating of the emergency electrical power, all VFDs associated with supply and exhaust fans serving BSL-3 or ABSL-3 spaces, which are required to maintain bio-containment, shall be provided with the ability to restart into a coasting motor without delays and without damaging the motor. That is, the drive shall be able to catch the motor on the fly. The drive shall be able to identify motor rotation and when the opposite rotation is detected, slow the motor down to zero speed, otherwise, smoothly accelerate the motor to the commanded speed with the correct direction without tripping on an overvoltage or overcurrent condition. Mechanical brakes or anti-ratcheting devices can be used to ensure that a fan does not rotate in the wrong direction.

Emergency Electrical Power

Supply air fans, exhaust air fans, and all devices and equipment serving and/or associated with BSL-3 and ABSL-3, which are required to maintain bio-containment of the space shall be connected to an emergency electrical power system. Emergency loads shall be able to supply standby power in 10 seconds or less.

Equipment, Ductwork, and Piping Identification

Equipment, ductwork, and piping systems shall be accurately identified and services specific to containment spaces shall clearly designate the specific function. Identification shall include the universal biohazard sign at ductwork, piping, and at equipment.

Biosecurity

Systems and equipment shall be located only in secured areas compliant with facility biosecurity requirements and the Risk Assessment. Suitable containment support spaces should be coordinated with the Risk Assessment.

Seismic Accommodation

In areas of seismic activity, accommodation shall be provided to preclude shearing of piping, ductwork, or critical equipment damage due to differential movements. Fixed equipment shall be properly anchored to structure. Such analysis and accommodation shall be performed by qualified structural and mechanical engineers in coordination with NIH Office of Research Facilities (ORF) and DOHS.

HVAC Plans

All design phases of the construction documents shall be reviewed and approved by the DTR and the DOHS. Documents shall include room pressurization diagrams, leakage/pressure calculations, and location of exhaust equipment.

Inspection, Testing, Validation, and Certification

Conformance with the requirements of this chapter shall be confirmed in the installation of HVAC systems serving BSL-3 containment. Systems shall be inspected throughout installation to ensure conformance with the requirements of the DRM. In addition, the following specific issues shall be addressed as part of quality control, testing, and commissioning plans. Below are some of the specific items to be reviewed and inspected within the HVAC discipline. The list is not intended to identify commissioning requirements or to be all inclusive.

(a) Visual inspection of all systems for compliance with the requirements of the DRM, Risk Assessment, and this section.

(b) Ensure all required standby power has been provided and proper response to integrated systems testing.

(c) Construction documents for BSL-3 and ABSL-3 facilities shall include the requirement to comply with and to obtain the BSL-3 laboratory certification in accordance with the requirements in the NIH Biosafety Level 3 – Laboratory Certification Requirements (http://orf.od.nih.gov/PoliciesAndGuidelines/Bioenvironmental/Documents/BSL3CertificationGuidelinesFINAL_508.pdf).

(d) The testing of ventilation system and controls shall follow the American National Standard Institute (ANSI) Standard Z9.14 Testing and Performance Verification Methodologies for Ventilation Systems for Biological Safety Level 3 (BSL-3) and Animal Biological Safety Level 3 (ABSL-3) Facilities.

(e) Refer to DRM chapter 7 Building Automation Systems Design for information on BAS, controls, and failure testing scenarios for HVAC systems serving BSL-3 and ABSL-3 bio-containment facilities.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx
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Spot Network System

Spot network systems are used in areas of high electrical load density such as metropolitan and suburban business districts because they provide increased distribution reliability where power interruptions can have serious consequences to public and personal safety by assuring electrical service continuity. The term "spot network" refers to any set (two or more) of network protectors and transformers which supply power to one specific location or spot through a common bus. A power interruption can only occur when there is a simultaneous failure off all primary feeders or when a fault occurs on the secondary bus. There are no momentary interruptions caused by the operation of the transfer switches that occur on this type of primary selective system. Spot network systems are employed in many of the buildings in National Institutes of Health (NIH) campus at Bethesda, Maryland. Spot network systems are expensive because of the extra cost of the network protectors, specialized switchgear, and duplication of transformer capacity.

The typical secondary spot network distribution system consists of multiple medium voltage feeders fed from one common substation that terminate in the subject building at individual primary isolation switches typically integral to each network transformer. The primary isolation switches then feed to network distribution transformers that convert the medium voltage distribution voltage to the local building's utilization voltage level. The network transformer impedances are required to be selected so that the maximum thru-fault rating does not exceed the interrupting rating of the network protector and should be as close as manufacturing tolerances permit to reduce circulating current.

Network transformers are sized to be able to carry the full building load with some spare capacity for future load growth, with the ability to fully remove one transformer completely from active service indefinitely. This is defined as an N+1 redundancy and this scheme is deployed in spot network in NIH campus at Bethesda. One negative feature of this configuration under normal operating conditions is that the transformers are typically lightly loaded, operating in a range where they are less efficient than if they were more closely loaded to their nameplate ratings.

The key element of secondary spot network systems is the utilization of network protectors to permit multiple primary feeders to be connected simultaneously in parallel to provide power to a common low-voltage bus. The network protector typically consists of a special air power breaker, a breaker operating mechanism, network relays, control equipment and fusing to provide back-up protection for clearing faults on the primary feeder in the unlikely event the network protector fails to operate normally. The specialized network relays continually monitor the voltage across the open breaker contacts and current through the closed breaker contacts. In the event of a fault on a primary electrical distribution system cable or transformer, the network protector opens due to reverse power flow, thus isolating the fault from the network bus and avoiding load power disturbances. The network protector will automatically reclose its contacts if the power flow is back into the network, when in the automatic mode. The network protector will trip, in the absence of a primary feeder failure, when the substation breaker is opened. The network relay must be sensitive enough to sense the reverse magnetizing current of its associated transformer primary windings. The connected load to the common bus never experiences an outage or even a serious voltage dip, due to the fact that the common bus is continuously supplied from alternate feeders.

The load sides of the network protectors are then connected to the respective main circuit breakers in specialized service switchgear for use with spot networks, typically using copper busduct, with busduct lengths sized within 10% to minimize impedance differences.

The service switchgear is sectionalized using tie circuit breakers between the individual bus sections based on the number of transformers utilized to limit the extent of outages in the event of any downstream electrical fault. The switchgear is the source for the individual electrical feeder distribution for the major loads within a building.

The specialized switchgear is required to be provided with a typical ground bus, an insulated ground bus (also referred to as a ground return neutral bus), individual sectionalized neutral busses and typical sectionalized phase bussing connected with normally closed tie circuit breakers between each switchgear section. The insulated ground bus has only one point of connection to the grounding conductor. The transformer neutrals are brought into the switchgear and grounded at one, and only one location. This scheme permits selective tripping of the tie circuit breaker(s) to sectionalize the phase bussing, and then the corresponding network protector.

The expected available fault currents of spot network systems are inherently high. The use of current limiting fuses may be necessary to reduce available fault currents to manageable levels.

The protective device settings goal is to provide both continuity of service and protection to allow the closest device near a fault to clear before other upstream devices trip. Faults in a spot network system have more than one source, with a normally closed tie circuit breaker. It is very important that the network protector relay setting be slower than the tie circuit breaker to allow for isolation of switchgear faults between one side of the tie circuit breaker and the load side of a network protector without taking the whole network down. The tie circuit breaker thus clears one transformer's fault contribution, while the non-faulted side remains energized, then the network protector experiencing the remaining fault current will trip open, thereby isolating one section of the network bus for subsequent repair. Transformer secondary winding faults may open both the tie circuit breaker and a network protector, depending upon the magnitude of the secondary fault event.

The network protector should open first taking six to seven cycles to operate upon any value of reverse power. The ground fault relays for the tie circuit breakers and network protectors are set slightly higher in pickup and longer in time than the ground fault for the feeder devices. Network protector and tie circuit breakers usually are set at the same levels. Ground fault current originating from switchgear or incoming cable faults is directly seen by the ground fault relays on the tie circuit breaker. Subsequently, the ground fault relays on the faulted network protector circuit open, isolating the fault completely. Downstream ground faults are cleared by downstream circuit devices or the feeder circuit breaker serving the faulted circuit.

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1. Eaton Cutler-Hammer Commercial Spot Network Application Note, July, 2008.
Eaton Cutler-Hammer *Consulting Application Catalog*, 14th Edition.

2. Institute of Electrical and Electronic Engineers, Inc. (IEEE) *IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants* IEEE Std 141-1986.

3. Institute of Electrical and Electronic Engineers, Inc. (IEEE) *IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings* IEEE Std 241-1983.

4. National Institutes of Health (NIH) *Design Requirements Manual: 2008.*

5. National Renewable Energy Laboratory *Secondary Network Distribution Systems Background and Issues Related to the Interconnection of Distributed Resources*
Technical Report NREL/TP-560-38079, July 2005.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx
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Construction Drawing Graphics and Graphic Presentation

Graphics and graphic presentation are crucial aspects of construction drawings which are often overlooked by architects and engineers. Drawings have to be clear, concise and easily readable. Drawings should be developed with consideration for the end user: a contractor in the field in dim lighting working from a coffee-stained half-sized set of drawings. If the drawings are not legible and understandable they are not meeting their primary purpose.

All drawings shall be produced with Computer Aided Design (CAD) software supporting the creation of .dwg and/or .rvt formatted files. 2D construction drawings are the typical deliverable, but CAD software supporting and incorporating Building Information Modeling (BIM) shall be used on larger, complex projects and as required by the Scope of Work (SOW). The National CAD/CIFM Standards http://www.gsa.gov/portal/category/21590 shall be followed for all formatting. Regardless of the platform used, drawings shall be developed with the end goal of producing paper documents usable in the field.

In developing construction drawings a number of requirements must be met:

Sheet Organization: Drawing sheets shall be a standard size and include a standard NIH titleblock. All fields, including project identification, date and submission shall be completed.

The drawing set cover sheet shall contain the following information:

- NIH Building number
- Room number(s), if applicable
- Submission
- Date
- Work request number
- Area map
- Vicinity map showing project relative location
- Architect, engineer and other contributors to the set

The drawing set shall include a concise and accurate Table of Contents of all disciplines' sheets, organized in a rational and consistent sequence.

Lettering/dimension size: The lettering and dimensioning must be of a size that is readable on half-size drawings under site conditions. Lettering and dimensioning shall be a minimum of 1/8", in an easily readable font and line weight. Spacing of lines and letters, leaders, dimension lines and other graphic entities shall be distinct and clear.

Graphic scale, north arrows and column indicators: All scaled plans and details as appropriate must have a graphic scale, north arrows and column line indicators. It is important to be able to orient and navigate within a building, and be able to locate and reference items and locations using positional markers.

Projects within a large building shall have key plans on all plan sheets.

Dimension units and construction tolerance: Metric units must be used on new building projects, and on addition/renovation projects on buildings that were originally designed, or which have had major renovations, with metric units. Imperial units must be used on addition/renovation projects on buildings constructed with Imperial units. Dual metric/Imperial units can be used on all projects, but must be used consistently.

Metric dimensions shall be in millimeters, unless there is a specific reason to use another unit. On the drawings the unit symbol may be eliminated with an explanatory note such as "All dimensions are shown in millimeters" provided.

Imperial dimensions shall be in feet (') and inches (").

It is important that dimensioning recognize and address the limitations of construction tolerance that can be achieved in the field. In most conditions, it is not necessary or productive for dimensions to be of a greater tolerance than ½" or 10mm. It is recommended that metric dimensions end with a '0'. It should be recognized that a dimension to the millimeter is asking for a construction tolerance of 1/25th of an inch, which is an unrealistic and unnecessary expectation in most situations.

Line weights: Construction drawings must utilize multiple line weights which set a visually hierarchy to clearly differentiate drawing components. Line weights must be sufficiently dark to print and copy legibly without loss of detail. Shading and hatching can be used where necessary to convey information, but should not obscure underlying information.

Scale: Drawings must be of a scale that is appropriate for the level of detail of the drawing. Generally floor plans shall be 1/8" to 1'-0" scale (or the metric equivalent), plan details shall be 1/4" to 1'-0" scale, and construction details shall be at a scale sufficient to show connections, fasteners, material thicknesses and all other items clearly and distinctly.

Dimensions and dimension strings: Dimensions shall be in hierarchical strings, providing overall dimensions, wall dimensions and opening dimensions. Dimension lines shall be tied to column lines, exterior walls and other fixed components. Duplication of dimensions shall be avoided. In renovations, non-critical dimensions in a dimension string shall be denoted as '+/-', and critical dimensions shall be denoted as 'Verify in Field' or 'Minimum'.

Industry-standard symbols and abbreviations: All drawing sets shall have a list of abbreviations used, and all sheets shall have a legend of symbol used. Symbols and abbreviations shall be industry-standard where ever possible, and should be consistent throughout all disciplines' drawings. Notes, Symbols and abbreviations shall be project specific, with extraneous information removed.

Standardization between disciplines: Floor plans for all disciplines' work shall be at the same scale, and at the same orientation to make cross-discipline coordination easier.

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Medium Voltage Electrical Distribution

Medium voltage (13.8 KV) electrical distribution systems supplies electrical power to various buildings in the National Institutes of Health (NIH) Bethesda campus. Medium voltage electrical distribution systems comprised of primary switch, oil filled network transformer, secondary network protector and primary feeder cables. General requirements for installation of medium voltage distribution systems in NIH Bethesda campus are outlined in the following paragraphs.

Primary Switch: The 15kV primary switch shall be load break type with three-positions: OPEN, CLOSED, and GROUND. The center position is the CLOSED one. Key-interlock this switch with the transformer tap-changer mechanism such that the switch shall be in the ground position before the transformer taps can be changed.

Network Transformer: The network transformers, without any forced air cooling, shall be capable of supplying 100% of the total building loads along with 25% future expansion loads. General requirements for the network transformers are as follows:

1. Coil Material: Copper.
2. Insulating Liquid: NIH approved less flammable natural ester.
3. Cooling: Class OA/FFA, self-cooled, and with provisions for future forced-air-cooled rating.
4. Accessories: Include the following additional accessories:
    a. Temperature gauges with re-settable maximum pointers.
    b. Sampling valves.
    c. High pressure release valves.
    d. Key-interlocked tap changer with five settings, one at primary voltage, the other four nominal 2.5 percent taps - 2 above and 2 below rated primary voltage.
    e. Alarm contacts for SCADA interface.

Medium Voltage Cable: All medium voltage cable installation shall meet the following requirements:

1. Cable Type: MV 105.
2. Conductor: Copper, single conductor.
3. Insulation: Ethylene-propylene rubber (EPR).
    a. Voltage rating: 15 KV.
    b. Insulation Level: 133% insulation level.
    c. Strand screen: Extruded semiconducting EPR meeting or exceeding the electrical and physical requirements of ICEA S-68-639, AEIC CS8, and UL 1072.
    d. Shielding: Copper tape, 5 mil thick, helically applied with a 12.5% overlap.
    e. Cable Assembly: Three insulated, shielded conductors cabled together with a ground conductor.
    f. Cable Jacket: Sunlight-resistant polyvinyl chloride (PVC).
    g. Cable Size: 350 KCMIL or 500 KCMIL (sizes only for ease in maintaining NIH short circuit study and possible medium voltage feeders serving multiple buildings). 500 KCMIL is preferred for new construction in the NIH Bethesda campus.

Above-mentioned paragraphs highlighted some of the major requirements of the NIH design requirement manual (DRM). Refer to the DRM for additional requirements.

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News to Use
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The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_j U_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho\overline{U_i}\,\overline{U_j})=-\frac{\partial \overline{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U_i}}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho\overline{U_i}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ biomedical research facilities.
'Design Requirements Manual (DRM) News to Use' is a monthly ORF publication featuring salient technical information that should be applied to the design of NIH biomedical research laboratories and animal facilities. NIH Project Officers, A/E's and other consultants to the NIH, who develop intramural, extramural and American Recovery and Reinvestment Act (ARRA) projects will benefit from 'News to Use'.
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Plumbing Requirements for Biosafety Level 3 Laboratories

Biosafety Level 3 (BSL-3) laboratories present unique challenges and requirements for plumbing design. This article is not intended to be all-inclusive of these challenges, but will highlight a number of important considerations and unique aspects for plumbing systems serving BSL-3 containment areas.

Water Systems

All water supplies must be isolated from other functions with an approved backflow preventer installed outside of the containment area. N + 1 redundancy may be utilized to serve multiple suites.

Purified water systems shall be completely independent of any systems requiring sterile or pharmaceutical grade water supplies.

Point-of-use purified water production units, fed directly from the BSL-3 lab water, is the preferred method of providing high purity water within BSL-3 spaces.

Vacuum Systems

The use of disinfectant traps and hydrophobic filters are required at each point-of-use, including biosafety cabinets. *Filters utilized shall be at least HEPA efficiency and permanent type pipe-line filters should be sterilizing grade for repeated use.*

Isolation valves and decontamination ports shall be provided to allow independent isolation and decontamination of the pump without decontaminating the entire building-collection system.

Exhaust shall be separately piped above the roof at locations approved in consideration of the facility risk assessment and to prevent re-entrainment into facilities.

Compressed Gas Systems

No special provisions are necessary for isolating pressurized gases into BSL-3 containment labs serving typical turrets located within the open lab. Such systems may be common with other BSL-2 compressed gas systems, provided BSL-3 areas are zoned for independent service isolation.

Plumbing Fixtures

Sinks and Faucets: Hand-wash sinks located at the exit are a requirement for all containment areas.

All sinks/lavatories must have fully cleanable, non-porous, finished sanitary surfaces and deep seal traps.

Faucets within containment shall have gooseneck-type spouts and be fitted with an integral vacuum breaker and laminar flow, non-aerating, non-splash outlet. The use of separate outlet taps for hot and cold water is not acceptable. Faucets shall be fully hands-free.

Emergency Fixtures: Emergency fixtures (eye washes and emergency showers) shall be configured as an isolated potable supply, with backflow protection provided for services prior to entering containment.

Showers: Showers shall provide a minimum flow rate of 10 L/min (2.5 gal/min). Hand-held showers shall not be utilized, except where specifically required for barrier-free compliance and shall include a vacuum breaker.

Water Closets: Water closets located inside a containment area, shall have a deep-seal, vented, self-cleaning trap arrangement directly below the fixture, and a wall-mount 13.5 liter-per-flush (3.5 gal/flush) blow-out flushing action closet shall be required to prevent stoppages and clear traps.

Floor Drains and Floor Sinks: Floor drains and floor sinks should be avoided in containment unless specifically required by the program and in accordance with the risk assessment and approved by the DOHS.

Piping Routing and Insulation

Exposed piping shall be avoided in a containment area, and if necessary shall be installed with adequate clearance to allow for cleanability. Where exposed piping with insulation is necessary, the insulation shall be nonporous and impact-resistant with sealed joints.

Piping Identification

Piping systems shall be accurately identified and services specific to containment spaces shall clearly designate the specific function. Vacuum and biowaste piping shall include the universal biohazard sign at piping and at equipment, and pipe tag color code shall be in accordance with ANSI/ASME standards.

Biosecurity

Systems and equipment shall be located only in secured areas compliant with facility biosecurity requirements and the risk assessment. Piping systems and equipment not serving BSL-3 facilities shall not be located within containment areas. *In as much as possible, piping and service openings for systems serving other building areas should not require entrance into BSL-3 spaces.*

Decontamination

All plumbing system equipment, piping, seals, and components shall be compatible with the anticipated fumigation method and liquid disinfectant trap fluids as determined appropriate by the risk assessment.

Penetrations

Penetrations through the containment barrier shall be gas-tight, nonporous and visible for routine inspection and maintenance. *Penetrations shall be designed and constructed to that only controlled leakage occurs. The control of leakage through the containment barrier is especially important in fumigation activities.* Penetrating components shall be sufficiently rigid in construction or adequately braced to maintain the long-term integrity of the penetration.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManualPDF.aspx
DRM Chapter 8 Section 8-11 BSL3 & ABSL 3 Biocontainment

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Plumbing Requirements for Animal Biosafety Level 3 Laboratories

In general, Animal Biosafety Level 3 (ABSL-3) facilities must comply with all BSL-3 requirements in addition to requirements unique to animal facilities, a number of which are outlined below.

The term "BSL-3" as used within the scope of this section, refers to laboratory and animal research facilities performing work at Biosafety Level 3 as defined in the latest edition of HHS/CDC/NIH's *Biosafety for Microbiological and Biomedical Laboratories* (*BMBL*) (World Health Organization [WHO] Risk Group 3), including facilities where work may include select agents.

Piping systems and equipment not serving ABSL-3 facilities shall not be located within containment areas. Waste piping shall not be routed above food service, food storage, or surgical/aseptic areas.

Containment Piping systems or other isolated systems serving BSL-3/ABSL-3 areas shall not serve across higher or lower biosafety level.

Access panels and similar openings through containment barrier walls or ceilings shall be avoided. Access doors are not acceptable in ABSL-3 areas or insectaries.

Specific ABSL-3 system requirements include (but are not limited to):

Animal Drinking Water Systems:

The use of an automatic piped system (in lieu of bottled or prepackaged water) shall be evaluated by Risk Assessment with the program veterinarians. Piped systems require maintenance and sanitization and are not appropriate for all applications. Direct mouth contact with animals in low-pressure liquid streams is a potential cross-contamination concern.

Animal drinking water shall be completely independent of other containment levels. Water shall be taken directly from building potable water and shall be isolated from all other systems with backflow preventer located outside the containment barrier.

System Design Requirements:

- Only non-circulated (automatic flushing-type) systems shall be used for piped systems. Due to the risk of cross contamination, systems shall avoid serpentine arrangements of piping that could permit flow from one suite into another.
- Only systems that maintain appropriate disinfectant residuals may be utilized for piped systems.
- Methods of periodic sanitization for the system shall be planned and coordinated with the program during the design phase.
- Water production systems shall be located outside the containment barrier in program-controlled secure space to facilitate access for maintenance and service.
- Penetration protection and pipe mounting details shall meet requirements for other piping systems within ABSL-3.

Veterinary Medical Gas Systems (VMGS):

VMGS shall be independent of systems from areas outside ABSL-3 containment and protected from backflow or contamination with upstream filters located outside of the containment barrier. Filters must be disposable or sterilized between uses for cross-infection control and shall be suitable for medical gas service.

Portable gas cylinders may be an alternative to piped systems. Cylinders may be located in the anteroom or other accessible location.

Piped Vacuum Systems:

Piped vacuum systems shall not be utilized because it is unacceptable to pipe potentially infectious material out of containment. Where vacuum is required, point-of-use (portable) equipment shall be used. The type of filtration utilized on the equipment shall be reviewed and coordinated with standard operating procedures. Fluids shall be collected and autoclaved. Lab vacuum systems shall not be used for surgical vacuum.

Anesthetic Gas Scavenging:

Anesthetic gas scavenging shall be of the air-driven venturi type. The drive gas shall include an in-line filter or gas-tight check valve at the containment barrier. The terminal unit exhaust shall be piped to a capture device within containment, upstream of HVAC HEPA filters. Lab vacuum systems shall not be used for anesthetic scavenging.

Drainage Inlet Grinders:

Drainage inlet grinders (food waste disposers/garbage disposals) shall not be utilized in ABSL-3 facilities due to potential for aerosolization of infectious waste. All wastes must be autoclaved or disposed in accordance with the NIH and the BMBL.

Insectaries:

Plumbing connections in insectaries shall be subject to review and approval of DOHS and ORF, and shall be in accordance with an approved risk assessment.

Drain openings in insectaries shall be provided with durable, tight fitting double-layer stainless steel screens with openings sufficiently small to prevent escape (but not larger than #52 mesh), and free of sharps hazards. Sinks should include normally closed valves for each individual trap. Specific requirements shall be reviewed and verified with program use group. Floor drains shall be avoided. The use of approved, validated, effluent treatment and a controlled collection system suitable for fumigation may be required. There shall be no uncontrolled escape paths through piping networks.

Select Agents and Veterinary Pathogens:

Additional requirements for facilities handling select agents will be addressed on a project-specific basis with DOHS and in accordance with the approved risk assessment.

Where pathogens of veterinary or agricultural significance are manipulated, or animals housed such that the room becomes the primary containment barrier, additional requirements of the USDA APHIS may also apply and shall be discussed with the DOHS and ORF prior to design. Additional requirements do not typically apply to agents utilized only in diagnostic/small quantities within a primary containment device. Refer to the facility's risk assessment.

Further details on this month's topic are available on the DRM website
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