The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

December 2019

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The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ *biomedical research facilities.*

Pre-Design & Evolution of Design Part II

Pre-Design:
Last month's Part I emphasized the importance of pre-design efforts, particularly collecting data through Q&A sessions with the user prior to beginning the design process. The article stressed the significance of asking the right questions and **understanding** the reasoning behind the answers; the key is replacing the 'what do you want' questions with '*what do you do'* and *'how do you do it.'* This sort of in-depth analysis may be done through Questionnaires; the information collected during these Q&A sessions is used to generate the form-producing parameters used in the next phase of design: bubble diagrams.

Bubble Diagrams:
A bubble diagram is the first attempt at a graphic representation of the collected data, in the form of "bubbles" and lines. The "bubbles" depict the functions of the space, which are arranged in proximity to one another based on desired adjacencies and/or separation, line of sight, etc. Lines are drawn to connect the bubbles that portray the relationships between the functions. Bubble diagrams are used to establish spatial relationships between the functions and spaces and help determine the best layout for a particular program. Although this drawing may not ever make it into a formal submission, this is a critical step in the design process.

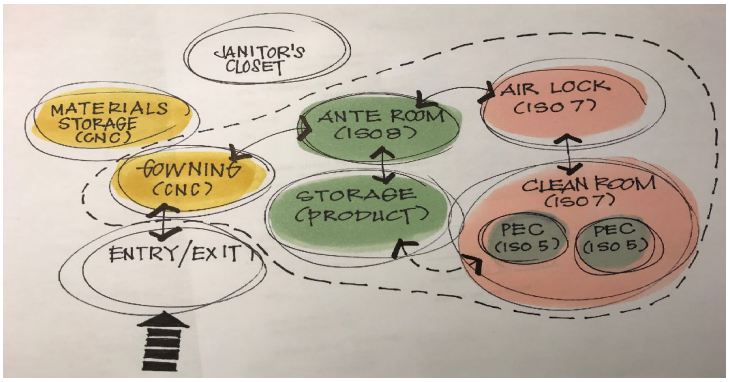

Figure 1: Bubble diagram

Further development of the bubble diagram places forms or rooms around the bubbles and functions to form the basis of schematic designs.

At the end of the pre-design phase, the following activities will have either commenced or been completed:

- Establish project program and parameters
- Establish Integrated Project Team
- Data gathering (Questionnaire)
- Establish codes, regulations, standards, guidelines, etc. applicable to the project
- Initiate Room Data Sheets
- Equipment Schedule
- Perform site and engineering surveys
- Conducted Preliminary Engineering analysis
- Conducted Preliminary Risk Assessment (RA) (as required)
- Perform Feasibility Studies (as required)
- Bubble diagrams

The information collected during the pre-design stage is captured in the Basis of Design (BOD), along with all major design criteria. The BOD is used as the Project Team's record of discussions, decisions, rationale, etc. made along the way, and serves as a reference document for all disciplines that is continually updated as the design progresses.

Schematic Design (SD):
In this phase, the designer introduces shape, size, location, and inter-relationships to the design concept from the bubble diagrams, and forms begin to take on three dimensions. Designers must integrate organizational, operational, and infrastructure challenges with innovative, thoughtful design to create spaces that are functional as well as inspirational for their clients. They must also explore alternative layouts to select the best solution for continued development.

Schematic design benefits from a high level of interaction between designers, clients, stakeholders, etc. Consider holding design charrettes involving all stakeholders, as this contributes to a collaborative, integrated planning process that leverages the collective knowledge and input of users, stakeholders, and Subject Matter Experts (SMEs) in conjunction with the creativity and technical building expertise of designers and participants. Also consider using computer modeling along with virtual reality or 3D sessions to help users understand the design layout and spatial concept in a 3D format.

At the end of the schematic design phase, all project criteria and parameters should be set and documented. The project shall proceed to Design Development and Construction Documents upon review and acceptance by all stakeholders.

Design Development (DD) /Construction Documents (CD):
As the design progresses, additional details and documents are added and the design is further refined, culminating in a series of documents (drawings, specifications, calculations, etc.) that are collectively referred to as Construction Documents (CD) and used in the follow-on phases, bidding and construction. These topics will be discussed in next month's follow-up article.

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Further details on this month's topic are available on the DRM website Chapters 2
https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx

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Pre-Design & Questionnaire Part I

Form Follows Function– a phrase attributed to Louis Sullivan, who in turn attributed it to Vitruvius. These three simple words elucidate the essence of the design process.

The design process encompasses different sub-processes beginning with pre-design and culminating with occupancy. This article will focus on the pre-design phase.

The time span from project inception to occupancy can feel like a very long time. Too often, due to schedule pressure or at the direction of the client, the designer skips or rushes through the pre-design process and begins with Design Development (DD). However, perceived needs of the client do not translate into actual needs, and all too often progress of the DD process is later impeded by in-progress re-design and change orders, all of which impact the overall project schedule and could have been avoided with a thorough pre-design. The challenge here lies in recognizing and then convincing the client of the value of investing time and resources in pre-design effort.

Pre-Design

Pre-design is an evolving process that requires a detailed and meaningful dialogue with the client through structured Question & Answer (Q&A) sessions, with the aim of capturing the client's needs, goals, and vision. It involves asking the right questions and understanding the reasoning behind the answers. This means replacing the question 'what do you want' with 'what do you do' and 'how do you do it.'

For a complex laboratory, clinical, or aseptic facility project, this requires an experienced medical or laboratory planner who is knowledgeable of the processes and procedures the space will be used for and their impact on the facility's design.

Data Gathering and the Use of Questionnaires

The aim of this stage is to collect information pertaining to the functions before ever putting pencil to paper.

Questions that seek to define and extract information regarding the program and its functions, processes, etc. shall be posed to the client. These questions may be qualitative or quantitative in nature.

Quantitative questions seek to develop an understanding of the functions and processes that the project will support, its associated requirements such as required utilities and adjacencies, light and sound requirements or restrictions, cleaning and decontamination processes, work processes, etc. This info will aid the designer in determining the applicable functional and spatial requirements, standards, regulations, etc. based on research type.

Qualitative questions help the designer develop an understanding of the client's vision for the character of the spaces or facility. These questions seek to understand the client's aesthetic and the nature of work areas. Topics of discussion include the client's desire for access to daylight (for personnel working in that space) or lack thereof (due to research type), nature views, desired adjacencies, aesthetics, and ergonomics. These sessions also guide the client and designer in establishing the budget parameters of the project.

The DRM provides template questionnaires for the designer's convenience in Exhibits 2.1, 2.2, 2.3 and 13.1 which can be tailored to accommodate the project's and researcher's unique needs. These questionnaires are for the most common NIH facility types such as BSL-2 Laboratory, Animal Research, Biocontainment, or Aseptic Processing Facility (APF).

At the conclusion of the data gathering stage, the designer must have a thorough understanding of:

- the functions that need to be housed within the given space
- its associated requirements such as utilities, security, shielding, etc.
- program processes such as the flow of people (i.e. researcher vs. husbandry staff), materials, specimens, final products, waste, equipment, etc.
- the levels of interconnection and/or separation amongst functions and processes
- both current and future needs of the space

The collected data and information are used to generate the form-producing parameters, which are used in the next phase of design, bubble diagrams. This article will be continued in next month's News to Use with a review of bubble diagrams as well as design development.

See Chapter 2: Planning and Programming of the NIH Design Requirements Manual (DRM) for additional guidance.

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Pipe Testing Part II

The July 2019 News to Use (Part I) focused on testing of plumbing systems. This News to Use will focus on testing requirements for HVAC piping. This article is specific to pressure testing, and does not address other aspects of testing, examination, and inspection.

General Requirements

All joints shall be left uninsulated and exposed for the duration of all testing and inspections. The test period commences after the system (or section) has been completed and brought up to the full test pressure; prior to hydrostatic testing, air must be properly vented from the system. As pressure is incrementally increased, the contractor should review the system at the first step (typically 10 to 25 PSIG), after which it should be slowly brought to full test pressure under observation. The test pressure should not exceed the maximum test pressure of any component within the system, and all equipment and parts with a lower pressure rating shall be properly isolated. In all cases, the stress from pressure testing must not exceed 90% of the specified minimum yield strength or 1.7 times the SE value, per ASME B31.9. Calibrated test gauges should be ASME B40.100 Grade 1A or better and in good condition, with a face diameter of no less than 3-inches and pressure intervals $\leq$ 2 PSIG. Gauge range should be at least 1.5x the test pressure. Digital gauges may be used, provided the combined error due to calibration and reading does not exceed 0.75% of the test pressure.

Piping Systems

DRM Chapter 6 Section 6.3.9.5 provides requirements for welded piping systems, including requirements for compliance with ASME Codes (B31.9, B31.1, and by extension the ASME Boiler and Pressure Vessel Code BPVC). These codes have specific minimum requirements for weld examination; additional requirements may be necessary on a project-specific basis (example: where hot-tapping occurs) or where custom Weld Procedure Specifications (WPS) are necessary. Non-destructive testing (NDT) associated with weld examination shall be conducted **prior** to pressure testing by an AWS Certified Weld Inspector (CWI/ SCWI) or by NDT personnel qualified for the test method per SNT-TC-1A of the American Society for Non-Destructive Testing.

ASME B31.9 requires every point in the system be hydrostatically tested to 1.5 times the design pressure (or greater) for a minimum of 10 minutes. Other sections of the DRM include more stringent requirements for specific piping material and joint type applications, and in some cases compliance with ASME B31.1 or ASME B31.3 is also required. Requirements for brazed and soldered piping systems are addressed in DRM Chapter 6 Section 6.3.9.5 Sub-section C. For these types of joints, the testing procedures shall conform to ASME B31.1 and ASME BPVC.

Pneumatic Testing

ASME codes provide guidelines for pneumatic testing. However, ASME has limitations on where pneumatic testing can be used due to the inherent dangers of testing with compressed gases. Hydrostatic testing is generally preferred for ease of leak location, lower system stresses, and increased safety. Some materials (particularly some plastics) are incompatible with pneumatic testing; however, NIH has many compressed gas piping systems, and pneumatic testing can be viable for certain applications so long as it is properly and safely applied to compatible materials.

When used, pneumatic testing requires development of and adherence to a safety plan and is typically less than 1 hour in duration. Pressure is applied incrementally and shall not be raised rapidly or without allowing time for stresses of pressurization to equalize and a leak review prior to raising to the next pressure stage. Overpressure protection is required, and repeated applications of test pressure shall be avoided. Upon completion pressure should be discharged to 3 PSIG or less.

Pressure Test Duration

In DRM Chapter 8 Section 8.3.16.B, plumbing water piping systems are to be tested at 150% of the working pressure for a minimum of 4 hours. As noted above, the ASME codes related to testing of hydronic systems have a minimum test duration of 10 minutes. Due to historical issues with leakage and failures, NIH prefers that hydrostatic tests of all hydronic systems be performed for a minimum of 4 hours, and though the current DRM accepts compliance with ASME Codes, a revision to require a minimum 4-hour test duration will be issued in the near future.

Conclusion

The testing requirements referenced above are minimum requirements for these systems; project officers have the option to increase the testing requirements for any application where critical systems are being installed and / or critical facilities are at risk. Piping testing is an important factor in ensuring well installed piping systems and reducing flood risk potential at NIH.

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Sound Design Metrics

Sound is a predictor of comfort for the individuals working within a space. When designing for healthcare environments, lab equipment or HVAC equipment designers often interchangeably use terms such as Sound Transmission Class (STC), Noise Criteria (NC), and Noise Reduction Coefficient (NRC). However, it should be noted that these are three distinct terms for measuring different aspects of acoustics by voice, decibels (dB), and material sound absorption.

STC is an attribute of a wall or floor-ceiling assembly that measures the amount of a sound, such as from the human voice, that is blocked as it passes from room to room. STC determines the sound isolation between spaces, which can be important for speech privacy. For example, in patient exam rooms in a medical building, conversations between patients and their doctors are meant to be private, as are closed-office discussions between an HR director and an employee. Even when speech privacy is not a concern, sound transmitting from one room into another can be distracting and inhibit productivity, concentration, or relaxation.

Figure 1: Sound blockage (image courtesy of The Soundproofing Company)

The Minnesota Sustainable Housing Initiative explains STC in the following way:
An STC rating roughly equals the decibel (dB) reduction in noise volume a wall or partition can provide… The STC number (i.e. decibel reduction) does not apply equally across the entire range of frequencies measured [because] in general, it is more difficult to block the transmission of low frequency sound, so any partition will have less sound attenuation at lower frequencies.[1]

For our example (see Figure 1), a sound that is 100dB on one side of a partition is reduced to 55dB as it passes through to the other side, which means the partition has an STC of 45.

The STC ratings for walls are only one aspect to consider when designing for sound reduction within laboratories. Labs containing specialized or sensitive equipment may have unusual utility, environmental, and other requirements. Reverberation from the room's surfaces or the noise of equipment should also be considered. According to DRM section 2.1.3.7.7, areas where noise-sensitive procedures occur particularly need to be isolated from noise sources, and it's important to consider that some instruments, such as high magnification microscopes, are sensitive to noise too. This means that coordinating with laboratory personnel to determine acoustic requirements for each type of specialty laboratory space is important. Consultants may include, but are not limited to, acousticians, vibration engineers, and shielding specialists. Acoustics play a vital part of learning in the lab and can significantly impact the focus (or lack thereof) of the scientists using the lab space. See News to Use article "Demising Partition Acoustic Requirements" (June 2018) for additional information on wall and acoustic STC.

NC is a measure of the background sound level in a space. According to Jonah Sacks, Principal Consultant at ACENTECH, dBA (A-weighted decibels) should be used to measure intrusive transient sounds and NC for steady background noise. Sacks says that this is because "Intrusive transient sounds, like voices, or a truck going by, or the bass beat of music, are more noticeable and disturbing than steady noise from HVAC." He adds that while there is no perfect conversion, a rule of thumb is 35 dBA is about NC-30, which is roughly 5 points smaller for the same actual sound level.

For mechanical system noise and vibration, sound analysis required by DRM section 6.5.2 begins with the supply fan, return, or exhaust fan and includes ductwork, terminal units, and diffusers. The primary objective of HVAC system acoustic design is to ensure that facility spaces are not unacceptably affected by HVAC system-related noise or vibration. However, HVAC acoustic design features such as duct silencers and vibration isolators are often added late in the construction document phase. This results in poorly integrated design and problematic acoustics and vibrations, which are significant issues because Sacks notes that the HVAC system is one of the noisiest parts of the building infrastructure.

NRC measures how much sound a material absorbs, which impacts how things sound inside the room for users. It does not relate to mechanical equipment noise or sound isolation between rooms, but instead to the reverberation of noise off surfaces. In most spaces, Sacks says the best way to control reverberation is to include a sound absorbing ceiling material with a rating of NRC 0.70 or greater. In situations where excess noise is a concern, the Facility Guidelines Institute has recommended noise levels which NIH expects designers to adhere to as a minimum requirement; designs with sound absorbing materials can help meet these requirements. See additional information from the references below.

Conclusion

STC, NC, and NRC are all unique measures of sound and are all important to consider, since acoustic quality can significantly impact a space and its occupants. Proper acoustic design requires broad engineering cooperation across multiple disciplines; waiting to design for sound after construction is expensive and poor planning. Instead, a stakeholder meeting should be held early in the project's programming stage to determine the scope and any additional studies required. The goal for designers should be to ascertain what equipment will be in the newly designed space, then discuss further with manufacturers to provide adequate sound absorption.

References

1. Minnesota Sustainable Housing Initiative, Information Brief – Sound Transmission www.mnshi.umn.edu/kb/scale/soundtransmission.html
2. Thank you to Jonah Sacks of Acentech for Publication Review.
3. Sykes, David and Tocci, Gregory C. *Sound & Vibration 2.0: Design Guidelines for Health Care Facilities*, 2010.

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Further details on this month's topic are available on the DRM website: Section 6.5 Noise and Vibration
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APF Closeout Documentation

Documentation is an essential part of Aseptic Processing Facility (APF) project development. Proper documentation is required to establish and maintain an efficient and compliant APF. This documentation provides evidence that the facility systems and equipment are designed, constructed, commissioned, qualified, validated, and maintained in a state of compliance in order to meet the current Good Manufacturing Practice (cGMP) requirements identified in 21 CFR Parts 210 & 211. Good Documentation Practices (GDP) should be followed throughout the process of developing, finalizing, and maintaining critical documents to ensure the quality of documentation meets cGMP requirements.

Project Closeout

The project "closeout" or "turnover" documents include all facility documentation that is approved after all project activities are concluded. A more detailed description of the Project Closeout and Handover phase is described in Section 13.18.0 of the Design Requirement Manual (DRM). Well organized and timely delivery of the closeout documents is expected from the responsible parties; to facilitate this delivery, a document process flow should be communicated early in the project to all parties involved which reviews the preparation, closeout, and maintenance of documents. The project documentation requirements must be clearly defined, along with the roles and responsibilities of all parties involved in developing, maintaining, and revising project documents. The Facilities Compliance and Inspection Section (FCIS) under the Division of Technical Resources (DTR) has created a Standard Operating Procedure (DTR-SOP-10021) for managing facility turnover documents.

The following are examples of typical documents that are developed throughout the various phases of a project (documents to be maintained as current for the life cycle of the community are underlined):

- **Planning Phase:** Facility Risk Assessment (FRA), Statement of Requirement (SOR), and Feasibility Study (FS)
- **Design Phase:** Quality Risk Management Report (QRM), Facility User Requirement Specifications (URS), Validation Mater Plan (VMP), GxP Harmonization Report, Basis of Design (BOD), Design Qualification (DQ), System Level Impact Assessment (SLIA), Design Drawings, and Design Specifications
- **Construction Phase:** Executed VMP protocols, such as Factory Acceptance Test (FAT), Site Acceptance Test (SAT), Testing and Balancing Report (TAB), Construction Submittals, Redline Drawings and Specifications
- **CQV Phase:** Component Level Impact Assessment (CLIA), Executed VMP Protocols, such as Installation Qualification (IQ), Operational Qualification (OQ), Airflow Visualization Study (AVS), Training Documents and Records
- **Hand-Over Phase:** Record Drawings and Specifications, Commissioning Report, Qualification Report, and Validation Report

Roles and Responsibilities

FCIS is responsible for collecting, tracking, controlling, and maintaining the critical facility documents identified in DRM Table 13.18.0.

The NIH **Project Officer** (PO) should coordinate with the contracted organizations (i.e., A/E, CM, CQV) to ensure timely delivery of APF turnover documents at the close of each phase. The PO identifies each applicable document to be included within the Scope of Work for each phase of the project. The PO also ensures that each turnover document is reviewed and approved by the applicable personnel prior to delivering documents to FCIS. It is highly encouraged that a document management specialist should be assigned to each group responsible for the closeout documents in order to manage the flow of documents throughout the project.

The FCIS **Document Management Specialist** (DMS) coordinates the project turnover document requirements with the PO to ensure the proper management, control, and delivery of documents at the end of each phase. Depending on the document type, the delivery of these critical documents should be either in an electronic format or both in electronic and hard copy with the original signature approval sheets for selected documents. Upon delivery of turnover documents, the FCIS DMS will store all electronic documents in a shared folder directory and a SharePoint site. All critical documents are stored in a secure location managed and controlled by the FCIS DMS.

Conclusion

Good communication and coordination are essential when managing the flow and progress of critical facility documents for a project closeout. Tools such as SOPs, flow diagrams, and document matrices will assist in the timely and accurate delivery of these documents by all parties throughout the project. It is essential to establish an early understanding of the document closeout process with all participants, because a team effort is necessary for the success of APF project document management.

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Pipe Testing Part I

When the DRM was updated in 2016, one focus of the manual's mechanical sections was reducing the potential for flooding from piping systems. A central strategy for reducing flood potential is proper testing of piping systems at the time of installation. This article will examine testing requirements in the DRM for liquid-carrying piping systems. A future article will review testing requirements for mechanical and gas systems. The cited requirements in this article are for pressure and integrity testing only; the DRM provides references for other mandatory testing of various piping systems which ensures service quality to the points of use and the protection of researchers, maintenance personnel, and the general public. In the 2018 International Plumbing Code (IPC), Section 312 "Tests and Inspections" – which is one code referenced in the DRM – provides testing requirements for all plumbing systems. DRM Chapter 8 provides more stringent requirements for testing water supply systems and therefore supersedes the IPC.

Plumbing Water Supply Piping

According to DRM 8.3.16.B, water systems shall be tested to at least 150% of their working pressure or 150 psig (1,034 kPa), whichever is greater, for a minimum of 4 hours. Where freezing conditions may occur, a pneumatic test of 60 psig (414 kPa) may be applied to metal systems with no incompatible plastic parts. ASME warns that pneumatic testing can be dangerous due to the sudden release of stored energy in the compressed air. Because of this, the use of pneumatic tested should only be used where freezing conditions can occur.

Figure 1 Pipe Testing

Plumbing and Laboratory Drainage and Vent Systems

DRM 8.4.22 provides requirements for water testing of drain and vent piping. All joints in a system must be tested with at least a 10-foot (3 m) water column of pressure for a minimum of 1 hour. Systems may be tested in sections as they are completed, provided every joint in the system is tested to at least a 10 foot (3048 mm) of head. When testing drainage and vent systems with water, the contractor must carefully plan the test to ensure the maximum pressure on the lowest joint does not exceed the rating of the joint material. Failure to keep the lowest joint from being overstressed can result in serious flooding that could impact the overall project, as well as occupied areas near test piping for renovation projects.

Non-Pressurized Drainage Systems

Testing requirements for storm systems are covered in DRM 8.4.22, which provides testing requirements for all drainage systems including all sanitary drains, sanitary vents, and storm drainage systems.

Shower Liner Testing

Leaks around drains in showers have been a persistent issue in the plumbing industry and are a particularly serious issue in clinical applications. DRM 8.2.9.D requires testing of shower drain membranes with a flood test of at least the curb height of the shower pan for no less than 24 hours. For shower pans that do not have a lip, like handicap accessible pans, the contractor is responsible for building a temporary dam to obtain the 2" flood level of the shower membrane.

High Purity Water Systems

Due to the critical nature of high purity water systems, pressure testing requirements are outlined in DRM Section 12.1.10.B. Systems are to be hydrostatically tested at 150% of the design operating pressure, or the maximum working pressure rating of the system, whichever is less. The minimum hydrostatic pressure shall be at least 100 psig (690 kPa). The A/E must consider the pressure ratings of any joint components which should not be subjected to this pressure and isolate or reduce pressures as appropriate. The minimum test period for all high purity water system tests shall be 8 hours.

Final Drainage Systems Testing

DRM Section 8.4.22.E provides requirements for final testing of all sanitary systems. The test requires that a U-Tube monometer be inserted into the sanitary system through a trap. The drain and vent systems should be plugged, and a pneumatic pressure applied to the system of 1 inch of water gauge (250 Pa) for 15 minutes with no loss of pressure. After successful completion of the test, all temporary plugs should be removed from the system.

Conclusion

The testing requirements referenced above are minimum requirements for these systems; the project officer has the option to increase the testing requirements for any application where critical facilities are at risk. Testing requirements for mechanical and gas systems will be reviewed in a future News to Use article.

'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:** shawm@nih.gov

Further details on this month's topic are available on the DRM website Chapter 8
https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx

The National Institutes of Health | Division of Technical Resources | Office of Research Facilities

Design Requirements Manual **News to Use**

June 2019

Vol. 02, No. 30

Seismic Design Parameters

Earthquakes are an unpredictable natural hazard and can result in loss of critical facilities and infrastructure. While strong earthquakes are unusual in the state of Maryland, perceptible seismic events still occasionally occur. In the fall of 2011, a 5.8 magnitude earthquake occurred in Mineral VA and effects were felt on the National Institutes of Health (NIH) campus in Bethesda. The Division of Technical Resources (DTR) subsequently undertook a Seismic Risk Assessment Study. The study reviewed available NIH geotechnical investigation reports, performed probabilistic seismic hazard analysis, performed structural analyses, and evaluated soil amplification effects in a simplified manner. As a result, section 5.2.1.G was introduced to the 2016 version of the Design Requirements Manual (DRM) to provide updated seismic design parameters that would be applied to critical facilities.

Seismic Risk Assessment and Categories

The Seismic Risk Assessment Study involved a structural and nonstructural assessment of representative components of the NIH campus in order to come up with a campus-wide risk assessment. The campus has more than 50 structures, including a hospital, animal facilities, research laboratories, and the Central Utility Plant. The study's assessment of these buildings classified them into risk categories, from I (lowest risk) to IV (highest risk) based on potential loss of life, research, and property in the event of a significant seismic event. Based on a building's assigned risk category, the DRM may require seismic parameters more conservative than those in the International Building Code (IBC) for critical facilities.

Basic IBC Seismic Requirements

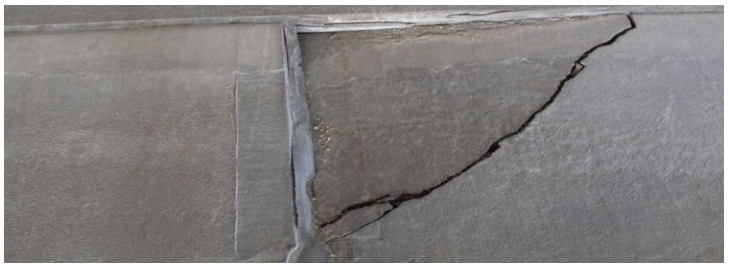
Seismic loads shall be determined using the provisions of the IBC. Seismic acceleration values may be developed using the contour maps in the IBC, or by developing a site-specific acceleration study. The site-specific seismic acceleration study shall be performed by a qualified geotechnical engineer. The engineer shall classify the site in accordance with the IBC based upon shear wave velocity using boring logs and other appropriate investigation techniques.

DRM Requirements

Following the release of the executive order 13717-Establishing a Federal Earthquake Risk Management Standard (dated February 5, 2016), DTR introduced a new section to its DRM. Section 5.2.1.G: Seismic Loads may require NIH-specific seismic design parameters for certain structures. Designers are advised to contact DTR at the initial stage of the design process to determine whether these parameters are applicable to the project. NIH-specific seismic design parameters may be required for the following cases:

- New buildings
- Existing buildings being proposed for renovation, including entire buildings or wings renovated between expansion joints.
- All buildings or sections of buildings classified as risk category IV by risk assessment using the IBC Risk Category Table.

If additional parameters are required, they may result in further structural and non-structural lateral restraint or increased lateral force-resisting structural capacity.



Example of damage caused by earthquake

Additional Recommendations

DTR also has several design recommendations based on experience and best practices, as follows:

Structural:

- Expansion joints should have sufficient clear distance to accommodate seismic movement.
- Buildings should comply with detailing requirements for ductility and deflection compatibility.

Non-Structural:

- All overhead lighting and emergency exit lights should have proper bracing to prevent swinging and negative interactions with other components.
- Pipe system and cable trays should be laterally braced.
- Telecommunication room racks shall be bolted together and secured to the floor.
- Large components, including generators, pumps, air handlers, and storage tanks, should be on isolation dampers with proper stoppers.
- Heavy items should not be stored on high shelves and each shelf shall clearly indicate weight restrictions.
- Glass and other breakable items should not be stored on open shelves and racks without lips or restraints.
- Doors on storage cabinets and industrial shelving units should latch or lock securely.

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Further details on this month's topic are available on the DRM website Chapter 5 Section 5.2.1.G
https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx

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The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ *biomedical research facilities.*

Emergency Eye Wash (EEW) Equipment and Backflow Prevention

There are several factors to consider when designing for EEW and facewash installations. These include but are not limited to: ensuring the location, specific type, and quantity of fixtures are sufficient to mitigate the risk; ensuring all devices are properly accessible; and, significantly, ensuring that the water supply serving the emergency fixture distribution loop and potable water system is adequately protected from potential contamination. This last consideration is the focus of this article.

The DRM 8.3.6.A states that "the design intent for water supply to the ARF and lab facilities is to minimize provision of testable backflow preventers within laboratories, ARFs, and other sensitive areas." This is key to maintaining safety and minimizing ongoing operational costs and flood risks in laboratories; proper application of backflow prevention devices reduces both these factors. Despite this requirement, DTR is seeing an increase in the number of backflow preventers being specified in new designs. Part of the effort to reduce the overall number of maintainable backflow preventers involves ensuring the correct application of backflow prevention on eyewash units.

Backflow Preventer Application

There are numerous requirements for proper backflow preventer application, all outlined in the DRM. These requirements vary based on equipment and device type. DRM 8.2.10.2 states that the vertical pull-down type of eyewash is the preferred type of unit for in lab applications. This type of fixture benefits in that no additional backflow protection is required at the point of use for pull-down and swing away type emergency fixtures when connected to a domestic potable water system, or dedicated passive purge water loop. Neither point-of-use or central backflow preventers are required for units located outside of laboratories (DRM 8.3.7), except where required by code because of the type of fixture selected. Emergency fixtures outside of laboratories are fed directly from potable hot and cold water supplies. Per DRM 8.3.7 and ANSI Z358.1, emergency fixture units, including those within laboratories, are to be served only from potable (not laboratory) water systems. The DRM also states that the supply is to be configured as a passive purge water loop and shall be protected centrally by ASSE 1013 backflow preventers located at the start of the loop.

ASSE 1013 backflow preventers require adequately sized drain receptors, annual testing/certification, and routine inspections, which creates an added burden on facility maintenance. The presence of such drains within laboratories can also pose a significant facility flood risk. This is why the DRM requires the RPZ backflow preventers to be located centrally outside of the laboratory, and in limited quantity; a common location would be at an interstitial floor or adjacent mechanical space. Generally, DRM Section 8.3.7 is not intended to require ASSE 1013 preventers at each local application unless necessary due to the specific eye wash fixture selected (e.g. drench hoses). Drench hoses incorporate a non-fixed, hose connected outlet that has an inherent risk of submergence, and thus by code must have adequate backflow preventer at the point of use. Where drench hose type units are used, additional requirements are necessary to ensure safety and comply with code. Many of the backflow prevention devices offered as optional or incorporated features for some models do not meet plumbing code or specific backflow preventer listing requirements, so it's important to check the DRM for specific guidance on preferred type and acceptable configurations.

Conclusion

Careful consideration of the types and locations of eyewashes and their associated backflow prevention devices can reduce overall maintenance, flood risks, and installation costs for the project while promoting water supply safety. Further information on these issues relative to backflow protection are available by reviewing USC FCCCHR and ASSE backflow preventer listing requirements and test reports.

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Further details on this month's topic are available on the DRM website: DRM Chapter 8 Section 2 & 3
https://www.orf.od.nih.gov/PoliciesAndGuidelines/Pages/DesignRequirementsManual2016.aspx

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Design Requirements Manual **News to Use**

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The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_j \bar{U}_i)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_j \bar{U}_i)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ *biomedical research facilities.*

DRM Update: Landscaping

The recent DRM update revamps "Section 3.5: Landscaping" with several important changes. These changes apply specifically to the NIH Bethesda campus, but their underlying principles can be applied to other locations. Notably, the specifications for plant replacement and removal have been modified and expanded. The previous edition of the DRM contained no replacement planting requirements for shrubs and groundcover that got removed as part of project demolition. The architect's original landscaping vision is often damaged because of this; the number of bare planting beds on campus has increased because little attention has been paid to replacement plantings in subsequent projects. The DRM update addresses this issue by requiring that all shrub and groundcover be replaced in kind with new nursery grown plants of the same species and quantity. In the case of projects where the site conditions will completely change, an alternative planting plan can be developed for the ORF Landscape Architect's review and approval. In addition, trees shall now only be removed as necessary for the final project rather than strictly for the benefit of temporary construction measures, a topic that the previous edition of the DRM had not addressed. Because of this change, projects should be encouraged to utilize areas that won't require tree removal, or where tree removal is in line with the project's ultimate goal, as places to conduct temporary construction activities.

Minimum plant size and spacing requirements for new plant material have also been added to this update. These requirements are necessary in order to clarify NIH expectations for landscape plantings. In the past, installations of undersized plant material and/or plants spaced too far apart have created a myriad of maintenance problems for the campus grounds crew, such as increased weed pressure, mulch washouts, dry oil, and deer damage. The new requirements are intended to rectify these issues.

The previous DRM edition referenced the old NIH 1:1 Tree Replacement Policy, which stipulated that for every tree removed within the Bethesda enclave, one new tree should be planted as its replacement. Per the old policy, the removal of a mature tree and the removal of a young sapling both required the same replacement. However, large trees are extremely valuable campus assets, especially with regard to environmental functions, and their loss should be appropriately mitigated. Large trees provide exponentially more benefit than small trees because they are better at sequestering carbon, intercepting storm water runoff, transpiring groundwater, and supporting wildlife habitat. Large trees also help promote human health and well-being by providing shade, environmental cooling, and overall greening of the campus. The DRM update includes a revision to the NIH Tree Replacement Policy that bases the ratio of tree replacement on the size of the tree being removed. This removal to replacement ratio is clearly expressed in the newly-added Exhibit 3.1 Tree Replacement Matrix. These new tree replacement requirements will ensure that the campus tree canopy continues to grow, and the removal of large trees will be more effectively deterred or mitigated. For reference, "Exhibit 3.2: Sample Tree Replacement Calculation Charts" was added to better convey how to apply and document the tree replacement requirements in submitted project drawings.

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Further details on this month's topic are available on the DRM website: DRM Section 3.5 Landscaping
https://www.orf.od.nih.gov/PoliciesAndGuidelines/Pages/DesignRequirementsManual2016.aspx

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Design Requirements Manual **News to Use**

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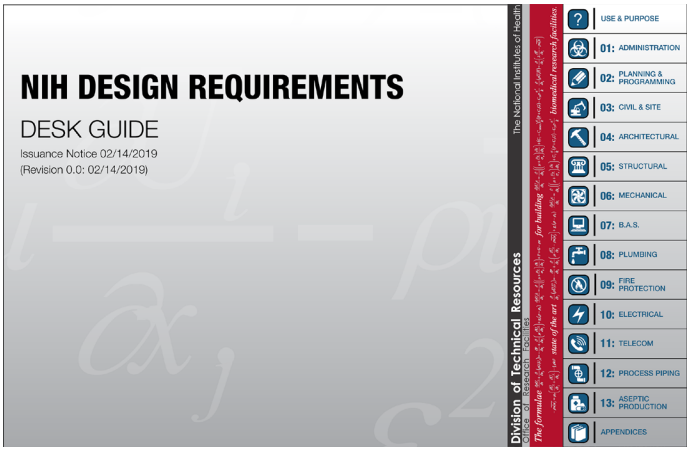
The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ for building $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ state of the art $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ biomedical research facilities.

The Design Requirements Desk Guide

Laboratory design is a complex undertaking, which necessitates that the DRM be a complex document. Navigating the 1,000+ pages of the DRM, including its exhibits and appendices, can be challenging; because of this, the Design Requirements Desk Guide has been developed as a resource.

https://www.orf.od.nih.gov/PoliciesAndGuidelines/Documents/DRM/DRMDeskGuide.pdf

The DRM establishes policy, design requirements, standards, and technical criteria for use in planning, programming, renovating, and designing all NIH occupied and funded buildings. It also provides objective and performance-based criteria for a wide range of systems, materials, assemblies, and equipment which impact the safe and efficient operation and maintenance of NIH facilities.



The Design Requirements Desk Guide

The DRM and the Desk Guide

During the course of a facilities project, the designers, Project Officers, reviewers, and other stakeholders must determine whether the DRM addresses a particular point or issue. If it does, they must navigate to the appropriate chapter, section, and subsection to find it. The electronic copy of the DRM has numerous built in navigational tools for ease of use: **most importantly, the document is easily searchable with the CTRL+F command,** meaning users can quickly find key words or phrases instead of combing through a whole section for a relevant line. The electronic DRM also contains links throughout the text to easily access sections from the table of contents or other sections that reference them, and it has bookmarks to each chapter and appendix. The Desk Guide is a quick reference to be used in conjunction with these existing tools; it can also serve to facilitate learning of DRM content and the content's location within the manual.

Use of the Desk Guide

The Desk Guide has 13 chapters and a section on appendices, which replicates the DRM's organizational structure. It is also searchable and linked in a similar fashion to the DRM, with a menu directly linked to chapters located on the right border of every sheet, and chapters have sections and subsections which list which criteria is contained therein. It is important to note that the Desk Guide does not provide the criteria itself, only an overview of criteria, therefore the Desk Guide must be used in conjunction with the DRM rather than as a substitute for it. Once the user has determined the location of the appropriate content in the Desk Guide, they must then use the DRM to find the corresponding criteria for practical use.

Although it can be printed, the Desk Guide is best used digitally, and is therefore available for download. This way, users will be able to utilize the numerous hyperlinks to specific DRM criteria. Like the DRM, the Desk guide will be updated as needed, and users should reference the most currently available version or the version applicable to a particular project.

As always, any questions, comments, or suggestions about the DRM or the Desk Guide can be submitted to the Division of Technical Resources through email to Shawm@nih.gov.

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Further details on this month's topic are available on the DRM website: NIH Design Requirements Desk Guide
https://www.orf.od.nih.gov/PoliciesAndGuidelines/Pages/DesignRequirementsManual2016.aspx

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The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ *biomedical research facilities.*

Corrosive Storage Cabinets

Corrosive storage cabinets are an important component of laboratory safety. Corrosives are hazardous because they chemically destroy materials, including exposed body tissues, and emit vapors which can be harmful if inhaled. Because of this, DRM section 2.1.3.7.6C states that "laboratories where fume hoods are located or corrosives are handled shall be equipped with an emergency shower and corrosive storage cabinet." Most corrosives are strong acids or bases – due to their hazardous nature, many of the procedures using them are performed in a fume hood or other protective enclosure. Strong acids and bases must be stored separately, which may require multiple corrosive storage cabinets within a single laboratory. The NIH Chemical Safety Guide recommends storing acids in a dedicated corrosive storage cabinet beneath the chemical fume hood.[1]

Hazardous Chemicals

Hazardous chemicals are classified as primarily corrosive or flammable. If a classification is in doubt, the Division of Health and Safety shall be consulted. All hazardous chemicals should always be properly labeled, sealed and stored in appropriate cabinets; the storage requirements of corrosive and flammable chemicals are different, and both must be accommodated appropriately. Flammable chemicals are stored in flammable storage cabinets, which are non-vented to contain combustible vapors.[2] Corrosive chemicals are stored in corrosive storage cabinets, which are vented to evacuate hazardous vapors.

Corrosive Storage Cabinet Requirements

Due to their critical function, corrosive storage cabinets must be specified to meet special requirements, including the following:

- A single-piece, leak-proof floor pan is required to contain spills.
- A lock is required to maintain materials securely.
- The cabinet must be labeled for clear identification, including specification of the hazardous nature of its contents.
- Shelves must be strong enough to support heavy bottles.
- The cabinet must be vented to the fume hood or the lab exhaust system as appropriate.
- The cabinet interior must be constructed of corrosive-resistant materials.
- The capacity of the cabinet must be adequate for storing all chemicals anticipated to be used in the lab.

If the laboratory has a fume hood, the corrosive storage cabinet is typically located as a base directly below the hood and vented through the fume hood behind the baffle. If the lab does not have a fume hood, the corrosive storage cabinet is vented to the laboratory exhaust system and can be undercounter, benchtop, or free-standing.

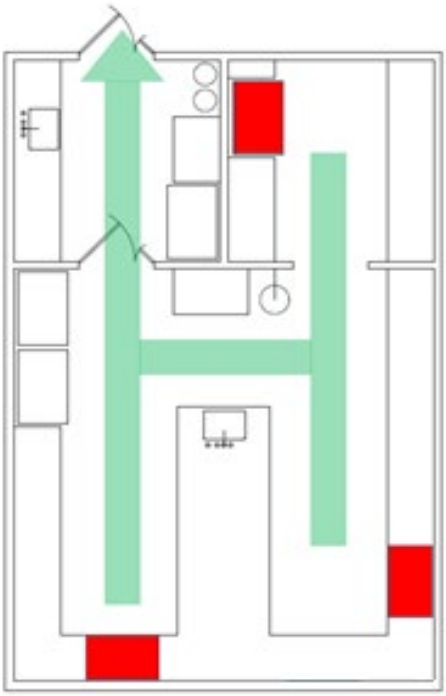

Figure 1: Possible corrosive cabinet locations at the ends of egress paths

In recognition of their hazardous nature, DRM section 1.11.3.4K requires that cabinets be located towards the back of the laboratory, away from the laboratory entrance. This ensures that they are at the end of egress paths so that no one will be trapped in case of a hazardous event at a cabinet (figure 1). Section 1.11.3.4K also requires that flammable storage cabinets and corrosive storage cabinets be located "diametrically opposed from each other." Although this is not always possible, it is a recognition of the hazardous nature of these items and the best practice of locating them as far from each other as is practical.

Reference

[1]Chemical Safety Guide, NIH Division of Occupational Health and Safety, 2015

[2]NIH Technical News Bulletin, Flammable Storage Cabinets, January 2016

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Further details on this month's topic are available on the DRM website DRM Section 2.1.3, Laboratory Planning
https://www.orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Pages/DesignRequirementsManual2016

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Design Requirements Manual **News to Use**

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The formulae $\frac{\partial \rho \bar{U}_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho \bar{U}_i \bar{U}_j)=-\frac{\partial \bar{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu \frac{\partial \bar{U}_i}{\partial x_j}-\rho \overline{u_i' u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho \bar{U}_i \bar{H})=\frac{\partial}{\partial x_i}\left(\lambda \frac{\partial \bar{T}}{\partial x_i}-\rho \overline{u_i' h'}\right)$ *biomedical research facilities.*

DRM Appendix O.1: Insect Facilities

A new appendix, Appendix O Specialty Labs, has been added to the DRM. Currently there are two sections in the Appendix: O.1 Insect Facilities, which is new, and O.2 Electron Microscope Facilities which has been in previous editions. It is expected that additional Specialty Lab sections will be added to Appendix O as the need for them is identified and they subsequently written; future additions will be announced in News to Use articles.

Insect Facilities

Section O.1 Insect Facilities addresses the design of facilities where insects are housed, reared, and/or genetically modified. Most insects are not intrinsically dangerous, but they become a public health concern when they are infected and become vectors (carriers) of pathogens. Insects are vectors for malaria, West Nile Virus, Zika, dengue fever and other serious diseases. Insects of primary interest to biomedical researchers include mosquitoes, flies, and fleas, but in addition to insects, the principles outlined in Section O.1 can be applied to facilities designed for ticks, spiders, and other biting and stinging arthropods.

Insect facilities must be designed for the safe, secure, and efficient handling of pathogens as well as pathogen-infected insects, which adds complexity due to the insects' size, mobility, and unpredictable behavior. In addition to facility and insect-specific requirements, systems shall comply with all appropriate sections of the DRM.

Overview of Contents

Containment. Containment is required to prevent insects from either escaping from or entering the facility. This is especially important with populations that are infected, genetically modified, or invasive species.

Arthropod Containment Level (ACL). Insect facilities are classified by ACL, which is somewhat analogous to BSL levels for biocontainment labs. ACLs are determined by the risks and safety considerations related to working with particular pathogens.

Planning Considerations. Information gathering and developing a Basis of Design are essential for defining the requirements and functionality of the facility. Key information includes the species and varieties of insects, pathogens, procedures to be performed, security and containment requirements, equipment to be used, environmental parameters, and all other factors that will have an impact on the facility design, maintenance, and operations.

Mosquito housing in an insect facility.

Environmental Requirements. The appropriate environmental conditions for insects, staff, and research must be determined and provided. HVAC systems must be designed for varied temperature and humidity as well as reliability, flexibility, testing, and certification.

Facility Design. The facility must be designed to safely and efficiently perform the established standard operating procedures and to address all required facility functions including security access, containment, flows (e.g. of people, material, and equipment), maintenance, cleaning, decontamination, waste management, and operation and support functions. Important aspects of facility design are:

- Architectural Design, including all-white finishes, low ceilings, minimized fixed casework
- Heating, Ventilation and Air Conditioning, including screens on all air devices and containment via airflow direction
- Plumbing, including screens on all devices and plumbing fixtures, design for disinfection
- Electrical, including sealed devices, boxes and conduits, diurnal lighting, access control

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Further details on this month's topic are available on the DRM website DRM Appendix O.
https://www.orf.od.nih.gov/PoliciesAndGuidelines/Pages/DesignRequirementsManual2016.aspx