PURPOSE

This document outlines the key design and safety considerations for the construction or renovation of laboratories at Wayne State University (WSU). And serves as a foundational resource. However, it is essential to recognize that specific laboratory operations may introduce unique hazards and require tailored design solutions. The specific requirements for each laboratory will be determined based on a thorough hazard assessment of the intended research activities and operational procedures conducted by Occupational and Environmental Health and Safety (OEHS).

Collaboration with OEHS is recommended throughout the design process to ensure that all safety and regulatory requirements are met and that the final design effectively mitigates potential risks associated with the intended laboratory use.

CODES AND STANDARDS

This section presents a selection of key regulatory and guidance documents pertaining to laboratory design. It is explicitly stated that this compilation does not constitute a complete and exhaustive listing of all applicable legal and best-practice requirements. Contractors are solely responsible for identifying, understanding, and adhering to all relevant local, state, and federal codes, standards, regulations, and guidelines.

Building Codes and Standards:

- International Building Code (IBC)
- International Fire Code (IFC)
- International Mechanical Code (IMC)
- International Plumbing Code (IPC)
- National Electrical Code (NEC) (NFPA 70)
- NFPA 45: Fire Protection for Laboratories Using Chemicals
- NFPA 99: Health Care Facilities Code
- NFPA 70E: Standard for Electrical Safety in the Workplace
- Americans with Disabilities Act (ADA) Accessibility Guidelines

Occupational Safety and Health Administration (OSHA) Regulations (29 CFR 1910) and State of Michigan Equivalent Regulations:

- 1910.1450: Occupational exposure to hazardous chemicals in laboratories ("Laboratory Standard")
- 1910 Subpart Z: Toxic and Hazardous Substances
- 1910.1030: Bloodborne Pathogens
- 1910.1200: Hazard Communication Standard (HazCom)
- 1910.134: Respiratory Protection
- 1910.38: Emergency Action Plans

Environmental Protection Agency (EPA) Regulations:

- Resource Conservation and Recovery Act (RCRA)
- Clean Air Act (CAA)
- Clean Water Act (CWA)

National Institutes of Health (NIH) Guidelines:

- NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (NIH Guidelines)
- Biosafety in Microbiological and Biomedical Laboratories (BMBL)

Animal Research Regulations:

- Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC International) Standards
- Public Health Service (PHS) Policy on Humane Care and Use of Laboratory Animals

Other Relevant Standards and Guidelines:

- American National Standards Institute (ANSI) Standards
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards
- American Industrial Hygiene Association (AIHA) Guidelines

Specific Regulations for Radioactive Materials (If Applicable):

- U.S. Nuclear Regulatory Commission (NRC) Regulations (10 CFR)

FUNCTIONALITY AND WORKFLOW

Flexibility and Modularity:	Flexibility and Modularity: Design for adaptability to future research needs and growth. Consider modular lab furniture, movable partitions, and flexible utility connections allow for reconfiguration.
Workflow Optimization:	Arrange equipment and workspaces to support logical workflows, minimizing unnecessary movement and potential cross-contamination. Consider the sequence of experimental steps.
Space Allocation:	Provide adequate space for equipment, personnel, and movement. Avoid overcrowding, which can lead to safety hazards and inefficiencies.
Ergonomics:	Design workspaces to promote good posture and minimize repetitive strain injuries. Solutions that include adjustable/variable height benches, comfortable seating, and proper equipment placement should be considered.
Accessibility:	Ensure compliance with ADA guidelines for accessibility for individuals with disabilities.
Break/Eating Areas:	Each floor containing laboratory spaces shall have a designated area for food storage and lunch breaks, such as a kitchenette. These areas shall be physically separated from laboratory spaces.
Office and Write-Up Space:	Offices and write-up desks for laboratory personnel shall be located outside of the laboratory space.
Personal Protection Equipment (PPE) Proximity to Entrances:	PPE storage areas should be located near laboratory entrances to facilitate donning PPE before entering the lab and doffing upon exiting. This minimizes the spread of contamination outside the laboratory.
Ease of PPE Access:	Storage areas should be easily accessible and uncluttered. Avoid storing PPE in congested areas or blocking exits.
Separation of Clean and Used PPE:	Provide separate areas or containers for clean and used PPE to prevent cross-contamination.
Lab Coats:	Provide hooks, hangers, or designated storage areas for lab coats. Ensure adequate spacing to prevent crowding and wrinkling.
Gloves:	Provide glove dispensers in various sizes near entrances and work areas. Consider using different colored dispensers for different glove types or sizes.
Eye Protection (Safety Glasses, Goggles, Face Shields):	Provide designated storage areas for eye protection, such as racks, shelves, or individual containers. Consider providing cleaning stations for eye protection.

Other PPE (e.g., Respirators, Shoe Covers, Hair Nets, Gowns):	Provide appropriate storage for other PPE as needed, such as racks, shelves, or bins.
Partitions:	Where physical separation is required, it shall consist of floor-to-ceiling partitions with doors and self-closing mechanisms.
Visual Connection:	If a visual connection between spaces is desired for safety or operational purposes, glass partitions should be considered.

ELECTRICAL

Electrical Capacity and Connections:	Electrical power supply, connections, and outlets shall be sufficient to meet the power demands of all anticipated equipment.
Electrical Outlet Placement:	Careful consideration shall be given to the placement of refrigerators and other equipment to ensure convenient and safe access to power. A sufficient number and variety of outlet types shall be provided.
Overhead Connections:	Drop-down or ceiling-mounted outlet connections shall be considered for equipment with unusual placement requirements.
Circuit Breaker Panel Location:	Circuit breaker panels shall be located outside of the laboratory space but *not* within fire-rated corridors.
Generator Backup:	Emergency generators shall be provided to supply power to essential laboratory equipment and systems during power outages. A detailed assessment shall be conducted to determine which areas and equipment require emergency power backup.

DESIGN, MATERIALS, AND FINISHES

Chemical Resistance:	This is paramount. Materials must withstand exposure to the chemicals used in the lab, including acids, bases, solvents, and other corrosive substances.
Cleanability and Decontamination:	Surfaces should be smooth, non-porous, and easy to clean and decontaminate to prevent the spread of contamination.
Durability and Wear Resistance:	Materials must withstand heavy use, impacts, and abrasion.
Moisture Resistance:	Especially important in areas with sinks or wet processes.

Fire Resistance:	Materials should meet fire safety codes and standards.
Slip Resistance:	Flooring should provide adequate traction to prevent slips and falls.
Ergonomics:	Consider materials that reduce glare and noise.
Joints and Seams:	Minimize joints and seams to prevent the accumulation of dirt and bacteria. Sealants should be chemical-resistant and durable.
Color and Lighting:	Choose colors that are easy on the eyes and provide good contrast. Adequate lighting is essential for safety and accuracy.
Maintenance:	Consider the long-term maintenance requirements of the materials.
Prohibited Materials:	The following materials shall not be used in laboratory spaces: Porous or unsealed concrete, Vinyl stick flooring, and Carpet
Unsealed Wood:	While sealed wood may be present in existing structures (e.g., sealed wooden drawers, cabinets), new construction and renovations should minimize or eliminate the use of wood wherever feasible due to its inherent porosity and flammability.
Flooring Requirements:	The flooring shall be non-pervious, seamless (one-piece), and coved (extending up the wall to create a sealed junction). This can be achieved through methods such as gluing, heat-welded vinyl sheet flooring, or epoxy-coated concrete slabs.
Benchtops Material Properties:	Benchtops shall be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals anticipated for use in the laboratory.
Bonding and Grounding:	Bonding and grounding connections shall comply with all applicable NFPA and OSHA requirements for flammable liquids, including the provision of grounding terminals and bars.
Heavy Equipment:	The potential placement of heavy equipment shall be considered during the design phase, and the building structure shall be designed to accommodate the anticipated weight loads.
Stationary Air Monitoring Devices and Alarms	Laboratories where hazardous gases are used or stored shall be equipped with appropriate stationary air monitoring devices and alarms to detect potentially hazardous concentrations. Examples of hazardous gases include, but are not limited to, flammable gases (e.g., hydrogen, methane), toxic gases (e.g., carbon monoxide, chlorine), and asphyxiant gases (e.g., nitrogen, helium). The type and placement of these devices shall be determined based on a hazard assessment of the specific gases present. Consultation with OEHS is required to determine the applicability of air monitoring requirements for specific laboratory operations.

Open Shelving Containment:	If open shelving is installed, shelves shall have a raised lip or edge to prevent chemical containers from falling.
Noise Isolation:	Design considerations shall address the isolation of noisy equipment to minimize noise pollution within the laboratory and adjacent spaces.

RADIATION

Design and construction/renovation activities related to spaces where radioactive materials will be used or stored, or where radiation-generating equipment will be installed, are contingent upon consultation with the Radiation Safety Officer (RSO). No work in these areas shall advance beyond the conceptual planning stage until this consultation has occurred and any resulting recommendations have been incorporated into the project plans.

Entryway Clearance:	If an MRI is to be included in the building, adequate entryway clearance shall be provided for the installation and removal of the equipment.
Structural Requirements:	Wall and floor construction shall be designed to accommodate the specific hazards and weight of the MRI unit.
Exhaust Connections:	Provisions for exhaust connections for sudden or emergency release of gases from the MRI unit shall be incorporated into the design.
Stationary Air Monitoring Devices and Alarms	Rooms housing MRI systems shall be equipped with stationary air monitoring devices and alarms to detect potentially hazardous levels of cryogens (e.g., helium) and other gases.

VENTILATION

General Laboratories:

Air Changes per Hour (ACH):	General laboratories utilizing hazardous materials shall maintain a minimum of six (6) air changes per hour (ACH).
Exhaust Ventilation:	Exhaust ventilation systems shall operate continuously.
Reduced Airflow During Nonbusiness Hours:	Upon consultation with OEHS, certain laboratories may be eligible for a reduction in airflow (from 6 ACH to 4 ACH) during unoccupied periods outside of normal business hours. This option should be carefully considered based on current and projected future use of the laboratory, as research needs may evolve. Inadequate exhaust ventilation may restrict future use of hazardous materials or necessitate potentially costly retrofitting.

Autoclave Rooms:

Air Changes per Hour (ACH): Autoclave rooms shall maintain a minimum of ten (10) air changes per hour (ACH).

Laboratory Pressurization:

Negative Pressure: Laboratories shall be maintained under negative pressure relative to adjacent corridors or other less hazardous areas.

Positive Pressure Clean Rooms: Clean rooms requiring positive pressure shall be equipped with entry vestibules incorporating door-closing mechanisms to prevent both doors from being open simultaneously.

CHEMICAL FUME HOODS

Sufficient Quantity: A sufficient number of chemical fume hoods shall be provided to accommodate the anticipated number of research groups housed in the building. The specific quantity (e.g., at least one per research group or at least one per lab suite) shall be determined based on a thorough needs assessment.

Recirculating Fume Hoods: The use of recirculating fume hoods is prohibited for chemical exposures. Applications involving particulate-based hazards will be evaluated and approved on a case-by-case basis by OEHS.

Operating Range: All chemical fume hoods shall operate within a face velocity range of 80 to 120 feet per minute (fpm).

Commissioning Velocity: During commissioning, fume hoods shall demonstrate a face velocity of 100 fpm.

Sash Position Performance: Fume hoods shall maintain their performance regardless of sash position for both upstream and downstream hoods.

Full Capacity Operation: Fume hood exhaust systems shall be designed to function effectively when 100% of all fume hoods in the lab are in simultaneous use.

Material Composition: The hood and ductwork shall be constructed of non-reactive and relatively impervious materials resistant to hydrofluoric acid attack. A Portland Cement hood interior or other suitable, chemically resistant material is recommended.

Visual Inspection: The hood shall be constructed to allow for easy visual inspection of all interior surfaces.

Specific Materials:	A transparent plastic sash and PVC ductwork are required.
Cup Sink Spill Prevention (If Present	If fume hood cup sinks are included, they shall have a raised lip to prevent spills of chemicals or other substances from entering drains. Sink lips or berms shall be greater than or equal to 0.25 inches (≥ 0.25 inches).
Hood Space per Student (For Intensive Chemical Use):	A facility designed for intensive chemical use should provide at least 2.5 linear feet of hood space per student. Evaluating the operational and research needs of users is essential to ensure that the appropriate type and number of hoods are integrated into the laboratory design.

HYDROFLUORIC ACID HOODS

Material Substitution:	Due to the highly corrosive nature of hydrofluoric acid, standard laboratory fume hood construction materials shall be substituted with materials specifically resistant to hydrofluoric acid attack.
Specific Requirements:	For hydrofluoric acid use, the standard fume hood design shall be supplemented by the following specifications on construction and materials: Polymerized Vinyl Chloride (PVC) ductwork is required for hydrofluoric acid exhaust applications. Note: PVC material can become brittle over time and is susceptible to cracking.

PERCHLORIC ACID HOODS

Specific Requirements:	Concentrated or hot perchloric acid is highly oxidizing and extremely corrosive. Additionally, the fumes can settle and form shock-sensitive crystals. Therefore, specially designed fume hoods and ductwork are required for perchloric acid use.

BIOSAFETY CABINET (BSC)

Biosafety cabinets (BSCs) are essential primary containment devices used to protect personnel, the environment, and research materials from biohazards. Proper selection, placement, installation, and use of BSCs are crucial for laboratory safety.

Appropriate Class:	The appropriate class of BSC (Class I, Class II [A1, A2, B1, B2], or Class III) must be selected based on the specific biohazards being handled and the type of research being conducted. Consult OEHS for guidance on BSC selection.

Placement Considerations: BSCs should be located away from doorways, high-traffic areas, and other disruptions to airflow (e.g., supply air diffusers, return air grilles). Placement should minimize cross drafts that can compromise the cabinet's containment. Consult OEHS for guidance for detailed guidance on BSC placement relative to doorways, walking paths, and other BSCs.

General Exhaust: BSCs that handle biological agents not requiring hard ducting to the building exhaust system, such as those used for sterile cell culture, should be placed to minimize air turbulence.

Ducted BSCs (Required for Chemical Use): If toxic or malodorous chemicals are used within the BSC, the cabinet must be ducted to the building exhaust system. This prevents the recirculation of hazardous chemicals into the laboratory. This is also required for work with volatile radionuclides.

Dedicated Exhaust System: Where ducted, the BSC exhaust system should be dedicated and independent of other exhaust systems to prevent cross-contamination.

Exhaust Discharge: The exhaust from ducted BSCs should be discharged to the outside of the building in a manner that prevents re-entry into the building's air intake systems and minimizes environmental impact.

Backflow Prevention: Backflow prevention devices (e.g., backdraft dampers) should be installed in the exhaust ductwork to prevent contaminated air from flowing back into the laboratory in the event of an exhaust system failure.

Professional Installation: BSCs should be installed by qualified professionals in accordance with manufacturer's instructions and relevant standards (e.g., NSF/ANSI 49).

Initial Certification: After installation, BSCs must be certified by OEHS to ensure proper operation and containment.

SAFETY SHOWERS

Installation Locations: Safety showers shall be installed in areas where injurious or hazardous chemicals are used, such as laboratories and mechanical spaces.

Showers Without Floor Drains: For showers installed without a floor drain, a thorough assessment of the potential impact of shower activation (i.e., water discharge location) shall be conducted. Collaboration with all potentially impacted parties is required to minimize adverse effects, such as equipment damage.

Proximity to Electrical Equipment: Safety showers shall be located a sufficient distance from electrical outlets and other equipment to mitigate electrical hazards.

Tempered Water: Safety showers shall be provided with tempered water meeting MIOSHA requirements. The optimal temperature range is 60-77°F (15-25°C).

Modesty Curtains: The inclusion of modesty curtains for emergency showers should be considered.

EYEWASHES

Installation Locations: Eyewash stations shall be installed in areas where injurious or hazardous chemicals, radiological materials, or biological agents are used, such as laboratories and mechanical spaces.

Drain Configuration: The drain configuration shall allow for easy collection of water during weekly function testing (i.e., the outlet should be positioned with sufficient clearance to accommodate a collection receptacle).

Tempered Water: Eyewash units shall be provided with tempered water meeting MIOSHA requirements. The optimal temperature range is 60-77°F (15-25°C).

LAB SINKS

Waste System Connection: Although chemical hygiene plans prohibit direct disposal of chemicals into drains, a chemical-resistant lab waste system connected to lab sinks, fume hood cup sinks, and similar plumbing fixtures shall be provided in laboratories using chemicals.

HANDWASHING SINKS

Installation Locations: Handwashing sinks shall be installed in areas where injurious or hazardous chemicals, radiological materials, or biological agents are used, such as laboratories and mechanical spaces, and in mechanical spaces where chemicals are used.

Activation Method:	It is preferred that handwashing sinks are designed to be hands-free (optical or foot-activated controls).
Location Relative to Exit:	Handwashing sinks shall be located near the exit door of the space.

POTABLE WATER SYSTEMS:

Design Requirements:	For construction or renovation projects, the design shall eliminate low-flow conditions and the potential for stagnant water. Consultation with the WSU Water Safety Officer is required as needed. The design shall include the ability to measure generation, mixing valve, and return temperatures.
Verification of Water Quality:	Potable water quality shall be verified by OEHS in newly acquired buildings and newly built or renovated areas. Treatment, flushing, and/or blow-out procedures shall be implemented as warranted. In new buildings, ensure that water does not remain stagnant in the plumbing system prior to occupancy. If full occupancy is not immediately achieved, augment normal use with periodic flushing to properly treat new pipes and minimize the leaching of metals into the water and bacterial growth until full occupancy is achieved.
Water Quality Testing Prior to Renovations:	Water quality testing must be performed by OEHS prior to and after renovations.

EMERGENCY SHUT OFF VALVES

Location:	Each laboratory space must have a single shutoff valve through which all such gas outlets are supplied. The shutoff valve must be located within the laboratory or adjacent to the laboratory's egress door and identified. Consult with OEHS if multiple gases will be present.

COMPRESSED GAS CYLINDER STORAGE

Egress Routes:	Wall brackets or storage racks for compressed gas cylinders shall not be placed within egress routes (e.g., hallways, corridors, exit pathways).
Proximity to Critical Equipment:	Wall brackets or storage racks shall not be placed adjacent to electrical panels, emergency shut-off switches/valves, or critical safety equipment (e.g., safety showers, eyewash units, fire extinguishers).

Designated Storage Area: Designated compressed gas cylinder storage cages or racks shall be provided in the building receiving area for the exchange of empty and full cylinders by vendors.

CHEMICAL STORAGE

Flammable Chemicals: At least one (1) flammable liquid storage cabinet shall be provided per laboratory space or suite. Flammable liquid storage cabinets shall not be located near exit doorways, stairways, or in any location that would impede egress.

Corrosive Chemicals: At least one (1) corrosive cabinet shall be provided per laboratory space or suite.

Solid Chemical Storage: Ventilated chemical storage cabinets shall be provided for the storage of solid chemicals that require ventilation.

Explosion-Proof/Flammable-Rated Refrigerators: Explosion-proof or flammable-rated refrigerators, equipped with alarms, shall be provided for the storage of temperature-sensitive flammable materials.

Flammable Storage Rooms: The need for dedicated flammable storage room(s) shall be evaluated based on the expected laboratory usage of flammable liquids and gases within the building. Please consult with the WSU Fire Inspector.

BIOSAFETY LEVEL 2 (BSL-2)

Design and construction/renovation activities related to BSL-2 laboratories, including the design and placement of tissue culture rooms, autoclaves, and associated equipment, are contingent upon consultation with the WSU Biosafety Officer.

Work in these areas shall not advance beyond the conceptual planning stage until this consultation has occurred and any resulting recommendations have been incorporated into the project plans.

Handwashing and Eyewash Facilities: A handwashing sink, and an eyewash station shall be located at the entrance to each tissue culture room.

BIOSAFETY LEVEL 3 (BSL-3)

Due to the critical nature of BSL-3 containment and the stringent regulatory requirements governing these spaces, all design, construction, and renovation activities related to BSL-3 laboratories are strictly contingent upon mandatory consultation with the WSU Biosafety Officer.

Work on these areas shall not commence under any circumstances without prior written approval from the Biosafety Officer, confirming adherence to all applicable biosafety standards and regulations.

ANIMAL HOUSING AREAS

The design and construction/renovation of animal housing facilities are subject to specific requirements to ensure the health, well-being, and humane care of research animals. Therefore, early and continuous consultation with the Attending Veterinarian and the Division of Laboratory Resources (DLR) is required throughout all phases of the design process, from initial planning to final construction.

VERSION CONTROL

Version	Date	Notes
1.0	January 2025	Initial