Division of Technical Resources
Office of Research Facilities
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News to Use
Design Requirements Manual
The formulae for building state of the art 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'. Please address questions or comments to: ms252u@nih.gov

Emergency Power

Emergency electrical power shall be provided to all life safety and critical mechanical systems and laboratory equipment. The DRM provides a comprehensive list of equipment and systems that must be placed and list of equipment and systems recommended being on emergency power as listed below.

Life safety loads shall be wired separately from normal powered, legally required and optional standby loads.

The following devices/systems shall be connected to the life safety emergency power system:
Emergency egress lighting; Egress signage; Communications systems (including PA systems); Fire alarm systems; Self-contained battery-powered lighting at generator set location; Medical gas alarm systems; Fire suppression systems (fire pumps, compressors, valves, etc); Security, intrusion detection and access control systems; Building Automation Systems including control air compressor for buildings with smoke evacuation; Automatic doors used for egress; Elevator cab lighting, control, communication and signal systems; Generator day tank pump.

The following systems shall be considered legally required standby loads and shall be connected to the emergency power system:
Fire department receptacles; Pumps, components and all devices associated with fuel stored in large storage tanks serving the emergency generator; Sewage ejector systems; Sump pumps; Sump dewatering pumps; Lighting provided at the generator; Critical supply and exhaust fans; Operating rooms; One elevator per bank of elevators and associated elevator machine room air handling units (All elevators shall be on emergency power with only one elevator per each bank of elevators to run at a given time. The lock-out of the elevators shall be provided by the elevator controller); Building Automation Systems including control air compressor for buildings without smoke evacuation; Air handling systems associated with active smoke purge/evacuation systems; Medical gas systems; Fume hood exhaust fans.

The following systems shall be considered optional stand-by loads and are recommended to be connected to the emergency power system based on the critical nature of the scientific program requirements and project budget.

UPS systems, Automatic temperature control system components; Auxiliary mechanical equipment that supports heating and cooling systems; One light fixture per module per laboratory minimum; Biosafety cabinets, Incubators, Biobubbles, Containment devices, etc.; Supply and Exhaust fans and associated controls for animal areas; Laboratory equipment alarm monitoring system; High-value specimen refrigerators, Freezers, Cold rooms, Warm rooms, etc.; Closed circuit television cameras and associated equipment; Lighting control systems; Select lighting and receptacles in electrical distribution equipment, mechanical rooms and major telecommunication rooms; Lighting in animal facilities, if defined by program requirements; Computer room air handling units; Air-conditioning units serving main telecommunication room; Cooling systems such as water chillers, cooling towers, pumps and associated systems which serve critical areas; Heating systems including: boilers, heating water pumps and associated fuel oil system; Steam condensate pumps; Domestic water pumps; Hands free toilet flushers and lavatory faucets; Electrical heat tracing for hydronic piping; Critical scientific equipment identified by program requirements.

The users and the owner should realize the impact of losing valuable research due to power outage that may occur only once or twice a year versus increased initial cost for a larger generator and associated distribution system.

Commissioning and testing/verification of emergency systems are crucial for system reliability.

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Backflow Prevention Devices

Back Flow Prevention/protection (BFP) devices in NIH facilities shall be installed in compliance with all applicable plumbing codes and the device listing requirements in order to protect water supply from contamination or pollution.

A minimum two-step BFP approach shall be utilized to protect the potable water supply and maintain fluid quality in each system.

1. "Isolation" – Providing a proper air gap at the water supply outlet is preferred. It may also consist of approved BFPs that are appropriately matched to the hazard level and specific application. Special attention shall be provided to devices and use application points with a high potential as a backflow hazard.
2. "Containment" – The A/E shall assume that a complete individual system could be potentially contaminated when BFP are applied at this level. Select a protection device that will protect the upstream water supply. This consists of reduced-pressure principal backflow preventers applied to the incoming water service and at the start of sub-systems such as laboratory water supply, fire protection, etc.

Additional NIH BFP requirements include:

- Use of appropriate equipment and materials.
- Proper design of supply systems for sufficient pressure and operation.
- Assessment of potential hazard at each use point.
- Proper identification and labeling of specific piping system contents and areas served.
- Ensuring the appropriate water supply system is extended and readily available to serve all areas.
- Consider location of piping distribution systems relative to program function and connection from the appropriate system to each use point.
- Unconcealed and readily accessible location of BFP devices.

The Architect/Engineer shall consider the annual maintenance and service requirements for testable devices, and ancillary requirements such as drains, trap primers, etc. Project specifications shall include testing and certification of each testable device after installation by a registered cross connection control device tester, prior to acceptance by NIH. Final test reports and a list of device locations, type and service shall be included in project Operations & Maintenance manuals.

NIH lab facilities shall utilize a segregated laboratory water distribution system, independent of potable water to minimize the need for point of use backflow preventers, drains, and significant costs and disruption associated with these devices. This includes the use of reduced-pressure principal devices or vacuum breakers at equipment outlets of particularly high hazard or probability of cross connection, but does not mean that a BFP or reduced-pressure device shall be provided at every outlet or to the degree required of a potable, unprotected system.

Backflow preventers shall be provided with proper service clearances and adequate drainage.

- Provide an automatic shutoff and alarm signal to BAS based on drain system capacity and location of a reduced-pressure principal device.
- Automatic shutoffs shall function independently for each device, shutting off only the single affected BFP in the event of malfunction.
- Where Reduced Pressure Zone (RPZ) devices 50 mm (2 in.) and larger are used, the A/E shall demonstrate that the drainage system can pass the maximum possible flow rate through the device relief valve of the device, or shall provide independent automatic shut-off and alarm annunciation. The flow sensor shall be designed to preclude nuisance tripping during low flows.
- Even where automatic shut-off devices or other provisions are provided, the device shall be arranged to route normal low-flow drainage to an adjacent floor drain.

Low-point drains equipped with hose pattern threads and serving a potable water system shall be provided with ASSE 1011 hose bib vacuum breakers and a hose cap. Where a hose bib is provided near any sewage pump, laboratory waste treatment system, or liquid waste decontamination system, the hose bib shall be provided with a RPZ-BFP. Bypass arrangements shall not be permitted around the BFP.

Water supplies to BSL-3 and ABSL-3 spaces shall be isolated from other functions with an approved BFP installed outside the containment barrier. A single device may be provided for each individual penetration, or parallel devices to provide N+1 redundancy may be utilized to serve multiple suites.

BFPs are also required for connections to mechanical make-up water, high hazard equipment, and must be appropriate for the application and hazard, outside the containment barrier.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 8, Section 8-3-00 A. Water Service; Exhibit X-8-3-D Backflow Prevention Device Application Guidance; Chapter 8, Section 8-11-00 BSL-3 & ABSL-3 Biocontainment - Water Systems Serving BSL-3 & ABSL-3

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Noise in Biomedical Research Laboratories and Animal Facilities

Noise is an environmental stressor for both people and animals. In laboratories, noise sensitive areas include space where procedures that require a high degree of manual precision or mental concentration are performed. Equipment such as chemical fume hoods, centrifuges, and vacuum pumps contribute to the high noise levels within the laboratory. Noise levels in laboratories and animal facilities are difficult to control because room finishes are generally hard and nonabsorbent.

In an animal research facility, the immediate environment directly and indirectly affects an animal's biological and behavioral responses and thus will have an effect on the research being performed. Most small animals are stimulated and may be stressed by noise. Noise disturbances are less of a factor for large animals unless they are involved in behavioral testing. Different species of animals will have different tolerances for high or low frequency noises. Certain frequencies can have an adverse affect on sensitive animals. These issues must be discussed with the facility users.

Animal species that generate noise should be isolated from those that are noise sensitive by either distance or sufficient acoustical isolation. Often, large animals generate noise whereas smaller animals are typically less noisy. Birds are noisier in relation to their size than rodents. Thus it is important for the designer to be familiar with the species that will be housed in the facility.

Although rodents can adjust to constant low level background noise, background noise should be minimized or removed through the use of innovative design. It is imperative to eliminate the effects of sudden and variable noise producing elements, such as fire alarms, throughout the animal holding environments.

Power ventilated racks generate noise. The rack density in a room will affect the noise level. Mechanical equipment may generate noise frequencies that are not noticeable to humans but will potentially affect animals housed near the source of the noise. Equipment that generates noise should be remote or acoustically isolated from animal holding rooms wherever possible. Noise exposure to personnel must be considered when selecting cage rack washers. Noise conductivity through the duct system should also be taken into consideration. Sound attenuators shall be used for controlling noise. Duct lining is not permitted in NIH facilities.

For aquatic species research, the location of pumps and other mechanical equipment associated with the aquatic facility is a critical design feature and shall be located remotely from the holding rooms so as not to create noise and vibration.

Noise is characterized by a certain spectrum indicating the sound pressure level at various frequencies. Very often, the spectrum of a noise is as important as its absolute level. The level of such background sounds is commonly related to a series of noise criteria (NC) or room criteria (RC) curves. To determine the NC/RC value in the field, sound pressure levels should be measured with an octave-band sound-level meter.

The maximum allowable background Noise Criteria (NC) for a research laboratory is 40-45 NC based on rooms not being occupied with all user equipment off. When evaluating the noise levels in research animal housing areas, it is necessary to consider both the people and the animals in these spaces. For reasonable speech communication in these spaces, a maximum noise level of NC-45 shall be maintained. The acoustical consultant shall determine specific requirements for animal research areas on a per project basis with the Project Officer and research staff. All rooms in all buildings, except special acoustical laboratories, are exposed to some level of audible and measurable ambient sound. The maximum allowed airborne sound power levels from mechanical system equipment shall not exceed the values listed in the DRM Chapter 6.5. For each piece of machinery in the human environment, do not exceed the maximum airborne sound levels 84 dB.

Acoustical control is an important planning consideration and shall be evaluated during design. By examining adjacencies, the effects of noise can be addressed in the design layout.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 2, Section 2-3, Section 2-4, Section 2-5; Chapter 4.F3.1; Chapter 6 Section 6-5.

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HVAC Thermal Insulation Systems

Thermal insulation systems are the key element to prevent heat loss and heat gain and to improve energy efficiency. Thermal insulation systems specified for use at NIH shall meet current industry standards.

The Design Guidance portion of DRM Section 6-4 defines the minimum insulation standards (i.e. material specifications and thicknesses) for NIH projects and is intended as a guide for the specific services listed as well as other similar services that may not be indicated. The A/E shall select the most suitable insulation material for piping based on the latest applicable energy efficiency standard(s) or DRM Exhibit X6-4-A, whichever is more stringent. The DRM Exhibit X6-4-B provides minimum insulation thicknesses for piping, cold equipment, hot equipment, supply air ductwork, and outdoor air ductwork. The A/E shall select the most suitable insulation thicknesses based on the latest version of ASHRAE 90.1 or DRM Exhibit X6-4-B, whichever is more stringent.

Insulation materials approved for use in NIH buildings shall have a fire hazard rating not to exceed 25 for flame spread and 50 for smoke developed. All materials shall be factory tested as an assembly. Fire ratings shall be determined by the standard method of testing for surface-burning characteristics of building materials, ASTM E84 or NFPA Standard 255. Insulation shall have a UL label or a certified test report from an approved testing laboratory.

All insulation installations shall be in accordance with the National Commercial & Industrial Insulation standards published by the Midwest Insulation Contractors Association. All adhesives, sealers, vapor barrier coatings, etc. used in conjunction with insulation shall be compatible with the material to which they are applied. Any cement, sealer or coating used shall be resistant to vermin and mold. Metallic components used for the installation of insulation systems shall be suitable for the intended environment and shall be non-corrosive.

All insulation surfaces shall be durable and, where exposed, protected from damage due to maintenance operations, vandalism, weather, and normal wear and tear. Insulation exposed to weather shall be covered with 0.41 mm (0.016 in.) aluminum jackets.

Insulation shall be continuous at all hangers, hanger rods, supports, sleeves, and openings. Vapor barrier shall be provided for all cold surfaces and shall be continuous. Where supports occur below the insulation surface, the thickness shall be maintained over the support and shall extend sufficiently beyond the support to prevent condensation. Insulation shall be sealed at all termination points.

All insulation shall be arranged to permit expansion and contraction of systems without causing damage to the insulation or surface. High-density pipe saddles or welded pipe standoffs shall be provided at all points of pipe support.

Valves shall be insulated up to and including bonnets. Cold water valves shall be insulated over packing nuts in a manner to permit removal for adjustment and repacking.

Insulation in containment spaces must be sealed at each end and must have a smooth and cleanable jacket.

The A/E shall specify that the constructor shall not insulate the specified systems until all necessary tests have been conducted for each component; surfaces have been thoroughly cleaned; and surfaces are in a dry state.

Not all systems require thermal insulation. Systems not requiring insulation include:

- Brass or copper pipe specified to be chrome plated (typically applies to toilet rooms),
- Steam traps, steam powered pumps,
- Steam condensate pumps,
- Concealed relief piping from safety valves,
- Fire protection piping and components,
- Fuel oil piping and components;
- Exposed ducts in air-conditioned spaces if duct is not prone to condensation,
- ASME stamps,
- Access plates of fan housings,
- Cleanouts or hand-holds.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 6, Section 6-4; Exhibits X6-4-A & X6-4-B; ASHRAE 90.1; ASTM E84 and NFPA Standard 255.

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Applications of Sealants in Biomedical and Animal Research Facilities

Sealing of walls, windows, doors, mechanical ducts, pipes and other penetrations plays an important role in Biomedical and Animal research facilities. This minimizes air infiltration, moisture seepage, pest harborage, vermin infestation and escape of infected species. In addition, sealing promotes cleanliness of work surfaces in laboratory.

To effectively reduce encroachment of pests and vermin infestation within a building, the Design Requirement Manual (DRM) requires thorough sealing of areas that have the highest potential of encroachment, particularly in an animal research facility. These areas include: storage and staging area, loading docks, radioactive waste storage area, cage - washing area, autoclave area, glass wash area and laboratories. In addition, sealing of cage wash area including equipment pit area shall form a complete barrier between the clean and dirty cage area. All gaps between an environmental room and adjacent construction shall be sealed. Joint sealants shall be applied throughout for thermal and moisture protection as architectural practice dictates, and as required for fire stopping penetrations per industry standards.

Containment of biohazards is an important consideration in the design of biomedical laboratories. Depending on the types of research involved, some Biosafety Level 3 (BSL3) and Animal Biosafety Level 3 (ABSL3) areas may need to be completely sealed to allow gaseous decontamination. Sealing of laboratory casework including work surfaces shall prevent contamination of surrounding spaces. Autoclaves integral to the containment barrier require biological seal. BSL3 facilities usually employ: sealed windows, sealed penetrations, sealed access panels, sealed (electrical, communication and fire alarm) device boxes and sealed lighting fixtures. In addition to these requirements, ABSL3 facilities utilize sealed and break resistant vision panels. In animal facilities, wall and corner guards, used for protection against impact damage, shall be sealed to the mounting surfaces.

All utilities installation within BSL3 and ABSL3 facilities shall be sealed to the containment barrier and shall be constructed to meet NIH Biosafety Level 3 – Laboratory Certification Requirements. Heating Ventilating and Air Conditioning system ductwork penetrations shall be sealed with appropriate sealants. Insulation in containment spaces shall be sealed at each end and must have a smooth and cleanable jacket. Exhaust plenums in ABSL3 containment area shall be sealed to prevent escape of microorganisms if the ventilation system becomes static.

Water, sewer and fire protection piping seals shall preclude concealed fouling and allow easy cleaning. Penetrations thru containment barriers shall meet the room-tightness integrity testing requirements. All drainpipes shall have seals to prevent infiltration of sewer gases and other contaminants. Hot water piping shall not use seals constructed of natural rubber, which often serves as nutrient to bacteria.

Lighting fixtures used in ABSL2, BSL3 and ABSL3 facilities shall be factory sealed and gasketed. These fixtures shall be designed to ensure that biohazards are contained within the containment area. In addition, penetrations of electrical conduits, cables, and boxes in those spaces shall be completely sealed. Conductors for power, data or any other system in BSL3 and ABSL3 areas shall be sealed to meet room-tightness integrity testing. Exposed conduits shall be separated from the surrounding surfaces either by standoffs or by sealing both sides to the adjacent surfaces.

The types of sealants used are very important as the sealants used need to be low emitting type, non-corrosive and non-deleterious to insulation of the wires. The Project team shall contact the Division of Occupation Health and Safety (DOHS) Community Health Branch (CHB), during early planning stages of any design project to ensure that the design addresses all areas relative to pest management. Animal facilities present some of the most challenging circumstances to an effective pest management program and the performance of integrated pest management (IPM) services. Selection of types of sealants and installation details require approval of DOHS CHB. Refer to DRM for the recommended sealant types and sealant application locations. Finally, all penetrations of fire stoppings shall maintain integrity of the fire rating of construction.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chap. 1, Sections 1-(9-11); Chap. 2, Sections 2-(3-6); Chap. 4, Sections 4-(2,3 & 5-7); Chap. 6, Sections 6-(2-4 & 6); Chap. 8, Sections 8-(1-3 & 6-7 & 11); Chap. 9, Sections 9-(2&6)

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Introduction to NIH Building Automation Systems

The Building Automation System (BAS) at NIH is configured as a network with control functions at multiple levels and with multiple points of operator control and supervision. The BAS includes central servers, local building engineer's workstations, data transmission systems, field panels and controllers, necessary interfacing controls, sensors and actuators. The controller contains a microprocessor and other supporting electronics, and performs local control functions and executes application programs without requiring communications with the central server or workstations. All new facilities shall use digital controls in accordance with the DRM. The Architect/Engineers (A/E) and Project Officers (PO) shall meet with maintenance staff early in the project to coordinate new digital controls with existing.

BAS design shall provide uniformity of design; combine the best overall economy with suitability of design; and be compatible with all other building systems. Provisions for future expansion shall be made as determined by NIH on a project-by-project basis.

BAS installations shall strive for standardization across institutes and operating organizations to maintain consistency and increase reliability. It is the responsibility of the institute and/or operating organization to define and present those standards to the design and construction community. Appendix D of the DRM provides site-specific standards that apply to the Bethesda Campus while Section 7-3 of Chapter 7 provides physical Input/Output (I/O) requirements, sequences, and system requirements related to how the BAS is applied to the building areas and systems. This section is organized by "element" of the building and systems and includes applications for specialized areas such as high containment.

The functional intent of the BAS is to provide standardization and to ensure access requirements are met. BAS applications as described by the DRM shall control and/or monitor all systems in the building with the exception of vivarium lighting systems; scientific equipment monitoring systems; fire alarm systems; elevators; security; chilled water plants; and hot water or steam plants. The DRM covers building level connections to campus steam, campus hot water generating, and campus chilled water systems.

The BAS shall be an integrated digital control system composed of a tiered Local Area Network (LAN) architecture connecting supervisory servers/interfaces and distributed stand-alone multi-level controllers. Supervisory graphic software system configuration and backup software shall use a client/server architecture to store and serve the graphics, user databases, system configuration databases, site controller programming backup/upload/download, etc.

Throughout the design process, the A/E shall coordinate with the organizations that will support or use the BAS. A/Es shall coordinate, in concert with the PO, the designation of a building system telecommunication hub and required building support hardware to support the BAS. The A/E shall develop clear specifications for the control contractor relative to the LAN and its point of connectivity with the institute provided services and required interface hardware as part of their design. Requirements for Internet Protocol (IP) addresses shall be established and secured through the PO.

A/Es shall coordinate through the PO to determine point naming and equipment numbering conventions; graphic formats and layouts; location of operator interfaces and required number of portable operator workstations; training requirements; required user accounts and levels of access; and the routing of alarms and notifications. A/Es shall coordinate with the users and applicable safety organizations for control parameters and condition tolerances.

The design documents shall include, at a minimum:

- Specifications detailing the BAS requirements.
- Schematic drawings indicating the systems/zones and all control system input and output.
- List of all points with summary counts.
- Detailed written sequences of operation.
- BAS infrastructure schematics.
- Valve schedules.
- Indication of control elements on the applicable discipline design floor plans

Additional detailed drawing and specification requirements are indicated in Section 7-1-30 B. of the DRM.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 7, Sections 7-1, 7-2, 7-3; Appendix D

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Power Quality

Power quality is one of the major issue that affects sensitive electronic equipment prevalent in modern research facilities such as NIH. Power quality parameters include voltage sags/swells, momentary interruptions, harmonics, etc. In designing new electrical systems or in major renovations, power quality issues must be addressed to ensure proper operation of all sensitive electronic equipment including research lab equipment, communication equipment, computer, etc.

Use of power electronics in adjustable speed drives improves the operating efficiency but increases electrical system harmonic contents. Likewise, use of non-linear load such as fluorescent lamp, switch mode power supply of computer/printer, and uninterruptible power source (UPS) increases system performance while contributing to harmonic distortions. The NIH Design Requirements Manual (DRM) requires proper selection of equipment to minimize harmonic distortions generated in the electrical system.

The DRM requires that all fluorescent lighting have electronic ballasts that have less than ten percent (10%) total harmonic distortions. In addition, the DRM requires use of 18 pulse variable frequency drives (VFD) for motors rated 75 horsepower and above. For motors rated less than 75 horsepower, provide 6 or 12 pulse VFD with harmonic filters (passive or active), phase multiplication devices, or any other components required to mitigate total harmonic distortion (THD) of voltage to 5% and THD of current to 5% at any load and with both having no individual harmonic distortion greater than 3%.

VFDs that employ shunt tuned filters shall be designed to prevent the importation of outside harmonics which could cause system resonance or filter failure. Provide calculations supporting the design, including a system harmonic flow analysis, as part of the submittal process for shunt tuned filters.

To effectively address the power quality issues, the DRM also requires that power system analysis be performed to determine if mitigating measures are required when a large number of harmonic generators are anticipated. To mitigate power quality issues, the following steps may be taken i.e. oversizing the transformer serving the harmonic load, specifying k-rated transformer, specifying harmonic filter, oversizing neutral conductors, etc.

The DRM requires that when a large percentage (50% or more) of the load is non-linear, provide the following:

(1) K-13 rated transformers with 200% neutral wires from transformers to switchboards or panelboards.
(2) Branch circuit panelboards with 200% neutrals.
(3) Full-size individual neutrals for each branch circuits.
(4) Oversized neutrals for shared circuit homeruns for modular furniture.

The DRM requires suppression of transient voltage surges at different levels of the electrical distribution systems to protect the sensitive equipment when a UPS system is not provided as the power source of the sensitive equipment. The protection systems shall include category B3 TVSS protection up to downstream branch circuit level. Furthermore, provide ANSI/IEEE Standard C62.41 compliant Category C3 TVSS protection at the building electrical service entrance when a complete building lightning protection system is required.

To ensure proper operation of the sensitive equipment, specify equipment with low THD output and other mitigating measures as necessary for operation of sensitive equipment.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 10, Section 10-6, 10-8 and 6-2.

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Variable Frequency Drive

Variable frequency drive (VFD) use has increased dramatically in past decades to reduce energy as most industrial and commercial motor applications do not require constant speed operation. In addition to energy savings, VFDs offer the following advantages: low motor starting current, high power factor, lower KVA and reduction of thermal and mechanical stresses on motors and belts during the starts. VFDs are commonly applied to air handlers, pumps, chillers and fans. Proper specifications and installations of VFDs are crucial for the prevention of premature failures and elimination of electrical nuisances.

The Design Requirement Manual (DRM) requires that VFD installation in the NIH facilities shall meet the following requirements:

1) Harmonic distortion on both supply and motor side of the VFD.
2) De-rating of equipment due to harmonic produced by VFDs.
3) Audible noise caused by high frequency (several KHz) components in the current and voltage.
4) Require dedicated and independent VFD for each prime and secondary motor.
5) Matching VFD with the motor so that low speed can be achieved.
6) VFDs shall have a manual bypass independent of the drive. For motor 37.3 kW (50HP) and larger, provide a reduced voltage starter in the bypass circuit. Motors shall operate at full speed while in the bypass position whenever the speed drive is de-energized and/or open for service.
7) VFDs that serve fans shall be able to maintain operation during short power fluctuations.
8) Provide 18 Pulse VFD for all motors 56 kW (75 HP) and above and provide 6 or 12 pulse VFDs for all motors less than 56 KW (75 HP).
9) VFDs shall have integral passive or active harmonic filters, phase multiplication devices and any other components required to mitigate voltage total harmonic distortion (THD) to 5%, current THD to 5% at any load level, and no individual harmonic greater than 3% distortion.
10) Conduct THD measurements at VFD circuit breaker terminals at full load to show compliance with the above mentioned requirements.
11) Locate VFDs in environments that are within manufacturer's specifications. VFD locations shall be as close as practical to the motor to minimize motor circuit conductor length.
12) Install incoming power wiring of VFD, wiring from VFD to motor, and motor control wiring in separate, dedicated conduits.
13) All VFD associated with supply and exhaust fans serving BSL3 or ABSL3 spaces, which are required to maintain biocontainment, shall be provided with the ability to restart into a coasting motor without delays and without damaging the motor following a power outage and the initiating of the emergency electrical power.

In addition to above mentioned requirements, refer to the DRM, Appendix E.4 "Harmonic Control in Electric Power Systems" for additional information regarding harmonic distortion concerns and refer to the DRM, Appendix E.6 "Selecting and Specify Variable Frequency Drives for HVAC Systems" for additional information regarding variable frequency drives concerns.

A/E shall carefully select VFD to avoid damage to the equipment and preclude introduction of excessive harmonics and noise to the electrical systems.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 6, Section 6-2, 6-6, and 10-6.

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News to Use

Design Requirements Manual

The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_j U_i)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho\overline{U_j U_i})=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}-\rho\overline{u_i u_j}\right)+g_i(\rho-\rho_0)$ 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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Sustainable Design

The Department of Health and Human Services policy for Sustainable and High Performance Buildings applies to all buildings under the control of the NIH. The policy stated in Section 1-10 of the DRM is as follows: All construction projects will incorporate the *Guiding Principles* of the Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU) into the planning, design, construction, operation, maintenance, and decommissioning processes. Construction projects under the scope of this policy, which have a total project cost equal to or greater than $3 million, will obtain a third party certification to meet the requirements of a multi-attribute green building standard or rating system developed by an ANSI-accredited organizations (such as U.S. Green Building Council's (USGBC) and the Green Building Initiative's (GBI)).

Existing facilities will incorporate the *Guiding Principles* of the MOU to the maximum extent feasible in all improvement, repair and maintenance projects. In addition to incorporating the *Guiding Principles* of the MOU, improvements and repair projects, which have a total project cost equal to or greater than $10 million and/or impacting 40% or more of the overall floor area, will obtain a third party certification that meets the requirements of a multi-attribute green building standard or rating system developed by an ANSI-accredited organization.

NIH incorporates the Guiding Principles established by the MOU as follows:

1. Employ Integrated Design Principles

a. Integrated Design – An integrated project team is involved in planning to delivery for all projects.

b. Commissioning – NIH requires commissioning for all projects. The level or scope of commissioning for any single project shall be determined by the complexity of the project requirements. Commissioning is a comprehensive process for ensuring that:

i. All building systems are installed and perform according to the design intent.

ii. Systems are efficient, cost effective and meet the user's operational needs.

iii. The installation is adequately documented.

iv. The operators are adequately trained.

2. Optimize Energy Performance

a. Energy Efficiency – NIH projects are required to incorporate energy efficient strategies in Architectural, Heating Ventilating Air Conditioning, Electrical and Plumbing systems. Renewable energy is implemented based on life cycle cost analysis.

b. Measurement and Verification – Utility metering shall be provided for primary utility services, capable of automatically registering peak flow and totalization to NIH building automation utility monitoring systems

3. Protect and Conserve Water

a. Indoor Water – To conserve indoor water, the DRM specifies flow rate for faucets and showers; maximum flush rates are specified for urinals and water closets.

b. Outdoor Water – Water efficient landscape is required for NIH projects.

c. Process Water – Systems are designed to conserve water. Existing process water systems are retrofitted with water saving measures as applicable.

d. Water-Efficient Products

4. Enhance Indoor Environmental Quality

a. Ventilation and Thermal Comfort – DRM specifies minimum requirements for ventilation rate and indoor design conditions for temperature and humidity.

b. Moisture control – Water tight envelope including roof is designed for new construction projects.

c. Daylighting – Incorporated in applicable areas of buildings with proper controls.

d. Low-emitting Materials – DRM requires specifying materials and products with low pollutant emissions, including adhesives, sealants, paints, carpet systems, and furnishings.

e. Protect Indoor Air Quality during construction - Sheet Metal and Air Conditioning Contractor's National Association Indoor Air Quality Guidelines for Occupied Buildings are required to be followed during Construction.

5. Reduce Environmental Impact of materials

a. Recycled content – Materials with recycled content are specified.

b. Biobased content – Products with Biobased content is purchased and specified.

c. Environmentally preferable products

d. Construction waste and materials management - Demolition waste is separated and recycled to the maximum extent practicable.

e. Ozone-depleting compounds – Refrigerants and Fire suppressions agents are specified with non-Ozone-depleting compounds.

References relating to sustainable design found in the DRM are listed in Exhibit X1-10-A.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 1, Sections 1-1, 1-7, 1-10, 1-11, & Exhibit X1-10A;

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Design Requirements Manual
The formulae for building state of the art biomedical research facilities.

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Special Requirements for Laboratories using Radioactive Materials

All laboratory modules using radioactive materials shall be designed for the safe storage of radioactive waste. The volume of radioactive waste generated by a laboratory is a function of the type of work being performed. The A/E shall gather information regarding the function of the laboratory to determine the space necessary for radioactive waste storage; recognize that some types of radioactive waste require segregation from other types; and design the radioactive waste storage area to accommodate multiple containers. All laboratories shall be designed to fit the appropriate low-level radioactive waste (LLRW) storage receptacles and/or containers. NIH Division of Radiation Safety (DRS) provides specifications on these containers. Five LLRW streams have been identified from the NIH Waste Disposal Calendar, current edition:

- Liquids - Aqueous waste and/or solvents/other hazardous chemical constituents (mixed waste)
- Dry or solid waste (dry active waste) - Disposable lab ware and/or sharps (can also be categorized as Medical Pathological Waste - MPW)
- Liquid scintillation vials and/or bulk liquid scintillation media
- Animal carcasses and/or tissues
- Animal bedding and/or solid excreta

Radioactive waste management policies and procedures are available in the radioactive Waste Disposal guide available at http://orf.od.nih.gov/NR/rdonlyres/7F729619-4E2F-4A21-8281-0724E5E6840C/25635/RadioactiveWastesection508.pdf. A standard location of the radioactive waste storage in laboratories shall be established to assist emergency response personnel. For laboratory modules with a service corridor, this storage shall be located near the service entrance rather than the hall entrance, eliminating the need for moving radioactive waste through the main corridors of the laboratory building. The configuration of the radioactive waste storage area in the laboratory shall be designed to facilitate radioactive material spill cleanup and decontamination. Interior surfaces of the storage area shall be readily cleanable for ease in decontamination. Corridors and public space shall not be designated and used for storage, and equipment such as refrigerators and freezers shall not be designated to store this material in these areas. The A/E shall include the following in the design:

- Physical security measures and mechanisms against unauthorized access in all laboratories.
- Security for all radioactive materials in laboratories when unattended.
- Space for shielding waste containers.
- Appropriately sized laboratory and marshaling areas for reduction of storage and/or waste accumulation.
- Appropriate spill containment for all storage areas.
- Potential shielding requirements between adjoining or adjacent laboratory bench areas for high-energy beta emitter radionuclides.
- Compensation for the additional weight required for lead shielding in the design of countertops and hoods if the laboratory is used for high-energy gamma emitter radionuclides.
- Secure equipment alcoves for storage of radioactive materials and/or irradiator equipment.
- Security provisions in construction specifications (e.g., locks as part of the integrated system, to secure this equipment) when storing radioactive materials in refrigerators and/or freezers.

Beta barriers for shielding energetic beta emitters (P-32), often transparent plastic sheets, 0.95 cm to 1.27 cm thick, shall be provided to protect personnel in adjacent and close work areas.

All radioisotope fume hoods shall meet requirements identified in DRM Chapter 6, Section 6-1-00 D.7.d.

Refer to Section 1-9 F for Ventilation System, Radioactive Airborne and Liquid Effluent discharge and Vacuum requirements.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chapter 1, Section 1-9 and Chapter 6, Section 6-1, 6-2.

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Interior Finishes in Biomedical and Animal Research Facilities

Materials selected for the finishes of laboratories shall be durable, smooth, and easily cleaned, provide ease of maintenance, minimize pest access, and contribute to the creation of a comfortable, productive, and safe work environment. All finishes shall be sealed to provide a positive barrier against the harborage of pests and vermin.

For most laboratory spaces, lay-in acoustical ceiling tiles shall be provided. Acoustic tiles shall have a cleanable, smooth surface with a vinyl face or equivalent and have a square edge. Tegular edges are not permitted. Ceiling tiles must be laid out symmetrically so that tiles and grid members retain modular dimensions. All ceiling suspended items shall be secured from independent structural assemblies attached directly to the structural floor and framing members overhead. Hard ceilings, (gypsum board, fiber reinforced polyester (FRP), glass-fiber reinforced composite panels (GFRC panels)) equipped with access panels, shall be provided in glass-ware washing and autoclave rooms or where the potential for a high moisture level exists. All areas within the animal facility, except personnel support spaces, require ceilings that are smooth, free of crevices and capable of withstanding scrubbing with detergents, disinfectants, and water under pressure on a frequent basis.

Wall surfaces shall be free from cracks, unsealed penetrations, and imperfect junctions with ceiling and floors. Materials shall be capable of withstanding washing with strong detergents and disinfectants. Selection of wall treatments shall be based on the functional use and purpose of the area, as well as any infection control and chemical resistance requirements. Sound control and acoustical properties within the area shall be considered when material selection is made.

Wall coverings and fabrics are NOT permitted in laboratories. Walls in animal facilities shall be constructed of concrete, concrete block, or surfaced with a heavy duty, impenetrable veneer, such as fiberglass reinforced panels (seamless) since these walls are subject to water daily, including impact damage from hose streams.

Laboratory floor materials shall be seamless, slip resistant nonabsorbent, resistant to wear, and resistant to the adverse effects of acids, lab chemicals, solvents, cleaning materials, decontamination chemicals and detergents. Floor materials shall be installed to allow for decontamination with liquid disinfectants and to minimize the potential spread of spills. Carpet is not permitted. The A/E selections shall be influenced by an understanding of the specific use of the particular area. When selecting floor finishes the A/E shall consider: durability and permanence; functionality of room/space; maintenance; floor flatness (F_F) and floor levelness (F_L). Flooring shall be installed under casework.

Floors in animal facilities shall be smooth, durable, moisture proof, nonabsorbent, and slip resistant and resistant to the adverse effects of disinfectants, high temperature water, detergent cleaning, and chemicals used in holding and procedure rooms and continuous movement of cages and equipment. If thresholds are used to separate dissimilar flooring materials, provide type that permits the easy wheeling of cages or other equipment through the animal facility. Rubber flooring, VCT, vinyl base are NOT permitted in Animal Facilities. Seamless, monolithic flooring material shall be carried up walls 150 mm (6") minimum, integral with floor with coved corner. A water vapor transmission and core test shall be performed prior to application. Control and expansion joints shall be flush. Concrete surface preparation shall be shot blast. Floor shall slope to drains and top coat shall be slip resistant.

The main criteria for high performance coatings or manufacturer applied composite systems within containment facilities are chemical resistance, smoothness, durability, and ease of cleaning. Finish material, factory or field installed, shall be selected based upon these and other project specific set of criteria. Consideration shall be given to the corrosive chemical activity of disinfectants, decontamination gases/vapors, and other chemicals used in the laboratory.

Finishes and construction details shall provide a barrier against the harborage of pests and vermin. Joints between dissimilar materials shall be considered as a stress point and shall be constructed to prevent cracking.

Walls and ceilings shall be finished with a scrubbable, chemically resistant material, free from cracks. Seal penetrations and imperfect junctions at ceilings and base. Materials shall be capable of withstanding the effects of strong detergents and disinfectants and be capable of withstanding the impact of normal traffic.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chap. 4, Sections 4-4, 4-7.

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High Purity Water Systems

The quality of high purity water from a central building distribution system shall be established as a joint decision among the researchers and design team. Water quality requirements must reference an appropriate industry standard (such as ASTM or NCCLS) or be very specific as to the necessary parameters so that the system can be appropriately engineered and maintained. In making these decisions, the team must consider not only water quality requirements and the need of individual researchers to have confidence and a clear definition of the delivered water quality, but also the immediate and long term economies toward achieving and maintaining that end product and meeting the need for flexibility. The use of process terminology such as "RO" and "DI" is never adequate in itself to define required water quality.

Numerous types and combinations of water systems are installed for laboratory use, and specific applications may require use of distillation, deionization, and Reverse Osmosis (RO) technologies to achieve specific water quality requirements. A central fully circulating RO system to supply general use purified water with application of local polishing equipment at specific point-of-use areas is most commonly provided at NIH facilities. Typically, these systems are arranged to provide a medium grade (ASTM and NCCLS Reagent Grade Type III or Type II) water quality with enhanced parameters to limit bacterial colonization. Type III grade water as specified in ASTM Standard D 1193 shall be provided for heat exchangers used for steam humidification, electrically powered sterilizers, and similar applications.

Common Requirements are as follows:

1. A site-specific water supply analysis shall be prepared during the design stage to determine required water treatment.
2. Water for pharmaceutical or animal drinking water purposes shall be from completely independent, dedicated purification systems sourced directly from potable water, and not combined with other water systems.
3. The A/E shall clearly define sizing parameters of the systems including total daily consumption, peak system flow, distribution flow to each floor or zone, and maximum flow per outlet. Each floor or zone distribution main shall be field adjusted so that all research functions are satisfied.
4. Primary equipment downstream of the storage tank shall be arranged in parallel to allow for continuous supply of purified water to research spaces.
5. 254 nm UV light and submicron filters shall be provided for all systems. Additional UV light (such as 185 nm) should be provided only as needed for Total Organic Carbon (TOC) reduction, based on a more stringent required water quality parameter.
6. The distribution system shall be designed to maintain the temperature of the water under 29°C (85°F).
7. System fluid must be shielded from light with opaque materials; pH, nitrogen, phosphate and CO2 levels controlled and sanitation methods followed to preclude growth of algae.
8. Drainage systems receiving waste water from high purity water systems and production equipment shall be corrosion resistant.
9. Distribution systems shall be continuous circulating type with features to minimize bacterial colonization. A minimum velocity corresponding with turbulence Reynolds Number (Re) of not less than 10,000 is required throughout the system under all conditions, including at peak design demand. Higher scouring velocities may be required in some applications.
10. The system shall be designed to provide a minimum residual pressure of 140 kPa (20 psi) at outlets (after polishers) and maximum pressure shall not exceed 550 kPa (80 psi). Pressure requirements at polisher inlets shall be verified and can often be as much as 240 kPa (35 psi).
11. Surge pressure ratings of the system components must be considered in determining required system zoning.
12. Pressure reducing valves shall not be used in the distribution system as a substitute for multiple distribution zone pumps/ tanks, with the exception that pressure control devices shall be provided at the end of supply or end of return as required to maintain adequate pressure under varying demand conditions. The use of pressure reducing valves in these fully circulating systems can cause numerous pressure control problems and fouling issues.
13. Plastic piping may require continuous or more frequent supports based on manufacturer's recommendation.

The piping system distribution on each floor shall be independent of other floors to the connection with the main supply and return riser. Where serpentine distribution systems are utilized from one laboratory into another, they shall be arranged such that the supply and return system serves only a single floor and only a single laboratory wing prior to connecting to the main supply and return risers. For large facilities, the system shall be further segregated to facilitate shutdown of services by corridor or groups of laboratories to minimize potential disruption during future modifications. Direct return arrangements consisting of a parallel supply and return main with a branch takeoff from both the supply and return main to serve each laboratory shall be considered to allow for individual shut-down, reduced branch pipe sizing, and maximize future flexibility. Where recirculating faucets are required, direct return arrangements shall be utilized to provide a connection point for return water flow. Each connection to the return main shall be provided with a balancing valve or engineered flow restrictor and appropriate flow meter.

Equipment and piping materials must be carefully selected for compatibility with the degree of water purity required. The DRM provides guidance as to acceptable materials. It is especially important that system installers are properly certified in pipe joining technologies and that all fusion equipment is calibrated, quality control strictly maintained, and systems properly tested.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Chap. 8, Sections 8-4.