

News to Use

Design Requirements Manual

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Biomedical Laboratory Design Requirements

A general understanding of laboratory design is required for preparing the NIH Program of Requirements (POR) and other planning and programming documents.

Laboratories at the NIH are designed to a minimum of Biosafety Level 2 (BSL-2). Biosafety levels above BSL-2 meet minimum level 2 requirements plus additional safety and security requirements as defined in separate chapters of the DRM. When designing an NIH Biomedical Research Laboratory, it is important to pay particular attention to security, ventilation strategies, fume hood and biosafety cabinet (BSC) location, surface finishes and seam seals, lighting, noise, vibration stability particularly for the use of specialized equipment, traffic patterns, plumbing materials, etc. It is also important to include the users in the planning and programming of the facility.

At a minimum, a NIH lab requires inclusion of a hand washing sink with an emergency eyewash; a safety shower where fume hoods are located or corrosives are handled; a UL rated flammable storage cabinet; an "INTERNALLY EXPLOSION SAFE" refrigerator, and a corrosive storage cabinet. All design features must be considered in relation to the program and discussed with representative users.

There are many types of laboratories at the NIH. Most labs, however are 'wet labs' where solutions or biological materials are used. Wet labs require bench space with kneeholes, work & hand washing sinks, chemical fume hoods and/or BSCs. A wet lab is fitted out with a full range of piped services such as deionized (DI) or reverse osmosis (RO) water, lab cold and hot water, lab waste/vents, carbon dioxide (CO₂), vacuum, compressed air, eyewash, safety showers, natural gas, telephone, local area network (LAN), lighting, power and accommodation for medical pathologic waste (MPW).

Development of a functional adjacency plan is important when planning for associated lab spaces. Associated lab spaces that are often overlooked but that are essential to the labs operation include shared spaces such as instrument rooms, wet and dry ice storage, and a restricted access workroom for radioactivity; the loading dock, materials management, building operational areas such as toilets, shipping and receiving areas, mechanical and electrical rooms, telecommunications, utility distribution areas and provisions for controlled access as required by the specific program.

Utility capacity and redundancy must be considered. Three concepts should be addressed in the NIH lab design process. Lab space and utility services must be flexible so they can be readily adapted to accommodate future changes in research protocols. The laboratory building must be capable of providing all the utility services necessary to conduct the research. Reserve capacity should be designed into the primary building utility systems to allow researchers to add equipment and instrumentation as needs change without compromising lab health and safety. Last but not least, state-of-the-art research buildings must be designed to accommodate expansion.

Use of a modular design is critical for future flexibility. The laboratory module is the basic laboratory building block and should offer predictability and reliability in the distribution of laboratory services. At the NIH, the lab module is typically 3 350 mm (11'-0") wide and 10 056 mm long (33'-0") with an aisle width of 1 525 mm (5'-0") between the bench or equipment space on each side of the aisle. A general 'rule of thumb' for planning biomedical labs, assuming 2 persons per module, is that lab support space is based on 50% of the laboratory space.

The gross building area includes the total area of all floors, including basements, mezzanines, penthouses, mechanical and electrical spaces, and enclosed loading docks. Gross area is measured from the exterior surfaces of all enclosing walls except where the exterior wall surface overhangs the exterior window surface by 300 mm (1'-0") or more. For research labs, a grossing factor of 1.54 to 2.00 is typical.

All utilities should be carefully organized into specific zones, both horizontally and vertically. The connection point of each service should be in a uniform position relative to the module with simple extension into the laboratory without disruption of adjacent modules.

In planning a biomedical research laboratory, it is helpful to use resources such as the Room Data Matrix, Appendix C of the DRM. Information regarding Biosafety Level 3 and Animal Biosafety Level 3 can be found in DRM Chapter 2 Sections 5 & 6.

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Animal Research Facility Design Requirements

Most of the same design principles that apply to biomedical research laboratories also apply to animal research facilities (ARF) (see April 2010). For example, the NIH ARF is designed to a minimum of Biosafety Level 2 (BSL-2). Biosafety levels above BSL-2 meet minimum level 2 requirements plus additional safety and security requirements as defined in separate chapters of the DRM. Many additional features must be considered for an ARF. Minimum ARF requirements to meet AAALAC certification are outlined in the "Guide for the Care and Use of Laboratory Animals (Guide)." The NIH generally exceeds AAALAC requirements. During planning, it is crucial to identify the variety of species to be housed in the facility over time; the temperature and humidity range that each species can tolerate; and the degree of flexibility and adaptability required to accommodate different species. Vibration stability, noise damping, diurnal lighting, prep space, surface finishes, sealing and caulking, and ventilation, are other critical considerations in designing an ARF. Since animal facilities present some of the most challenging pest management concerns, the NIH integrated pest management (IPM) program must be incorporated into the design. The DRM provides guidance to create an ergonomic and reduced allergen environment for facility workers. For example, an operating noise level of 85 dBA should not be exceeded in the cage wash area and changing stations are used to change the bedding to keep dust levels as low as possible.

At NIH, most of the animal holding rooms are designed for small animals such as rodents or for non-human primates. The DRM contains guidance about other species that are less frequently used at NIH but may require specialized facilities. Generally, any area where animals are held for more than 24 hours is treated as holding area. Often an NIH ARF includes surgical and pathology areas, diagnostic equipment, multiple types of storage including drug and cold carcass storage.

Natural light is not used in rodent housing areas where the research often requires regulated lighting cycles. Lighting should be on emergency power and monitored at the room level independent from the method used to control the lights. Most small animals are stressed by noise so it is important to consider noise damping and acoustical isolation from animal holding rooms wherever possible.

Animal holding room modular size is based on cage rack system size which may be different than a standard laboratory module.

The minimum recommended space between racks is 915 mm. The ceiling height of the animal room and doors must be carefully planned for. The height is a function of the maximum rack height including rack fans. Adequate space above the rack must be allowed for uniform airflow distribution in the room.

The ARF HVAC units are designed with N+1 redundant system arrangements or with standby equipment with capability to ensure continuous operation during equipment failure, power outages, and scheduled maintenance outages. Although it is acceptable to have a common air intake system for both animal holding and other parts of the building, the animal area exhaust system must be independent of the non-animal exhaust systems of the building. Utility connections to animal facility modules include a small sink in each small animal holding room; selection of an animal watering system; placement of weatherproof or waterproof protected electrical outlets with sufficient electrical loads to accommodate all the holding and procedure room needs. Rack systems shall be connected to the emergency power system. If a BSC or a laminar flow transfer station is required, the impact of these systems must be considered in determining the room's heat load and air circulation patterns. Consideration must be given to specific pathogen free (SPF) zones, and clean and dirty areas when planning functional adjacencies.

Cage wash rooms must be designed with a "dirty" side and a "clean" side. The dirty side may require prep or de-scale pit. The DRM provides guidance for the pit specifications. Dirty side equipment includes a bottle washer, a cage and rack washer, tunnel type washers, acid neutralization tanks, and an autoclave. The autoclave should be of sufficient size to contain full size or multiple cage racks and should be provided with "clean" steam to extend the useable life of the equipment. The clean side is equipped with a large autoclave, bedding dispenser, animal drinking water flush station, and water bottle filler. Linear space for marshalling is also required on the clean side.

An animal loading dock area shall be considered. The DRM provides detailed guidance to ensure safe and secure animal transfer into the facility.

For further information, refer to the Room Data Matrix, Appendix C-Vivarium of the DRM; the IPM program in Chapter 1 Section 1-11; animal biosafety level 3 (ABSL-3) in Chapter 2 Sections 6 and Section 3-3-10-C: Vivarium Loading Docks.

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Placement of a Biological Safety Cabinet in the Laboratory

Biological Safety Cabinets (BSCs) are designed to provide personnel, environmental and product protection when appropriate practices and procedures are followed. BSCs are typically used in research or pathology labs, animal facility procedure and housing areas. Three kinds of BSCs, designated as Class I, II and III, have been developed to meet varying research and clinical needs. At NIH, BSCs are typically Class II. Class III BSCs may be installed in BSL-3/BSL-4 laboratories.

Class I BSCs include HEPA filtration of the exhaust air leaving the cabinet. Class II BSCs include internal down airflow, which is HEPA filtered. This is in addition to the separate HEPA filtration of the exhaust air leaving the cabinet. Class III BSCs consist of ventilated glove boxes, which are gas-tight chambers. They include HEPA filtration of the inward airflow and double HEPA filtration of the exhaust air leaving the cabinet.

Recognized standards for the design, fabrication and performance of BSCs include: NSF/ANSI 49-2009 Class II (Laminar Flow) Biosafety Cabinetry by the National Sanitation Foundation and the American National Standard Institute; and the CDC/NIH 2007 "Primary Containment for Biohazards: *Selection, Installation and Use of Biological Safety Cabinets*" 3rd Edition. These standards are intended to provide: personnel, product, and environmental protection; reliable operation; durability and structural stability; ease of cleaning; limitations on noise level; illumination; vibration; and motor/blower performance.

When designing a room containing one or more BSCs, consideration must be given to the location of each BSC in relation to room heat loads and air circulation patterns within the room.

Appendix I of the DRM: Biosafety Cabinet (BSC) Placement Requirements for new Buildings and Renovations was added to the DRM in May 2010. Appendix I clearly defines specific minimum requirements for placement of a BSC through the use of "Do's and Don'ts" diagrams. The design team should refer to Appendix I for the placement of every BSC.

Performance of BSCs can be affected by the presence of disruptive air flow patterns. Placement of BSCs shall avoid disruptive air flow patterns at the face of the cabinets. They shall be located out of the laboratory mainstream personnel traffic pattern or at the end of isles.

In addition, they shall not be placed directly across from one another.

A work zone around the BSC needs to be established. The work zone must include: a minimum of 40 inches in front of the BSC; a minimum of 12 inches, on either side, to adjacent walls or columns. In addition, clear spaces are needed around BSCs: a minimum of 80 inches from opposing walls and/or 60 inches to opposing bench tops or areas of occasional traffic; and a minimum of 40 inches are also needed between the BSC and bench tops along a perpendicular wall. This clear floor space shall not overlap with another BSC.

In rooms with multiple BSCs, the use of staggered arrangements is preferred. If this is not possible, there shall be at least 120 inches between two BSCs facing each other. If two BSCs are placed next to each other, there shall be at least 40 inches between them. BSCs along perpendicular walls shall be placed 48 inches apart.

It is not recommended that a BSC be placed near an entryway. If the placement of a BSC near an entryway is unavoidable, the BSC face shall be placed, at least, 60 inches from behind the doorway or 40 inches from an adjacent doorway.

Air supply diffusers or exhaust vents shall not be placed directly over or in front of BSCs, where air movement can affect the airflow into the cabinet. In BSL-3 laboratories, the placement of BSCs shall consider the total room ventilation rates. The design team shall be responsible for coordinating the exhaust air requirements for the BSCs.

Lack of compliance with the criteria listed above can affect the ability of a BSC to maintain proper airflow to ensure safety and proper containment of contaminants.

Pressurized gases shall not be piped into BSCs. The use of compressed gasses (such as lab air) has been shown to disturb intended airflow patterns within BSCs. The use of fuel gas has also proven hazardous, and is generally not required or desired in BSCs.

BSL-3 laboratories, with Class III BSCs, shall be provided with a dedicated exhaust air system. This dedicated exhaust air system shall not be used to serve the rest of the laboratory space. Redundant exhaust fans and assessment of the location where the exhaust air is discharged are very important to ensure there is no re-entrainment back to outdoor air intake.

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Fume Hood Requirements and Testing

Fume Hoods provide local exhaust ventilation to control airborne hazards e.g. chemical fumes, flammable vapors and potentially dangerous dusts. Fume Hoods may be variable air volume (VAV) or constant air volume (CV) type. Although the use of VAV Fume Hoods is highly recommended, the decision shall be based on a comprehensive lifecycle cost analysis that accounts for all system features required by NIH.

All Fume Hoods shall be manufactured under the ANSI/ASHRAE STD 110 and shall meet minimum performance ratings as described in DRM Chapter 6, Section 6-1-00 D.7.d. These performance criteria define the parameters for accurately validating the proper operation of the Fume Hoods. Fume Hoods to be used in NIH facilities shall meet specific criteria as detailed in the latest NIH Design Requirements Manual (DRM). The criteria are defined in NIH Specification Section 11810, NIH Specification Section 11820, NIH Specification Section 11830.

All Fume Hoods installed in NIH facilities shall comply with the following NIH testing requirements:

- NIH Specification Section 15991-On Site Testing-CV Fume Hoods
- NIH Specification Section.15992-On Site Testing-VAV Fume Hoods
- Appendix E.3 "Fume Hoods Testing and Alarm System."

The NIH testing protocol, unlike ANSI/ASHRAE STD 110, has clear pass and fail criteria whose target values must meet prescribed acceptance levels for dynamic and static tests. It assesses turbulent intensity (TI) which is more representative of containment effectiveness than the parameters measured in the Standard ANSI/ASHRAE 110 protocol. Contaminant leakage is observed from different positions within the hood, with a variety of sash opening settings, at different face velocities and with movement across the face of the hood with and without an operator. It is important to perform a risk assessment, or in other words, to evaluate the Fume Hoods placement and working conditions when establishing the face velocity. On-site testing and off site mock up to perform the NIH protocol is conducted independently of both the fume hood manufacturer and the fume hood control system manufacturer. Testing shall be conducted for at least 50% of the hoods provided in the project.

All ARRA funded projects must comply with the NIH Fume Hood manufacturing, testing and performance requirements per the specifications listed in the DRM.

VAV Fume Hoods in non-containment type labs shall have no air-cleaning (HEPA or charcoal), except for radiological hoods.

The laboratory in which a VAV Fume Hood is installed shall remain under negative pressure with respect to the corridor or adjoining rooms even when the Fume Hood operates at the minimum exhaust air rate. When the exhaust air quantity is reduced, supply air quantity shall be reduced by the same volume. Laboratory minimum ventilation requirement of six (6) air changes per hour (ACH) shall be met even when the Fume Hood operates in the minimum exhaust air rate position. Airflow monitoring/alarm devices shall be installed at each Fume Hood to provide the user with operating information. These devices shall monitor the face velocity at the sash opening.

Low flow Fume Hoods may be used at NIH as long as they meet ALL the requirements as outlined in the NIH / ASHRAE 110 Modified Fume Hood Testing Protocol. The face velocity of low flow hoods should **NEVER be below 0.41 m/s (80 fpm)**.

Auxiliary air-type Fume Hoods shall NOT be used in any NIH facilities. In the event of a retrofit application, the A/E shall investigate the capacities of the existing system exclusive of the auxiliary air, laboratory supply and exhaust system characteristics. Once it has been established that the system can support the addition or replacement of an existing Fume Hood, this information shall be forwarded to the project officer for approval before the design is allowed to proceed.

For further information, refer to the DRM Chapter 6 Section 6-1-00 D.7.d Fume Hoods; Chapter 6 Section 6-1-00 D.7.e Variable Volume Fume Hoods; Chapter 6 Section 6-1-00 D.7.f Low Flow and Auxiliary Air Fume Hoods; Appendix E, Section E.3: Fume Hood Testing and Alarm Systems; Biosafety in Microbiological and Biomedical 5th ed. 2007, CDC/NIH; *Methodology for Optimization of Laboratory Hood Containment*; Farhad Memarzadeh, National Institutes of Health, 1996; ACGIH, Industrial Ventilation, a manual of recommended practices. Chapter VIII-HVAC.

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Piping Systems - Design and Materials

The DRM specifies piping materials for use in systems within and outside of the laboratory that are intended to provide uniformity of design, be cost effective, and promote compatibility with other building materials and building systems. Hydronic plumbing and process piping systems in NIH facilities shall be designed for ease of system maintenance and component replacement, system reliability, and extended service life.

Piping systems consisting of different hydronic zones shall be provided with interconnecting means to be used when serving critical areas. Each piece of equipment shall be provided with a means to determine balance and control water flow. Balancing valve and flow meter fittings shall be provided at each floor for every riser. Hydronic equipment and systems shall not be installed inside BSL-3 containment.

NIH has researched and made recommendations regarding the use of specific pipe materials and quality. For example, the use of stainless steel traps is described in <http://orf.od.nih.gov/PoliciesAndGuidelines/Bioenvironmental/>. It is incumbent upon the A/E to consult the available resources to determine piping material compatibility with the specific program requirements. Construction documents shall include specifications for testing procedures and commissioning of all systems installed in the project.

Selection of pipe materials and installation methods shall incorporate special requirements unique to individual program areas, such as consideration of magnetic fields, special materials, shielding, and chemical exposure, etc. Piping/plumbing (p/p) systems may differ in animal facilities versus in a laboratory. Animal facility p/p systems may include cage wash, waste drainage, animal drinking water, and vivarium gas systems. These systems require close review with an animal care specialist to determine the exact requirements for specialized equipment, drainage, steam, and corrosive criteria.

BSL-3 and ABSL-3 p/p criteria are specified in the DRM in Section 8-11: BSL3 & ABSL3 Biocontainment. Piping systems not serving BSL-3 spaces shall not be routed in containment areas. Penetrations into the containment barrier of BSL-3 spaces shall be fully detailed in the construction documents, and shall require mock-ups to be constructed and tested prior to installation. All penetrations shall be durable, sealed, and tested to meet the room tightness criteria for BSL-3 containment. Insulation shall terminate at the back face of the penetrated material, prior to the containment barrier. Escutcheons shall not be utilized. Special attention shall be given to sealing, caulking and corrosion resistance criteria as described in the DRM Chapter 2, "BSL-3 Testing, Validation, and Calibration"

and Chapter 4 Architectural Exhibit X4-7-A "BSL3 Caulking and Sealants."

General requirements for p/p are the same for all facility types. Adequate fluid temperature, pressure, and volume shall be delivered to meet laboratory functions through conservatively sized pipe mains. Future capacity (20%) allowances shall include building design calculations, utility services, main risers and major branch lines, equipment room space planning and interdisciplinary coordination of projected future requirements. To the extent possible, **equipment should be sized to provide an additional 20% capacity above the calculated system requirements to offset aging and wear and tear performance losses.**

The DRM specifies piping design criteria for steam and steam condensate piping (Sec.6-3.D.4). Regardless of steam and condensate pressure classification, all pipe and fittings shall be rated for a minimum pressure of 2,067 kPa (300 psi). Steam piping shall be a minimum Schedule 40 and condensate piping, a minimum Schedule 80.

Heating water systems in NIH buildings shall serve preheat coils, reheat coils, perimeter radiation fan coil units, etc. These systems can be constant or variable flow and include heat exchangers, duplex distribution pumps, expansion tank(s), makeup water provisions, air separator and two or three way terminal device control valves. Heating water systems shall be designed to offer N+1 reliability and maintain 100% capacity in the event a lead component fails.

Cooling in NIH facilities is to be provided by the use of chilled water. Chilled-water cooling coils shall be selected to ensure that the interior space relative humidity is maintained at full and part-load conditions. Chilled water coils shall be selected for an entering water temperature of 7.2°C (45°F) and leaving water temperature of 15.6°C (60°F) at peak demand.

Water piping installation at the NIH Bethesda campus and Poolesville facilities shall utilize Type K (hard-drawn) tubing. Extramural projects located outside of the metropolitan Washington DC area may use Type L (hard-drawn) copper piping for above ground water piping installations if prevailing practices and water supply conditions are compatible with Type L (hard-drawn) copper tubing.

Materials and application of pipe hangers, supports, joint welding, brazing and soldering shall conform to the latest requirements of ANSI/ASME B31.1 or ANSI/ASME B31.9 and MSS Standard Practice SP-58, SP-69, and SP-89, and other applicable specifications. All p/p systems shall be provided with a complete identification system that conforms to the requirements published in ANSI/ASME Standard 13.1 and NFPA 99.

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Heating Ventilation and Cooling (HVAC) System Redundancy

Since research laboratories and animal facilities may conduct studies of long duration, which need to be performed under consistent environmental conditions in order to achieve repeatable results, a failure of the HVAC system and other systems is unacceptable. A variety of mechanical and electrical systems in NIH facilities are to be designed with N+1 redundancy to maintain operation at all times. Among these are supply air handling systems, certain exhaust systems and chilled water systems dedicated to special areas.

Systems serving areas of critical nature shall offer 100% redundancy for all vital components and shall be powered from an emergency power source. Planning for redundancy begins in the pre-design phase. The A/E shall review redundancy requirements for each particular system with the program user and the NIH/DOHS.

Central HVAC systems shall be provided with multiple air handling units and exhaust fans to provide redundancy and improve reliability. These systems shall be designed to include manifolded air handling units (AHU) to achieve redundancy and maintain operation at all times.

Air handling systems shall be provided with the following:

- AHUs shall be designed to provided N+1 reliability and maintain 100% capacity in the event of a lead component failure.
- Multiple parallel AHUs shall be provided to operate simultaneously to meet full load conditions. Each AHU and its related components shall be capable of total isolation by the use of isolation dampers located upstream and downstream of each AHU.
- Upon failure of any major component related to an AHU serving non-containment such as biosafety level (BSL) 2 biomedical laboratories, the remaining available air handling equipment

shall provide a minimum ventilation rate of 6 air changes per hour (ACH) in the affected area.

- Upon failure of any major component related to an AHU serving non-containment such as animal biosafety level (ABSL) 2 animal housing and support facilities, the remaining air handling equipment shall meet the entire HVAC load in the affected areas.
- Manifolding of AHUs to the same header shall be allowed for units operating at external static pressure differing not more than 0.19 kPa (0.75 in. wg) from each other.
- AHUs serving ABSL facilities shall be completely separate from other air handling systems.

Exhaust air systems shall be arranged with multiple manifolded fans designed to achieve N+1 redundancy and maintain the exhaust air system fully operational, at all times. Each manifolded fan shall be designed to be fully isolated while the overall system remains fully operational. In the case of single fan systems, in addition to the main fan, a standby fan shall be provided. Regardless of the system size, the following exhaust systems shall be provided with an N+1 redundancy:

- Isolation rooms
- Laboratory general research areas
- Fume hood exhaust
- Radioisotope/radioactive fume hoods
- Animal general research areas
- Cage washers
- Any other function as designated by NIH/DOHS

All critical associated systems and components serving the HVAC systems (electrical, controls, chilled water, hot water, etc.) shall be arranged to provide N+1 redundancy to preclude single point failures from compromising the reliability of the HVAC systems.

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HVAC - Air Distribution Systems

Heating, ventilation, and air conditioning (HVAC) air distribution systems for Research Laboratories and Animal Facilities shall deliver heated or cooled air to all spaces to maintain the allowable range of space temperatures.

Supply, exhaust, and outside air shall be **ducted** for all spaces, i.e., not taken through ceiling plenums, shafts, mechanical equipment rooms, corridors, or furred spaces. Plenums and air shafts for distribution of supply or exhaust air is prohibited in NIH laboratories. Common outdoor air ductwork may be permitted for outdoor air intakes to multiple air-handling units due to space constraints and building configuration.

The circulation of air directly between areas is not permitted except in the following situations. Air circulation is permitted between toilet rooms, locker rooms, janitors' closets, between adjacent corridors into negative pressure areas and out of positive pressure areas.

Supply air to each individual room shall be balanced for the actual airflow requirements (the highest cooling load or makeup air/ventilation airflow requirement). The central supply and exhaust air systems shall be balanced for the total of the individual airflow requirements in each room plus the allowable duct leak based on the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) duct construction manual. Air temperature and air amount to each space shall automatically adjust as appropriate to accommodate variations in the space heating and cooling loads.

Supply air distribution system shall be designed to minimize turbulence and to avoid having an impact on the performance of primary containment equipment such as chemical fume hoods and Biosafety Cabinets (BSC).

- Air outlets shall not discharge into the face of fume hoods or BSCs.
- Exhaust grilles and registers shall be located away from supply air diffusers in a manner that creates uniform, low velocity airflow across the room.

The duct system design for NIH buildings shall consider space configuration, space air diffusion, noise levels, duct leakage, duct heat gains and losses, balancing methods, fire and smoke control, initial investment cost, and system operating cost.

The ductwork systems shall be designed, fabricated and installed in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and SMACNA standards. Refer to Exhibit X6-2-A for a list of acceptable air velocities to be used in the design and sizing of different HVAC components.

Ductwork may be single-wall or double-wall construction. It may also be round, flat oval, or rectangular shape. Duct fittings, joint methods, supports, and construction details shall be in accordance with SMACNA standards. All fittings shall have documented pressure loss coefficients by either SMACNA or ASHRAE. Irregular or makeshift fittings are not acceptable. Factory-fabricated fittings by independent manufacturers may be utilized provided they have catalogued performance criteria.

Specification for ductwork construction material, sealing and leakage class, and pressure classification construction shall be as per SMACNA standards.

Refer to exhibit X6-2-B for minimum ductwork construction to be used in NIH facilities. The sheet metal contractor is required to conduct pressure tests of the installed ductwork per SMACNA to quantify the leakage rate of the installed systems.

News to Use

Design Requirements Manual

The formulae $\frac{\partial U_i}{\partial x} + \frac{\partial}{\partial x}(\rho U_i) = -\frac{\partial \sigma}{\partial x} + \frac{\partial}{\partial x}(\mu \frac{\partial U_i}{\partial x}) + \rho_i(p - \rho_i)$ for building $\frac{\partial}{\partial x}(\rho U_i) = -\frac{\partial \sigma}{\partial x} + \frac{\partial}{\partial x}(\mu \frac{\partial U_i}{\partial x} - \rho \omega^2 U_i) + \rho_i(p - \rho_i)$ state of the art $\frac{\partial}{\partial x}(\rho U_i) = \frac{\partial}{\partial x}(\rho \omega^2 U_i)$ 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

Vibration Criteria

Vibration can be a serious issue if mitigation measures are not considered during the design of a Research and/or an Animal facility. The structural system shall be designed stiff to the extent that any transmitted vibration occurs at high frequencies, as these are effectively dampened with instrumentation vibration dampening systems and isolation tables than vibrations occurring at lower frequencies. The transmissibility curves for the isolation systems (active or passive) should be reviewed to choose the appropriate system.

The following are some options to control vibration within the laboratory and animal research facility space:

- Design a structural system with short column spacing.
- Isolate laboratory spaces from sources of vibration.
- Locate extremely vibration-sensitive equipment on grade-supported slabs.
- Locate vibration-sensitive equipment near columns on framed floors.
- Avoid combining corridors and laboratory spans in the same structural bay on framed floors.

The table in Chapter 5, Section 5-2-00 C recommends floor vibration velocity limits in (micrometers per sec) and structural criterion (kips/in-sec) for vibrations produced by footfall based on the following criteria.

- Walking pace for a closed corridor (a corridor with walls on both sides and doors on either or both wall) shall be 90 steps/minute.
- Walking pace for open or "ghost" corridor (a corridor with a wall on one side, with or without doors, and the ends of laboratory benches or

other laboratory paraphernalia on the opposite side) shall be 75 steps/minute.

- Walking pace for cross aisles (walkways between laboratory benches) shall be 60 steps/minute.

The ambient vibration shall be limited to 20 micro meters per second (800 micro-inches per second) in research facilities. The structural design shall meet specific vibration limits specified by the manufacturer of the sensitive equipment.

Vibration stability is important to maintaining a constant experimental environment for sensitive animals such as rodents. Therefore, rodent holding and test rooms should be located away from areas such as a cage wash, major circulation corridors where racks are frequently in transit, mechanical rooms and elevator shafts. Vibration can adversely affect aquatic species and should be controlled and buffered as much as possible. 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. Vibration stability is required where specialized equipment will be used such as animal imaging equipment, electron microscopy, and electrophysiology procedures including intracellular data collection equipment.

All elevators, rotating machinery, mechanical/electrical equipment, ductwork, piping and conduits shall be provided with appropriate vibration isolation as required by relevant sections of the DRM. It is imperative to ensure that these vibration isolators are installed per project specifications.