Division of Technical Resources
Office of Research Facilities
The National Institutes of Health Vol. 01, No. 22
January 2012
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

NIH Laboratory Sealant Requirements

Joint sealants are an important requirement for key interior areas of NIH laboratory facilities. The function of the sealant is to prevent the penetration of air, pest, gas, dust, smoke and liquid from one location through a barrier into another. Sealants are also required for thermal and moisture protection, fire stopping and finish work. Sealants are a requirement for proper compliance with the NIH Integrated Pest Management program and for ensuring building integrity. Reference the Design Requirements Manual (DRM) Chapter 4, Exhibit X4-2-A Sealant Table for additional information. This table provides detailed information on the types of sealants and locations of areas requiring sealants. Exhibit X4-2-A has been updated to include information from Exhibit X4-7A which now has been deleted from the DRM.

Non-Laboratory spaces and each category of biosafety level laboratories require specific type of sealant. Reference the appropriate biosafety level column for guidance in the proper selection and the location of the sealant. The minimum standard for the sealants are provided within the American Society for Testing and Material (ASTM) standards:

- JS-1 Architectural Urethane Sealant ASTM C1620
- JS-2 100% Silicone ASTM C1518
- JS-3 100 % Silicone Mildew Resistant ASTM C1518
- JS-4 Siliconized Acrylic Latex ASTM C1518, ASTM C834
- JS-5 Urethane ASTM C1620
- JS-6 Non-Halogenated Latex- Based Elastomeric Sealant ASTM C920
- JS-7 100% Silicone Aluminum Finish ASTM C920

Non-Laboratory

The Non-Laboratory spaces are defined as spaces outside of lab zone. Some sealant requirements for Non-laboratory spaces are the following:

- JS-4 to seal door frames to wall boards and joints between walls of dissimilar materials.
- JS-1 shall be used to seal the door threshold to the floor, as well as control joints in floors.
- JS-6 is to be used to seal all penetrations on the top and bottom of the slabs, as well as wall penetrations for sleeves, collars and the surrounding construction.
- JS-3 shall be used to seal the lavatory fixtures and to seal the toilet mounts to the surface and to seal the sink faucet to mounting surfaces.

BSL2

Some sealant requirements for Biosafety level 2 laboratories are the following:

- JS-4 shall be used at the door frame and wall board interface, openings in table legs, floor mounted supports, cabinets in contact with dissimilar materials and where they contact one another and all counter top connections with other surfaces.
- JS-4 sealant is also required at the top and bottom of wall mounted shelving brackets, shelving wall junctures, peninsula shelving support at counter top and at ceiling and cabinets where they contact one another.
- JS-4 sealant is required for all wall guards, bumpers, rails, top and bottom of cove base, perimeter of suspended acoustical ceiling frames at the wall juncture, interior window frames, at all wall and ceiling for surface mounted cover plates, at the baseboard molding, control joints in walls and ceilings and joints between walls of dissimilar materials.
- JS-1 is required to seal around floor surface-mounted mounting plates, control joints in the floor and at the door threshold to floor attachment.
- JS-6 is required at all wall penetrations on the top and bottom of the slabs, wall sleeves, collars, and surrounding construction.
- JS-5 is required to seal all floor mounted equipment supports, legs and standoff supports

BSL3, ABSL2 and ABSL3

The BSL3, ABSL2 and ABSL3 laboratories have the most comprehensive sealant guidelines. Sealants are required at all exposed connecting surfaces within all areas of the laboratory such as the doors, cabinetry, shelving, walls, floors, ceilings, HVAC, electrical, equipment and plumbing fixtures.

- The doors require the JS-4 at the penetrations, hinge plates (including piano hinge), frames where they meet the adjacent wall, around lock sets, view panel frames, view panel glass (even if gasketed), thresholds, door protection plates, door guards and door latch.
- JS-4 is required to seal ductwork that penetrates the wall, diffusers/grill joints, vacuum pass through, sprinkler collars, and piping penetrations.
- Seal conduit at wall and ceiling surfaces, perimeter of electrical panels, light fixture connections to walls and fixed equipment with JS-4.
- JS-5 is required to seal top and bottom of the cove base.
- JS-6 shall be used to seal space in wall penetrations, including inside sleeves, collars, and surround construction.
- JS-7 is required to seal all gaps and opening in racks, seams at the hot water insulation seams, gaps that exist between stainless steel sheet metal in all cage washers, tunnel washers and rack washers.

This article is a brief summary of the data presented in the DRM Sealant Table mainly addressing the architectural requirements and some mechanical and electrical requirements. Reference the Sealant Table for more detailed information and requirements such as the HVAC, plumbing and electrical items. In addition to the DRM, contact the NIH ORS Division of Occupational Health and Safety Community Health Branch (CHB) for guidance on sealing and pest management during design. For further information refer to the DRM Chapter 4.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
DRM Exhibit X4-2-A Sealant Table

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Compressed Gas Systems

Compressed gas systems are a typical component of biomedical research laboratories. Specific requirements for compressed air, natural gas, specialty lab gases, and vacuum shall be verified during the programming phase of a laboratory project. Compressed gas systems may consist of a cylinder or bulk supply system, each with a separate reserve supply. Specific reserve capacities are based on estimated average consumption and vary based on cylinder-based systems versus bulk systems. Sources of local resupply are also factored into the reserve duration and capacity requirements. Point-of-use gas cylinder systems are sized in accordance with program requirements through consultation with the use group. Compressed air may be produced with compressors or cylinders. Cylinders may be only be utilized for very limited applications where provision of central compressed air would be impractical and when the condition is approved by the NIH Project Officer. Bulk supply systems shall include a telemetry system that is compatible with the various vendor suppliers utilized by NIH.

Laboratory and vivarium gas supply and distribution systems shall be completely independent of gas systems serving clinical patients. Gas system components for medical or vivarium, or laboratory use shall, at a minimum be factory cleaned and packaged as for oxygen service. Prior to operation, all gas systems shall be verified free of cross connections, pressure tested to at least 150% design operating pressure using inert gas of cleanliness and purity not less than the design process fluid, and verified of required cleanliness and purity throughout the entire system.

Primary services to each floor of a building wing shall be connected to respective supply risers, independent of other floors or building wings. Risers shall be located either inside the building wing served, or in a common area to multiple building wings. In general, unless noted otherwise, maximum velocity in distribution systems shall not exceed 20 m/s (4000 fpm), and pressure drop shall not exceed 10% for systems operating above 380 kPa (55 psi), and shall not exceed 20 kPa (3 psi) for systems operating below 380 kPa (55 psi).

An adequate number of valves shall be provided so as to facilitate maintenance; and to isolate systems for renovations and unexpected emergencies without affecting operation of adjacent spaces. Valves shall be provided at the base of each riser, at each riser connection, at branch piping to each laboratory equipment group, and at equipment requiring maintenance. Each distribution loop or double-fed main and risers shall be provided with sectionalizing valves such that a branch or portion of the piping serving an individual lab and individual floors may be shutdown without disrupting the service to the entire floor, other floors or building areas. Where valves are located above ceilings, thorough coordination of piping services shall be required to ensure proper access for valve operation.

Pressurized gases shall not be piped into a biosafety cabinet. The use of compressed gases (such as lab air) has been shown to disturb intended airflow patterns within biosafety cabinets. Fuel gas has also proven hazardous, and is generally not required or desired in bio-safety cabinets following modern research techniques.

NIH requires most pressurized gases (with the exception of fuel gas, vacuum, and general instrument air) to be provided utilizing special materials and brazing methods to maintain system cleanliness, at least equivalent to that required for oxygen service. The A/E shall specify the performance qualifications to maintain system cleanliness. Brazing criteria of general lab gases shall meet Section IX, ASME Boiler and Pressure Vessel Code or ANSI/AWS B2.2 Standard for Brazing Procedure & Performance Qualifications, both as modified by NFPA-99 or the Copper Development Association for medical gas application. Where high purity gases are required, additional specification criteria shall be provided to ensure product standards, joint quality and cleanliness consistent with the required application.

Stubouts for lab gas turrets shall be secured to structure to provide rigidity and the A/E should provide a stainless steel plate for wall-mounted turrets to protect walls from damage.

Where sufficient demand exists, central bulk gas systems (including cryogenic tanks and vaporizers) shall be provided in lieu of numerous compressed gas cylinders. Typically, this applies to gases such as carbon dioxide and nitrogen, but may vary for each project. Bulk systems shall be located in a secured area and in full compliance with NFPA standards. The specific location of bulk tanks shall be subject to NIH approval. For cases where a set contract is in place, the NIH Project Officer can advise as to the gas purveyor is to be utilized for provision and service of the bulk cryogenic tank farm, as well as how systems are to be specified for purchase or (less common) rental. Duplex vaporizers, refrigeration units, etc. should generally be provided as necessary to ensure continuous service. Stand-off warning signage shall be provided for bulk tanks with regards to safety valve/rupture disc discharge. Cryogenic piping systems shall be vacuum jacketed.

Research at the NIH has requirements for many different specialty gases, including helium, argon, hydrogen, oxygen, nitrogen, carbon dioxide, carbogen, and numerous gas mixtures of various purity. Planning shall allow for the proper storage of full and empty gas cylinders, including separate storage areas for flammable and oxidizing gases. All compressed cylinders must be secured with cylinder restraints to the building structure, toggle bolts and similar designs are not acceptable. Cylinder restraints shall be provided in storage areas, local distribution closets, and at points of use in the laboratories. Gas systems shall be designed in accordance with NFPA standards and fire codes, including provision of special gas storage cabinets, flame arrestors, and ventilation. The arrangement of specialty gas systems shall be coordinated with NIH ORF, DOHS, and DFM. Ultra-high purity gases are typically located near to the point of use, and special system materials and procedures will be required to maintain system cleanliness and gas purity.

Specific differential requirements that distinguish between medical compressed gas systems and non-medical compressed gas systems (both gas production and distribution differences) will be covered in detail in next month's edition of *News to Use*.

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 3; DRM Chapter 8, Section 8

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Compressed Gas Systems for Medical Use

Compressed gas systems for medical use require special attention to detail. Medical gas systems shall comply with the latest edition of NFPA Standard 99. Bulk systems over 566,335 L (20,000 scf) shall comply with the latest edition of NFPA Standard 50. Services for animals shall be completely independent of medical gas systems (including separate source supply tanks). All medical gas and vivaria systems and alarms shall be served by the emergency power system.

A separate compressed-air system independent of the laboratory compressed air system shall be provided and shall contain oil-free air compressors, desiccant air dryers, air filters, and line pressure controls. Air compressors and equipment shall be not less than duplex configuration and shall be in full accordance with the current edition of NFPA 99. Only desiccant-type dryers shall be utilized for medical air systems. MA systems shall be equipped with a duplex purification package capable of removing particulates 0.01 micron and larger. 100% redundancy of this equipment shall be provided.

MA compressors shall take their source of air from filtered outside atmosphere (or air already filtered for use in operating room ventilating systems). Air shall not contain contaminants in the form of particulate matter, odors, or other gases. MA systems shall have continuous dew point monitors, CO monitors, duplex air dryers, redundant controls, and duplex storage tanks. The MA system pressure shall be 345 kPa (50 psi) at the most remote outlet. Except for very limited demands and with prior NIH project officer approval, medical air shall be produced by central, dedicated medical air compressors in conformance with the latest edition of NFPA-99.

Where oxygen is required to serve animal research facility spaces, it shall be provided from a separate system than that of the medical oxygen for patient use. Oxygen can be supplied by large outdoor bulk storage tank or from cylinder manifold systems.

Nitrous oxide shall be supplied by a cylinder manifolded central system and piped at a terminal unit pressure of 345 kPa (50 psi) in all operating, cystoscopy, cardiac catheterization, and angiography rooms, and other locations as required by program. Nitrous oxide gas manifolds shall not be located in unheated spaces.

Nitrogen for medical, or vivarium applications (typically tool use) is normally provided by dedicated high-pressure cylinders located in a medical gas closet, with distribution at pressures in the range of 1380 kPa (200 psi) and provision of local gas control panels. Where nitrogen is required for inhalation therapy, it shall be provided from a dedicated manifold gas supply system (380 kPa (55 psi) medical gas). Specialty medical gasses shall be provided as local manifold cylinder systems (unless otherwise supported by demand requirements), dedicated for medical gas use.

The use of intertied medical gas redundant risers and mains to preclude catastrophic single point failure, incorporation of backfeed insertion points, and service valving provisions is required and shall be thoroughly reviewed during system design to ensure system reliability and facilitate future renovation and maintenance with minimal disruption. Master and local area alarm panels to monitor line pressures and the status of supply equipment shall be provided for all medical gas systems. Master alarm panels shall be placed in two separate locations: the office or work area of the individual responsible for maintenance of the system, and at a second location monitored 24 hours per day, i.e. a switchboard or security office.

Medical and vivaria gas systems shall be tested in accordance with NFPA-99, and in addition, all piping shall be tested at 20% above normal line pressure for a 24 hour period. Conventional laboratory gas systems shall be tested at not less than 1035 kPa (150 psi) for 24 hours. The A/E shall specify additional tests for specialized systems to insure system integrity. The only allowable pressure changes shall be those caused by temperature variations.

The required quantity of medical gas and vacuum outlets shall be verified on a per-program basis. In no case shall the minimum outlet quantity or locations be less that that specified in the most current edition of NFPA-99 or as recommended in the AIA Guidelines for Design and Construction of Health Care Facilities and ASPE Design Handbook 3, Chapter 2.

Pressurized gas systems shall be sized so that at maximum demand the gas pressure at the outlet is not less than 21 kPa (3 psi) below the normal design pressure, except that pressure drop not to exceed 10% of system nominal operating pressure may be used for systems operating at or above 690 kPa (100 psi). Minimum pipe size for any service shall be 13 mm (1/2 in.). Specific project specifications requirements are detailed in the DRM. The type and style of outlet should be designed to meet the needs of the medical staff.

Sufficient service and emergency shut-off valves shall be provided in accordance with NFPA-99, and as required to permit independent isolation of each building, floor, and major building wing. Valves shall be appropriately located, including use of locking and monitoring as appropriate. The use of three-valve capped bypass arrangements to permit emergency backfeeding and continuity of service during future maintenance and renovations is encouraged and should be coordinated with ORF during facility design.

Only licensed plumbers or pipe fitters, certified as medical gas installers in accordance with the ANSI/ASSE Series 6010 Professional Qualification Standard for Medical Gas System Installers, by a qualified agency shall install medical and Animal Research Facility (ARF) gas systems.

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DRM Chapter 8, Section 8

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Animal Research Facility Lighting and Controls

Lighting level and control in areas within animal research facilities depend on the usage of the space and on the species occupying the space. All lighting fixtures in animal research facilities shall be factory sealed and gasketed to prevent vermin harborage and transmission in/through lighting fixtures. Lighting fixtures shall have number of ballasts as required for the lighting control. Feed-thru and/or tandem wiring is not acceptable.

Lighting fixtures shall be listed for damp locations except for areas subject to water such as large animal and non-human primate holding rooms and ante rooms; quarantine and cubicle holding rooms; cage wash rooms. Lighting in those areas shall be UL listed for wet location, capable of withstanding a hose directed spray (minimum 85 pound per square inch) or minimum ingress protection (IP) rating of 65. In environmental and waste holding rooms, lighting fixtures shall be vapor-proof.

Typically recessed lighting fixtures with fluorescent lamps are utilized in all areas except for loading docks, where other lamp types may be preferred. Animal holding areas may require a single lamp fixture with red (or possibly other color) sleeve or filmed lens at the discretion of veterinary program. The actual user shall provide information for sleeve or lens film color.

Lighting control systems for animal holding areas shall be programmable, using either the building automation system (BAS) or a stand-alone system (which may also be used for flushing operation of animal watering system), depending on which lighting control method is more cost effective. Consider using individual astronomical timers as a cost effective method for lighting control for small new facilities and small renovations. Provide a terminal for user control and adjustment of lighting cycles within the vivarium supervisor's office, or at another location within the vivarium as directed by the user. Coordinate dimming control requirements (to simulate dusk and dawn circadian cycles) with the veterinary program.

Animal holding area lighting control requires programmable diurnal lighting cycle, which typically provides 12 hours "on" cycle and 12 hours "off" cycle, allowing adjustment of either cycle duration or providing for multiple cycles in a single day at user discretion. Provide one local override switch outside each holding room door to turn on the lamp(s) associated with the "on" cycle, plus remaining fixture lamps to achieve an 800 lux (75 FC) level within each room during caretaker cycle. For both lighting operation scenarios, override switch shall circumvent the programmable lighting panel controls diurnal cycling for a user adjustable time period of between 0 to 60 minutes, and then have the programmable lighting control revert back to its normal diurnal cycle as previously programmed.

Lighting fixtures and controls for the animal holding rooms that require flexibility to handle either species shall follow the requirements of the large animal holding room.

In addition to legally required emergency lighting, provide at least one emergency lighting at the following areas:

- MPW Waste Holding Area
- Large animal and non-human primate holding room and ante room
- ABSL2 procedure, necropsy and treatment rooms
- Cage wash area
- Receiving/decontaminations areas.

However, in surgery rooms, at least half of the lighting fixtures (including task and exam lighting) shall be on emergency power. In addition, all lighting in animal holding rooms may require emergency power at the discretion of veterinary program. Provide a self-testing emergency battery ballast (non-audible, visual indication only) for one lighting fixture per animal holding room. Emergency battery ballasts shall operate under the same diurnal controls as normal power operation, i.e. the ballasts shall turn the lamp(s) on during the programmed "on" diurnal cycle only, and not turn on any lamps if a power outage occurs during the programmed "off" cycle. When either emergency power is available or normal power is restored, the emergency battery ballasts shall revert back to their standby operation.

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 8

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Laboratory Casework Requirements

Laboratory casework is a key element within a research laboratory. All casework must be functional as researchers utilize casework daily. It is critical that casework may be easily cleaned; finishes selected must be able to withstand the cleaning and disinfecting agents used. The type of research being conducted can be a deciding factor for the color and finishes of the benchtop and casework itself. Ex: white materials are easier to see on a black benchtop and red materials are easier to see on a white benchtop.

Casework shall be able to withstand chemicals and penetrating abrasions. Wood casework and shelving (both lumber and facing materials) are more susceptible and not permitted. Metal casework systems shall be provided, unless otherwise required by user's specialized laboratory requirements. Epoxy resin, polycarbonate and stainless steel are acceptable examples for the specialized laboratories. Minimum level of quality of casework shall be established by either the NIH Laboratory Casework Specifications, user requirements, or on a per project basis in coordination with the NIH Project Officer. Long runs of fixed casework shall be minimized. Racked equipment, mobile casework on wheels, or other options that minimize cost and maximize flexibility shall be considered. Fixed casework and countertops shall be sealed to walls and floors during installation to minimize harborage of pests and provide an easily cleaned joint. Refer to NIH Sealant Table. Cabinet installation shall be in accordance with the manufacturer's specifications

Shelving: Metal shelving shall be provided, unless otherwise required by user's specialized laboratory requirements. Shelving height shall not to exceed 2 300 mm (90") for safe reaching height OR height limitations as determined by Division of Fire Marshall, whichever is lower. This requirement also applies to shelving installed as a component of a laboratory casework system. The typical depth of shelves is 300 mm (12"). Shelving depths shall not exceed 355 mm (14") for wall mounted shelving and 450 mm (18") for peninsula shelving.

Anchorage of Shelving: Anchorage of vertical standards carrying shelving brackets shall be capable of safely carrying a fully loaded wall of shelving. Each shelf shall be capable of supporting a minimum design load of 7.5 kg per 100 mm (4") of shelf length. A fully loaded wall assumes all shelves are loaded to capacity. Anchorage for shelving carrying equipment that exceeds the 23 kg per 100 mm (4") of shelf length loading shall be designed for the specific application.

Plastic Laminate Faced (PLF) Shelves: PLF shelves constructed of a particle board or MDF core material shall be a minimum of 30 mm (1") thick and a solid plywood core shall be a minimum 19 mm (3/4") thick. Shelving shall be faced on all sides and edge banded, including concealed edges. This type of shelving is not permitted in animal research facilities.

Wall Mounted and Peninsula Shelving: An end guard shall be provided for the open ends and backs of all shelves not adjoining a wall. Spacing between vertical supports shall not exceed 1 200 mm (48"). The cantilevered distance between the last support and the end of the shelf shall not exceed 300 mm (12"). Staggered depth shelves (top shelf deeper than lower shelves) are permitted.

Countertops: Countertop materials will vary depending on usage. Traditional materials such as chemical resistant plastic laminates may be appropriate for some applications. When laminates are used, top and bottom surfaces of the substrate shall be faced and all edges banded. Epoxy resin shall apply to most applications where corrosive chemicals are used or where sinks or heavy water usage occurs. Other new materials shall be investigated for cost effectiveness and durability. All counter tops shall have a drip groove beneath the overhang. Stainless steel shall be used for cold rooms, glasswash areas, vivariums and other areas as the program requires.

Countertop Support Spacing: Countertop (bench top) support spacing shall not exceed 1 200 mm (48") without intermediate supports, and shall be designed to accommodate loading of special bench top equipment identified per program requirements.

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DRM Chapter 4, Section 5

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Structural Load Requirements

Laboratory buildings should be designed with floor loading criteria to meet both current and future needs. Some instruments and research equipment are heavy, and their weight may exceed the floor loading of many buildings.

Live Loads: Floor design live loads shall be simplified to accommodate future load occupancy changes. Generalized live load categories shall be applied to large areas. Compliance with the International Building Code occupancy/use minimum concentrated live loads is required. The design live loads shall be indicated on all structural plans.

For renovation projects, the live loads of adjacent existing areas shall be noted on the structural plans to aid the contractor in determining construction live loads in staging areas or areas to be accessed during construction or demolition. Specialized equipment loads and requirements shall be verified with the equipment manufacturer. The following minimum live loads shall be used except when higher loads for specific projects are required to meet program requirements. Refer to the first table in DRM section 5-2 for other types of spaces.

Type of Space	Min Live Load (kPa)
Animal Research Facility	5.0
Animal Research Facility With Primates	6.0
Aquatic Facilities	6.0
Cagewash	10.0
Equipment Imaging Spaces	10.0
Frozen Storage, Refrigeration Areas	10.0
Laboratories	5.0
Loading Docks And Receiving Areas	12.0
Mechanical Areas (or weight of equipment if greater)	7.5

Live Load reduction: Columns supporting a building roof level shall not be subjected to live-load reduction. The A/E shall comply with the IBC for live-load reduction, or the current model building code for the area, whichever is more stringent.

For the structural design evaluation of sound existing buildings for renovation and reuse, the A/E may use the allowable live-load reduction allowed by the building code of the year during which the building was originally constructed, unless judgment of the registered professional engineer deems the live-load reductions too liberal.

Dead Loads: The building shall be designed to support the actual weights of all materials. These include structural materials, finishes, ceilings, partitions, shielding, piping, and ductwork. Assumed weights shall be indicated on the design documents.

Superimposed Dead Loads: The design of the structure shall specifically account for vertical loads imposed on the building by systems or elements that do not act as part of the primary structural system. The design shall also include anticipated superimposed dead loads in any seismic load calculation. Refer to the second table in DRM section 5-2 for minimum superimposed dead loads for building systems.

Hanging Loads: Loads exceeding 20 kg shall not be suspended from metal decking. All ductwork, piping, etc. shall be suspended directly from the structural steel framing or supplementary steel members. Loads suspended from steel joists shall be suspended from the top chords unless structural analysis allows otherwise.

For new concrete construction, cast-in inserts shall be considered for hanging items in mechanical rooms, attaching overhead lights and equipment in operating rooms, or hanging heavy loads.

For plaster ceiling panels, an area of 14 sq. m. shall not be exceeded without a structural separation from an adjoining panel section. Loads exceeding 2kPa shall be suspended independently of suspended ceiling construction.

For existing construction, expansion anchors shall not be used to carry significant load in tension, except with written approval of a registered professional engineer for the specific application. The A/E shall specify that anchors must be installed with drill bits and equipment recommended by manufacturer of the anchors.

The building shall be designed to meet IBC requirements for Wind, Seismic and Snow loads.

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DRM Chapter 5, Section 2

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Commissioning Requirements

Commissioning is the process of making sure all building systems are working before occupants move in. This requires verification that all systems are: installed properly and perform according to design; cost effective; meet the users' needs; adequately documented and well understood by operators. NIH requires Commissioning (Cx) for most projects. The scope of Cx for a project shall be determined by the complexity of the project.

Cx entails coordinating the efforts of the various parties involved in the design, construction, use, and operation of a facility to achieve an optimal facility. NIH Cx focuses on the dynamic systems within the facility, such as the mechanical, electrical, plumbing, fire protection, and security systems.

Key Cx sequences during different project phases are listed below:

Programming Phase:

- Inclusion of Cx credentials related to Cx agent selection criteria, commissioning requirements in the project construction contracts and documentation of project requirements in a format that is transferable to the Cx documentation.
- Inclusion of Cx cost in the project budget.

Conceptual Design Phase:

- Commissioning authority (CA) develops initial Cx Plan.
- CA reviews the Basis of Design (BOD) and Room Data Sheets (RDS), and participates in the development of Facility Guide.

Schematic Phase:

- Identification of the Cx team and onset of participation in the Cx process.
- CA conducts the Cx kick off meeting, reviews schematic designs and design criteria, and produces preliminary versions of Cx specification sections.
- Establishes naming conventions to be used on project equipment identification.

Construction Documents Phase:

- A/E response to all design review comments including Cx comments, development of Systems Matrix in concert with the project specification
- Operators review and comment on Systems Matrix and other documents.
- CA develops detailed Cx requirements, Cx implementation plan and design phase version of the Facility Guide; review of other construction phase submittals, and development of a summary document that will track the Cx process.
- CA develops Cx precedent diagrams to reflect Cx tasks and how to most effectively sequence systems turn over to minimize the Cx impact on the schedule.
- A/E update of the BOD.

Construction Phase:

- Designation of a Cx Coordinator (CxC) by all major subcontractors and operators to represent them in the Cx process.
- Cx progress meeting conducted by CA.
- Incorporation of Cx tasks in detailed project schedule and presentation of an updated schedule at each Cx progress meeting by the contractor.
- CA reviews and comments on shop drawings and other submittals, inspections and attendance of meetings, and production of detailed project specific pre-functional and functional testing procedures.
- Supplementation of the pre-functional procedures developed by CA, contractor-provided training plan for review by CA and operators. CA and operators' review and approval of startup protocol.
- Submittals of Operations and Maintenance (O&M) portions of the Facility Guide and Temporary Conditioning Plan by the contractor for review by A/E, CA, and operators.
- Witnessing of close in inspections by operators, CA, and Project Officer.

Acceptance Phase:

- Establishment of trending and monitoring as applicable for systems by the contractors.
- Spot check start-ups and balancing by CA and the operators.
- Functional Operational Systems Test (FOST) directed/conducted by CA, in which most parties also participate to some degree, primarily for initial samples. Continued activity with FOST performing repetitive samples by CA and operators.
- FOST documentation by CA, recommendations of acceptance as applicable, and update of FOST status on Cx summary document.
- Development and performance of commissioned systems training by CA.
- Completion of record documentation and submittal for approval by the contractor and A/E.
- Remedies to issues that caused failure of FOSTs and CA retests by the contractor.

Endurance Test Phase:

During the endurance test phase, equipment is run continuously, monitored and trended. This phase is applicable to critical occupancies such as BSL-3, vivaria, data centers, and other areas as directed by the Project Officer. Cx sequence shall include:

- CA ensures monitoring is in place and functional throughout this period.
- Use of the space by occupants to confirm functionality.

Warranty Phase:

- Onset of warranty upon completion of the acceptance phase.
- Submittal of final Cx report by CA, and addition to Facility Guide important lessons learned, changes made, etc.
- Maintenance of log of warranty calls which tracks diagnosis and resolution by contractor.
- Performance of opposite season testing by CA.
- Documentation of issues and problems with the facility operation by the operators.

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 7

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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* $\frac{\partial}{\partial x_j}(\rho \overline{U_i U_j}) = -\frac{\partial P}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\mu \frac{\partial U_i}{\partial x_j} - \rho \overline{u_i u_j}\right) + g_i(\rho - \rho_0)$ *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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Central Vacuum Systems

Laboratory vacuum is typically required for each biomedical research facility, and is generally provided as a dedicated and central system that is piped to terminal inlets within each laboratory. Such systems are utilized for numerous applications, including transfer of liquids (aspiration), filtering, solvent extraction and degassing, gel electrophoresis, and samples desiccation to name a few.

Animal surgical vacuum is often required to serve vivarium areas where surgical procedures occur. Animal surgical vacuum systems may not be required when serving procedures for small rodents, but are usually necessary for procedures with larger animals. The program should always be consulted to determine need for services and to ensure designs incorporate appropriate programmatic flexibility.

Waste Anesthetic Gas Disposal (WAGD)/Animal anesthetic gas scavenging systems are often necessary for certain clinical areas (anesthetizing locations), but may not automatically be required for all vivaria. For example, in certain applications of small scale where only halogenated volatile anesthetics are utilized, the use of portable systems (such as charcoal canisters) may be acceptable if approved by the program veterinarian, project officer, and safety authority. Portable charcoal systems are often undesirable for routine applications, and are ineffective with some anesthetics (such as nitrous oxide). Passive systems are generally ineffective, and should be avoided. A variety of techniques are utilized in animal anesthesia, both with and without intubation, including various types of anesthesia machines with and without ventilators, induction boxes, and face masks; it is therefore important that users be provided with flexible systems that maintain safety without stress on the respiratory circuit. The proper operation and reliability of these systems is an important element to assuring the safety of program staff.

Regardless of the application, each vacuum system must be evaluated for the type of substance or products being evacuated. The design of systems must consider influencing factors such as the types of traps, the potential for ingestion of chemicals or solvents, operating conditions at vacuum pumps compatibility to withstand ingestion of liquid slugs, and even the potential for creating oxygen enriched or hazardous conditions at pump equipment and exhausts.

All vacuum systems shall comply with the following:

- The exhaust from the vacuum systems shall be discharged outdoors above the roof a minimum of 7.6 m (25 ft.) from air intakes or other building openings and areas where persons may congregate.
- The system design criteria shall be for 100% of the system peak load to remain upon failure of any one pump.
- Local control systems with system operating status and alarm condition readout shall be provided at the equipment. A fault signal to BAS shall be provided.

Laboratory Vacuum:

- Pumps, whenever possible, shall be of the single-stage, liquid ring type, with components designed for use in chemical laboratory applications.
- The vacuum system should be insensitive to occasional ingestion of liquid slugs as may occur from improper trapping or ingestion from vacuum inlets.
- The use of partial or fully recirculating systems should be provided to minimize water consumption.
- Systems are typically designed to provide 480 mm (19" HgG/ 275 Torr/ 65% vacuum) at the remote terminal inlet. Where vacuum levels deeper than 22" HgG are required, the use of localized vacuum pumps should be considered unless such demand is justified and widespread.

Animal Surgical Vacuum:

- Surgical vacuum systems for vivaria shall be completely independent of other systems (including medical systems serving humans), and shall be designed to be compliant with NFPA-99.
- A single alarm panel may serve both the master and area alarm functions, provided the alarm is appropriately located and provides alert to responsible personnel and BAS.
- Sufficient valving is required, and may be arranged per NFPA-99 or per the DRM. Drops to individual spaces are not required to be individually monitored by alarms where valves are located in secure locations.
- Where human medical/surgical vacuum systems are used in the same facility, distinctly different terminal outlet patterns should be utilized. The use of DISS connections is often recommended.

Animal Anesthetic Gas Scavenging/WAGD Vacuum:

- Scavenging requirements for animal applications shall be determined through consultation with the program veterinarian, and shall be based on low vacuum or high vacuum type active systems.
- Terminal units are typically required in procedure rooms and surgery areas.
- Systems are designed as active type, in accordance with either NFPA-99 WAGD systems, or in conformance with ISO 7396-2.
- Source equipment is typically liquid ring pumps or regenerative blowers. Small systems may choose to utilize compressed air driven active venturi type terminal units to eliminate the need for additional piped systems all together.
- Alarms are required per NFPA-99.
- High vacuum systems typically operate at approximately 5-inch HgG. Low pressure systems should comply with ISO 7396-2, and include source vacuum flow regulation.
- Systems are typically designed to provide 50 to 80 LPM (1.75 to 3.0 SCFM) per inlet.
- Effective anesthetic gas scavenging can also be accomplished through procedures performed within ducted biosafety cabinets and downdraft tables, or where similar controlled active means of capturing anesthetic are provided.

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 9

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Animal Clinical Compressed Gas Systems

Compressed gas systems are utilized to serve clinical applications within animal research facilities for a variety of inhalation and sedation procedures, typically utilizing oxygen and carbon dioxide, but additional gasses such as nitrous oxide, nitrogen, and various special gas mixtures are sometimes required. Closely related are the dedicated Animal Surgical Vacuum and Anesthetic Gas Scavenging systems (see the August 2012, News to Use). This article will focus specifically on gas systems as intended to serve animal-clinical applications for respiration, anesthesia/analgesia, and life support. These systems are distinctly different, and should be independent of common laboratory, medical and process gas systems which may not meet the necessary quality, cleanliness, or reliability requirements, or may be otherwise subject to risks of cross contamination.

Animal clinical compressed gas systems are generally designed in accordance with NFPA-99/ISO 7396-1, and must reliably deliver gasses that meet medical gas standards (designated as USP/NF Grade). Systems must be designed and installed to ensure the requirements for reliability, redundancy, cleanliness, and purity are met as described in these documents. It is especially important that systems undergo careful construction and materials handling procedures to maintain system cleanliness including the use of only qualified medical gas system installers (such as ASSE 6010), medical gas brazer/welder qualification reports, maintaining sealed systems and inert gas purge, and the use of CGA G-4.1/ASTM B819 oxygen clean piping and oxygen clean individually bagged fittings. Prior to placing in service, systems should be certified for cleanliness, purity, and free of cross connections in accordance with NFPA-99 Category 1. The use of a qualified medical gas system verification process (such as ASSE series 6030) is required.

While the needs of protecting research and animal safety require systems that meet "NFPA-99 Level-1" (now called "Category 1"), a number of differences may occur unique modes of operation and physical arrangement of animal facilities. The arrangement of valves, alarms, terminal outlets, and even system sizing criteria may be permitted to differ, so long as the basic intent to ensure system safety, purity, and continuity are reliably maintained.

It is not permissible to intertie animal clinical gas systems with medical gas systems serving humans. Medical gas systems for human life support and medical procedures are kept completely independent to preclude any risk of cross contamination and to maintain conformance with regulatory standards. It is therefore poor practice to refer to Animal Clinical Gas systems as "Medical Gas" (and even risky in the case of shared research/healthcare facilities) even though the applications and quality requirements are similar. Animal clinical gas systems must also not be interconnected with laboratory gas systems, though for certain applications (such as carbon dioxide for euthanasia, nitrogen/ high pressure air supplies for powering surgical tools, or air for non-respiratory purposes) the use of shared laboratory gasses may be acceptable provided the system incorporates appropriate quality and reliability. Oxygen systems (used for respiration) shall always be separate from other applications.

Animal clinical gas systems are typically sourced from dedicated compressed gas cylinder manifolds and must be located in appropriately secure areas (often a dedicated "closet") in accordance with NFPA-99, and frequently in close proximity to the vivarium or point of gas delivery. Fully automatic supply manifolds are utilized to automatically switch over and alarm when reserve supplies are in use and to provide remote alert where supply pressure is low or pressures are abnormal. Primary supply systems are sized to provide at least 2-weeks supply capacity, and reserves must provide not less than 3 days capacity (and greater where required by the program or for remote sites). For certain gasses such as CO2 (which may be required for euthanasia), it is important to consider facility disaster mitigation and emergency response plans to ensure adequate gas supplies are available for abnormal surge demands.

Valves are provided as for other pressurized gases, however must be locked open, monitored, or otherwise secure. Oxygen must typically include an emergency valve box for conformance with fire code. System pressure is monitored at significant mains/risers downstream of the supply manifold, and large facilities may require more than one monitoring point. A single "combined-type" alarm panel may serve both area alarm and master alarm functions and should be located in the vivarium corridor at a location where an alarm is likely to be monitored by responsible personnel. Alarms shall also alert to BAS and the vivaria monitoring system where such systems are provided, and/or to remote telemetry as necessary.

While the DRM provides minimum requirements to ensure programmatic flexibility, the program should always be consulted in determining the necessary locations and quantities for animal clinical gas outlets (often referred to as "terminal units"). Outlet requirements may be similar to those as described in the AIA Guidelines for Hospital Design and Construction. In many cases additional outlets may be required for programmatic flexibility and to facilitate work with multiple animals, and some services (such as animal clinical air) is not always needed. The maximum quantity of outlets that could be in simultaneous use in any given space (whether under normal or emergency conditions) must be discussed with the program, as well as loads from any ventilators.

The use of bold color coded faceplate DISS outlets is recommended as these can be easily adapted to accommodate a variety of instruments, and maintain protection from accidental connection to the wrong gas. Conventional serrated outlets are not utilized for oxygen or other life support gasses, though quick connect medical outlets can be used where coordinated with the program and not common to human clinical equipment needs within the facility. In shared hospital/research facilities, the outlet type should be distinctly different from outlets used to serve human patients.

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

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Integrated Pest Management Program

Integrated Pest Management (IPM) program is facilitated by professional entomologists in the Community Health Branch (CHB) of the NIH Division of Occupational Health and Safety (DOHS). Pest control is extremely important since pests carry disease organisms; cause physical damage; contaminate and compromise research and pests are unacceptable in work place. NIH has implemented effective long term prevention methods and strategies that work in unison with the building design and its use. Pests are dependent upon biotic factors to provide nourishment and moisture and abiotic factors to provide harborage and ingress into buildings. Through proactive steps taken during building planning, design, construction, and commissioning, resources for pests are minimized, thus diminishing pest infestation during the building's functional life cycle. The IPM program focuses on designing new projects that do not create conditions that encourage pests, and that minimize pesticide applications by reducing the amount of food, water, and harborage to pests.

To significantly reduce pest infestation, the following basic components should be instituted during the design and construction phases of buildings:

1. Facility Design: Proactive approach to facility designs not contributing to the harborage of pests.
2. Structural Repairs: Performance of small repairs that exclude pests.
3. Sanitation: Proper sanitation on the construction site; reduction of clutter and pest harborage; and banning cellulose type fill and/or debris.

Following should be implemented during construction and facility operation:

1. Monitoring: Regular surveillance areas using traps, visual inspections, interviews with staff, and surveys to determine if a pest problem exists; the location and size of the pest infestation; and conditions contributing to pest problems.
2. Communication: Staff cooperation in correcting conditions that contribute to pest problems.
3. Record-Keeping: Data monitoring of pest numbers and observations on housekeeping and structural deficiencies.
4. Pest Control without Pesticides: Pest exclusion, trapping, screening, and sealant used as effective, long-term methods of pest prevention and applied with a high degree of safety and effectiveness.
5. Pest Control with Pesticides: Pesticide application using the safest, most effective methods, and only where needed.
6. Program Evaluation: Data/observations monitoring periodically summarized and reviewed to evaluate program effectiveness.
7. Safety: Significant reduction of the use of pesticides through IPM; and emphasis on the use of more permanent non-pesticidal control practices, minimizing the potential of exposure to pesticides by the research environment and staff.
8. Quality Assurance: Technical oversight providing an objective, ongoing evaluation of program activities and effectiveness.
9. NIH DOHS CHB Involvement: CHB manages IPM programs in biomedical laboratories and animal research facilities, with involvement during the planning, design, and construction phases of new construction and alteration projects. For NIH projects, the Project Officer and design team shall involve the CHB early during the planning and design process for any project to obtain input on proposed designs from the pest management perspective.

Animal facilities present some of the most challenging circumstances to an effective pest management program and the performance of IPM services. Additional care and attention shall be paid during all phases of planning, design, and construction of animal facilities. Some components that require specialized design and review by DOHS CHB include:

1. Building integrity (site design, building envelope, exterior building lighting).
2. Receiving areas.
3. Interior wall, floor, and ceiling finishes.
4. Door types, locations, materials and requirements for door sweeps.
5. Wall and door protection design and materials.
6. Access panels.
7. Sealing locations and details.
8. Interior lighting.
9. Cage wash design.
10. Solid waste disposal, recycling, and storage facilities.
11. Floor drains.
12. Locker rooms and break rooms.
13. Administration areas.

These items shall be evaluated and reviewed with respect to the overall program requirements of the entire building, specific animal species, size of the facility, and anticipated future use(s) of the facility.

Lights are attractive to insects and to some vertebrates. The type and placement of lights around and in a facility can impact the occurrences of pests and nuisance incidental invaders indoors. Avoid light fixture design and installation that provide pest harborage outside a building, such as overhead lights with a flat upper surface which serve as nesting or roosting sites. The power conduit for the lights shall be designed so there is no provision for roosting or nesting sites for nuisance birds.

Landscape planting impacts the number and types of pests found around the exterior of the building, as well as within the building envelope. The following shall NOT be used in NIH projects:

1. Dense ground covers such as ivy, providing harborage for rodents.
2. Ornamental plants such as spirea, attracting certain beetle species that can become indoor pests.
3. Raised planters or garden beds, which can be nesting sites for rodents.
4. Dense foundation plantings, reducing air circulation around buildings, harboring pests such as wasps, and obstructing pest management survey and control activities.

Proper use of sealants in high containment labs is critical for pest management. Refer to DRM Exhibit X4-2A for sealant 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 11, Chapter 2 Section 2-4, Chapter 3 Section 3-4 and Chapter 4 Section 4-2

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Animal Drinking Water - Part 1

The type and selection of Animal Drinking Water (ADW) system (whether central bottle or packet fill, piped distribution, or pre-packaged water) is a significant program decision that must be made through consultation with the program veterinarian, principal investigator, and other representatives of the Animal Research Facility (ARF) use group. Bottle or packet fill systems may be advantageous for limited program areas (such as barrier facilities, high containment, and areas where risk of flooding of cages may be of high concern), however such arrangements can be labor intensive, provide a non-continuous supply and may not be ideal for many programs. While the use of automation can greatly reduce labor, piped distribution of ADW to each rack is typically preferred for large facilities (as well as for applications with non-human primates and large animals) and can be advantageous by reducing risks of injury to personnel and on-going labor costs associated with filling, husbandry, washing, and disposal. Regardless of method of delivery, water quality is always a critical consideration.

The minimum standard for makeup supply to ADW systems is potable water in conformance with the Safe Drinking Water Act (SDWA), 40 CFR Part 141, www.gpo.gov; AAALAC Guide www.aaalac.org. However even water that is deemed potable for human consumption will typically require additional treatment to render the water consistently suitable for various animal models in the biomedical research program, and to minimize risk of unacceptable contaminants and support stability of water quality.

Minimization of research variables is a key consideration in designing ADW systems and directly influences the types of systems utilized, including the need for water treatment. Tolerances of the research model to variability in the drinking water supply can be a significant concern, especially where such variables could pose a risk of achieving validatable/ reproducible results or result in loss of extensive, long-term research. Even where water supplies to systems start out as potable, it must be recognized that the characteristics of incoming water supplies can be subject to a range of variations. For example, municipal supplies are often subject to routine seasonal source water changes, unforeseen backflow or contamination (such as from a broken water main), normal changes in treatment processes (such as residual disinfectants, i.e. chlorine vs. chloramines, flocculants and other changes of treatment approach.); as well as introduction of contaminants upstream (fluxes, plasticizers, or even ionic or organic contaminants). In many cases even water supplies that are potable and in conformance with the SDWA (and therefore have maximum contaminant levels safe for human consumption) may have contaminant levels inappropriate for research applications, or may lose potability during distribution.

The use of potable water with an appropriate treatment train (typically activated carbon) followed by Reverse Osmosis (RO) is required for a majority of applications (along with appropriate provisions for water turn-over and microbial control). Such arrangements provide stability of source water with substantial reduction of ionic, organic, and microbial contaminants, as well as control of particles and colloids that can proliferate contamination. Make up of ADW from laboratory water or house purified water is not acceptable (even with downstream treatment) and could pose unacceptable risks. Both lab water systems and house purified water systems (i.e. RO/DI etc.) are subject to potential backflow (whether microbiological or chemical in nature) and in cases of house purified water systems, are also subject to routine maintenance shutdowns, increased risk of microbial contamination, fungi, algae, and even cyanobacteria. Such systems require routine sanitizations, and the sanitization process itself could pose risk to the ADW. Consequently and to ensure appropriate control for the critical research under the animal research facility program, the DRM mandates water systems serving ADW source to be completely independent of other systems, fed directly from potable water.

In the pretreatment train, activated carbon systems must be conservatively sized (series arrangements are recommended) for chlorine and chloramines, and should be routinely replaced. Quality RO membranes (typically thin film such as polyamide) are most often recommended. Provision of adequate water storage volume can be critical during an emergency or malfunction, and the reliability of upstream water supply, program and maintenance SOP's, and even location of the facility can influence storage tank sizing. Tanks should typically provide 48 hours of peak demand, and the use of duplex tanks (each sized for 24 hours) is recommended. Systems should be designed to minimize plausible risks of failure, and redundant distribution pumps are required. Treatment systems supplying the tanks should be able to do so in not more than 3 hours, and caution must be applied to consider the impact of large tanks on microbial control. Tanks should include a hydrophobic vent filter to reduce potential contamination.

Treatment and distribution systems must be on stand-by power and appropriately monitored to preclude unplanned disruptions and immediately alert of equipment or distribution failures. An appropriate disaster mitigation SOP should be in place to address system malfunctions or catastrophic loss of facility water supply. The use of automatic monitoring reporting to the appropriate staffed ARF monitoring system is typically required. Examples of parameters that should be monitored include make up water supply flow/pressure, RO system operation (typically reject percentage) and failures, ADW storage tank level, distribution system flow meter (for circulating systems) or pressure monitor (for flushing systems), proportioner chemical Oxidation Reduction Potential (ORP)/pH/dissolved ozone etc. (as applicable), distribution system water temperature, and pressure/flow monitoring of individual PRV/flush stations.

Next month's article will discuss ADW distribution, system microbial control, rack flood prevention, and related general requirements.

Further details on this month's topic are available on the DRM website
http://orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/DesignRequirementsManualPDF.htm
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Animal Drinking Water - Part 2

Maintenance of water quality and minimization of potential cross-contamination are significant considerations in the design of Animal Drinking Water (ADW) and are factors in the selection and arrangement of the treatment/ production/ distribution as well as systems operation and maintenance. Once water has passed through the carbon beds and subsequent RO, residual disinfectants from municipal potable water will have been removed leaving the system especially prone to microbial proliferation due to temperature, low flow, and the general nature of ADW distribution arrangements. Water is often acidified with USP grade sulfuric or hydrochloric acid or chlorinated as a means of microbial control, with acceptable chemical residuals determined through consultation with the program as appropriate to the research models prior to selecting system materials. The potential of disinfection by-products (DBP's) should be considered as may be influenced by the characteristics of the on-site water supply and selected microbial control method. Each ADW system should include an appropriate chemical proportioner with automatic injection to facilitate normal water treatment and routine sanitization, except where alternative routine microbial control protocols are utilized (such as active monitoring through SOP's to initiate frequent chemical sanitant, or periodic in-place or portable ozonation or heat methods which may be desirable for some applications where distribution of chemically treated water is undesirable). Where chemical proportioners are utilized, they must include fail-safe arrangements to monitor and preclude over-dosage. The use of 254nm UV and post-UV submicron filtration is recommended to reduce microorganisms and organic matter entering the distribution system post-production, though while critical for recirculating systems; UV does not provide residual protection.

A water quality monitoring plan which includes routine monitoring of microbial contaminants should be followed and will typically include monitoring of endotoxin (to provide a rapid indicator of system microbial condition -typically LAL or gel-blot), total heterotrophic plate count and/or periodic epifluorescence microscopy, or a number of other methods with samples taken at sufficient locations to provide appropriate representation of water quality. Acceptable levels of contaminants (whether chemical or microbiological) will be determined by the program but in no case should exceed levels acceptable for potable drinking water. Routine sanitizations are typically accomplished through injection of chemical sanitant (products such as hydrogen peroxide/ peracetic acid preparations, hyper- chlorination, or use of intermittent ozonation or heat); all of which require disconnect of racks during the process. Individual manifolds should be sanitized through a manifold flush station. It is important to maintain routine changes of the carbon cartridges serving the production train as such beds can be a haven to microorganisms.

In selecting wetted materials, consideration of chemical leaching, sanitization method compatibility, joint method, susceptibility to light infiltration (which can promote growth of algae), and durability must be evaluated. Even where systems are acidified or chlorinated, systems must be arranged and selected of materials to facilitate effective periodic sanitizations. The use of 316L clean joint stainless steel is recommended for most systems, but often unsuitable for hyperchlorination. Varying plastics, (including PVDF, PVC's, and pigmented IR fusion copolymer polypropylene) may also be acceptable, each with advantages and disadvantages dependent upon application. While PVC's may offer advantages of easy repair, unless low extractable PVC material is utilized, the potential elevated levels of leach out associated with common PVC/CPVC compounds and the solvent cement process throughout the initial months or year after start-up should be considered by the program along with particular attention to the selection and sufficient curing (at least 24 hours) of solvent cements to reduce such contamination. At a minimum, all components within the waterway (including elastomers) should be non-contaminating, system sanitant resistant, FDA compliant for food contact, including NSF-61. Natural rubber is avoided. Piping distribution must stand off from vivarium walls to promote cleanability, be adequately durable, located out of reach of animals (especially NHP's) and be protected from other potential damage (such as during rack movement).

Distribution pressures must be controlled as appropriate to the individual species and should be locally adjustable. The arrangement of system zoning and cross contamination control provisions between program areas, as well as flexibility to accommodate varying species and research models with their unique water quality and pressure requirements for each room or zone, shall be evaluated with the program prior to design. System zoning shall allow for independent isolation of the system to manageable sections without affecting zones on other floors, building wings, or other program areas. Distribution systems must be arranged to ensure either continuous circulating flow of the supply and returns piping mains with supplemental flushing of individual rack manifolds or rooms branch lines, or to provide for complete automated flushing of the entire system including individual rack manifolds. After the supply drop to individual rack manifolds, the manifold should flush to a room or individual manifold flush connection such that there is no distribution of water past drinking water nozzles from one rack manifold to the supply of the next manifold or room. Common systems shall not serve across higher biosafety levels, and appropriate means of cross-contamination control shall be considered by the program dependent upon application or risk (for example barrier facilities). Multiple zones shall be provided with dedicated PRV stations for each room to permit program flexibility, except that a single PRV station may serve multiple rooms housing the same species within the same suite where pre-approved. Systems shall be arranged to limit dead legs and accomplish complete flushing and turn-over of the system water contents at least daily, with an indirect discharge to an appropriate interceptor through an air-gap (typically a sink within the holding room), flush main to a remote receptor, or trough drain serving the space). Flushing flow rate must be at least 3 to 6 FPS to achieve adequate scouring efficiency.

Rack flooding can cause significant loss of research, whether due to animal drowning or thermal effects. Consideration during planning can minimize these risks and should be discussed during facility design. Cages may be fitted with screened drain openings and piped gutter systems, specific nozzle types may be selected to reduce flood risk, and automatic systems may be omitted in certain areas for areas deemed of special concern.

Precautions must be taken during construction to prevent contamination or establishment of biofilms prior to occupancy and ADW systems shall be commissioned, flushed, sanitized, and water quality comprehensively tested by qualified labs to ensure proper operation prior to use.

It is especially important that designs be reviewed and approved prior to issuance for construction, including where systems are documented for design-build or vendor construction.

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 5