

The formulae $\frac{\partial \rho U_i}{\partial t} + \frac{\partial (\rho U_i U_j)}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\mu \frac{\partial U_i}{\partial x_j} \right) + g_i (\rho - \rho_s)$ for building $\frac{\partial (\rho \bar{U}_i \bar{U}_j)}{\partial x_j} = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j} \left(\mu \frac{\partial \bar{U}_i}{\partial x_j} - \rho \bar{u}_i \bar{u}_j \right) + g_i (\rho - \rho_s)$ state of the art $\frac{\partial (\rho \bar{U}_i \bar{H})}{\partial x_i} = \frac{\partial}{\partial x_i} \left(\lambda \frac{\partial \bar{T}}{\partial x_i} - \rho \bar{u}_i \bar{h} \right)$ biomedical research facilities.

Designing for Leak and Flood Resistance

NIH buildings contain a myriad of plumbing and piping systems necessary for basic building operations as well as laboratory, clinical, and animal care functions. With so many systems, it is inevitable that leaks and floods occur, so it is incumbent for the design process to include appropriate risk assessment and for the design to incorporate appropriate flood-resistant measures. Leaks and floods can severely hinder the safety, efficiency, and operations of critical facilities and have detrimental effects on research. The consequences of water damage can include compromised infection control and aseptic conditions, loss of containment, damaged finishes and equipment, mold growth, and abeyance of services.

Flood-resistant detailing is addressed in many sections of the DRM. Section 2.2.1.3H, Leak and Flood Prevention, requires that mechanical rooms and interstitial levels be designed to prevent leaks and that floor assemblies be waterproofed. Section 4.3.1.1C, Flood Resistant Detailing, requires that a water-impervious material be installed at the base of gypsum board walls in all areas prone to flooding or water damage. These requirements are intended to limit the propagation of water from leak-prone areas to other areas of the building, and to protect walls from water damage when a flood occurs.

The DRM requirements listed above are minimums, and all projects must undergo a risk assessment to identify additional flood mitigation measures based on the criticality of the facility, age of the infrastructure, history of failures, and other pertinent factors. Risk Assessment is defined in Section 1.3, Definitions, and further clarified in Sections 1.14.1, Critical Facility Risk Assessment and Certification and section 1.15.6, Risk Assessment, Systems Failure and Disaster Mitigation.

Design Requirements

General Building Requirements. The DRM contains requirements for overall building design to minimize both the chance of flooding and any damage if flooding does occur. Section 1.15.6E12 prohibits the location of major infrastructure equipment in areas susceptible to flooding. Section 1.15.6E19 prohibits the installation of wet equipment rooms above critical facilities, and Section 1.15.3L requires a flood-monitoring system in areas where this cannot be avoided. Section 8.1.5.1A prohibits the location of piping above surgical areas, clean rooms, high containment areas, or other critical and sensitive spaces unless directly serving those

spaces. In addition to these general requirements, specific requirements are provided by area type.

Mechanical rooms and interstitial levels. Section 2.2.1.3H denotes mechanical rooms and interstitial levels as particular concerns for leaks and floods due to the concentration of piping, plumbing systems, and mechanical equipment. The floors in these areas must be waterproof and designed to contain water and direct water to drains. Concrete floors must be finished with a durable, abrasion-resistant waterproof system which will bridge cracks. Penetrations, shafts, slab edges, and other paths for water propagation must be detailed with curbs, sleeves, upturns, or other protective elements. Sloped floors, berms, or other methods must be provided at doors and corridors to contain water. Section 6.3.8 requires freeze protection measures for 100% Outside Air Handlers to prevent coil ruptures.

Vivariums. Vivariums are water-intensive facilities by necessity and are therefore susceptible to flooding. All floors within a vivarium must be seamless with integral bases per section 2.4.3F. Drains serving cage wash equipment must be designed to accommodate surge flow. If walls are constructed of gypsum board, the base must be backed by water-impervious board to protect the gypsum board from water per section 4.3.1.1C.

Laboratories. Laboratories can be a source of flooding and highly susceptible to flood damage. Areas that use a lot of water (autoclaves, glassware washers, equipment rooms, areas at emergency showers) are prone to flooding and should have seamless, waterproof flooring with integral bases to contain water. Aseptic production facilities, clinical laboratories, and other sensitive and critical areas should be detailed to protect them from water and to limit damage if flooding occurs. This can be done by detailing adjacent mechanical rooms and wet rooms appropriately and only using materials in their construction that are nonabsorbent and which will not support mold growth.

Conclusion

Leaks and floods cannot be eliminated entirely from laboratory, clinical, and animal care facilities. However, their impact can be minimized and the disruption to operations limited through risk assessment, thoughtful planning, and good design and detailing.

'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 Chapters 2 and 4
<https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx>