

The formulae  $\frac{\partial \mu_i}{\partial x_j} + \frac{\partial}{\partial x_j} (\rho \mu_i) = -\frac{\partial}{\partial x_j} \left( \mu \frac{\partial \mu_i}{\partial x_j} \right) + g_i (\rho - \rho_s)$  for building  $\frac{\partial}{\partial x_j} (\rho \bar{U}_i) = -\frac{\partial}{\partial x_j} \left( \mu \frac{\partial \bar{U}_i}{\partial x_j} - \rho u_i^2 \right) + g_i (\rho - \rho_s)$  state of the art  $\frac{\partial}{\partial x_j} (\rho \bar{U}_i) = -\frac{\partial}{\partial x_j} \left( \lambda \frac{\partial \bar{U}_i}{\partial x_j} - \rho u_i^2 \right)$  biomedical research facilities.

## Floor Area Considerations in Laboratory Design

The high value of laboratory space drives the need to utilize floor area as efficiently as possible. Although efficiency is a worthy goal, it must be tempered with the understanding that safety and function cannot be compromised. During the planning of a construction project, the designer must confirm that the identified floor area is sufficient to accommodate the program, including regulatory requirements, the needs of the specific laboratory activities, and good practice, without undue risk.

**Regulatory requirements** are issued by an authority having jurisdiction (AHJ) and are mandatory unless a given requirement is formally exempted by the appropriate AHJ. Regulatory requirements that affect floor area include:

- Building codes, including the International Building Code (IBC) and those published by the National Fire Protection Association (NFPA), provide minimum dimensions and clearances for building components, including egress and life safety. The NIH Fire Marshal is the AHJ for fire & life safety for NIH-owned facilities.
- Accessibility standards, including the Architectural Barriers Act (ABA) and the Americans with Disabilities Act (ADA), provide accessibility space requirements including turning radii, clear floor space, and clearances at doors. The US Access Board is the AHJ for accessibility.
- The NIH *Design Requirements Manual (DRM)* provides space requirements such as lab module size, lab aisle width, and Appendix A clearances. Additional requirements, including those published by the Facilities Guideline Institute (FGI), are required by reference. The Division of Technical Resources is the AHJ for the *DRM*, except for Chapter 9, for which the NIH Fire Marshal is the AHJ.
- The Occupational Safety and Health Administration (OSHA) and the NIH Division of Occupational Health and Safety (DOHS) are additional sources of regulatory requirements focused on safety.

**Specific laboratory activities** require movement and working clearances sufficient for laboratory functional operations to be conducted safely and without inefficiencies, congestion, and conflicts.

It is critical to develop a thorough understanding of the number and roles of staff, type, and frequency of work to be conducted, and materials, supplies, and equipment to be used. Workflow diagrams can illustrate critical flows (e.g., of personnel, materials, or waste) and help identify areas of congestion or

conflict. Once the specific requirements of lab operations have been determined, areas of concern can be addressed, including:

- Sufficient space for staff to perform procedures safely, comfortably, and ergonomically.
- Ease of movement for materials, including equipment, supplies, carts, cylinders, and deliveries.
- Sufficient clearances for equipment replacement and for equipment covers and access panels to be opened or removed for maintenance, calibration, and service activities.
- Adequate space and dedicated locations for ancillary and support equipment, such as tanks, UPSs, chillers, carts, and mobile equipment.
- Adequate space for PPE, including storage, disposal, charging, and donning/doffing.
- Facilities for waste management/decontamination and waste flows.
- Allowance for future growth, which may include additional personnel, equipment, or procedures.

**Good practices** are standards that are proven through experience to produce positive outcomes. Some good practices are codified (in the *DRM*, for example) and others are recognized by design professionals based on successful past projects. Good practices that affect floor area include:

- Designating dedicated locations for waste containers (including hazardous waste and sharps), configured so they don't become obstructions.
- Providing adequate in-lab storage for frequent-use supplies so that benchtops and aisles don't become cluttered.
- Providing out-of-lab staff lockers so personal items remain outside of the lab.
- Providing an appropriate level of flexibility to accommodate reconfiguration and program changes.
- Ensuring unobstructed access to all equipment, including safety equipment (e.g., handwashing sinks, safety showers, hazardous materials receptacles, flammable storage cabinets, fire extinguishers, emergency shut-down switches).

### Conclusion

Every laboratory project should aim to utilize the available floor area efficiently. The designer must confirm that floor area is sufficient to accommodate the program, including regulatory requirements, laboratory activities, and good practices, without compromise.