Laboratory Construction and Design

FSU Specifications for Systems and Safety Equipment associated with Laboratories and Hazardous Materials Storage or Usage Areas

Florida State University requires construction or renovation projects to meet all applicable code and regulatory compliance requirements. Incorporation of consensus standard recommendations and commonly recognized best practices is also expected. This guide is intended to supplement the requirements and the FSU Design Guidelines and Specifications in order to assist with compliance and address common problems and questions that have arisen related to safety equipment and systems during past projects. It is not intended to be all inclusive but should provide sufficient scope to design professionals for most FSU projects. The Department of Environmental Health & Safety (EH&S) may always be consulted for amplification or clarification related to these topics, especially for large, complex or unique projects.

The primary references containing legal compliance requirements specific to these types of applications are:

- NFPA30, 2003 edition*, Flammable and Combustible Liquids Code
- NFPA45, 2004 edition*, Standard on Fire Protection for Laboratories Using Chemicals
- NFPA55, 2005 edition*, Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks
- 29CFR1910 current edition, Occupational Safety and Health Standards
- Chapter 64E-5 F.A.C., Control of Ionizing Radiation Hazards (applicable for radiation producing machines or radioactive materials storage or use areas)

**These standards are adopted and required by the Florida Fire Prevention Code, Chapter 69A-60 F.A.C.*

The specifications and guidance contained in the following publications represent the primary non-mandatory references that shall also be followed to the greatest practical extent:

- ANSI/AIHA Z9.5-2003, Laboratory Ventilation
- ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods
- ANSI Z358.1-1998, Emergency Eyewash and Shower Equipment
- 29CFR1910.1450, App A, National Research Council Recommendations Concerning Chemical Hygiene in Laboratories
- CDC/NIH, Biosafety in Microbiological and Biomedical Laboratories, (applicable for potentially infectious organism storage or areas that require biological containment)

FSU EH&S specific requirements and interpretations are listed below. These are intended to provide consistency across all University properties and must be followed to most effectively utilize our resources while ensuring the protection of personnel and the environment. Design professionals should not deviate from this guidance without consulting with appropriate EH&S Industrial Safety and Health Engineers (i.e. – the University Biological, Chemical, Laboratory, or Radiation Safety Officer; their assistants; or supervisors).

Specific Design Requirements

Ventilation Design

Design professionals are encouraged to explore the latest technologies and approaches for optimizing system performance and providing safe and reliable systems that also conserve energy. However, priority for selection should always be given to tried and true system designs that have been proven by actual operation in similar environments. There is much room for improvement in reducing energy usage without sacrificing safety by properly utilizing currently available technologies. Design professionals need to always consider the actual needs of our researchers while planning these systems, as well as work with EH&S to maintain regulatory compliance. Unfortunately, past experience demonstrates that the needs of our researchers are not usually sufficiently delineated at the onset of new construction projects and future potential laboratory use is often unknown. This tends to drive designs in a direction that is much too conservative from a safety standpoint, utilizing too much energy without any real benefit. EH&S personnel will gladly consult with research group(s) and assist design professionals for an analysis of laboratory research needs.

Research laboratories have traditionally been designed to operate near 12 air changes per hour (ACH) throughout the entire facility when most areas do not require this high of an air exchange rate. EH&S recommends laboratories using chemicals be set to initially operate at 8 - 10 ACH, with sufficient capacity reserved to supply up to 12 ACH. 12 ACH should only be required as an initial rate for animal use areas, organic chemistry or other high hazard activity areas that frequently use volatile solvents. All laboratories should be adequately designed with supply and exhaust diffusers situated to ensure that air is well mixed in the entire ventilated space; turbulence is not created near fume hoods or other direct ventilation equipment; and proper differential pressures are maintained between spaces and within the building envelope. Ventilation systems shall also be designed with sufficient capacity to provide maximum rates to all spaces, with reasonable room for future equipment installation and system expansion, while still being able to operate under loads that will not cause excessive noise or wear and tear on system components. Ventilation ducts should be run in a manner that will reduce turbulence and shall never be internally insulated. Further, other internal obstructions shall be avoided.

Nighttime setbacks can often be utilized. 6 ACH should be the lowest setback rate programmed for any space containing volatile or flammable chemicals. Other spaces can be set lower with EH&S and FSU Utilities approval. These setback systems must be fail-safe such that the system reliably operates at normal ventilation rates when conditions warrant, such as when sensors indicate that the space is occupied; when indoor air quality parameters in the general exhaust are detected outside of prescribed bands; or some similar mechanism approved by FSU Utilities and EH&S is implemented.

<u>Fume Hoods</u>

- Fume hoods should be installed so that they will operate at an average face velocity between 90 and 100 fpm, single point readings between 80-120 fpm are acceptable. Variable Air Volume (VAV) hoods are preferred, Constant Air Volume (CAV) hoods may also be considered.
- Ductless fume hoods shall not be specified in lieu of a ducted fume hood and shall never be used for anything other than nuisance dust or odors.
- “High efficiency” type hoods that supposedly provide adequate containment at lower air flows or velocities have not proven to provide adequate containment within our typical campus environment at the lower ventilation rates prescribed by manufacturers. They have increased complexity and are more expensive, therefore EH&S recommends that these not be specified. If these are desired to be utilized, guarantees must be obtained from suppliers to ensure that future performance will remain adequate and future cost savings will be realized as an overall net benefit to FSU.

- After any new installation or major ventilation system repair work, the affected system fume hoods shall be tested in accordance with ASHRAE-110 (1995 or more current version). This testing shall be scheduled after all facility testing and balancing has been completed. The testing costs are expected to be paid by the fume hood supplier and shall be performed by a qualified and independent testing agent or company. Copies of all performed testing results (whether passed or failed) must be forwarded to EH&S along with the manufacturer's As-Manufactured (AM) testing results. If changes are made to the ventilation system after this testing is done which could be expected to affect fume hood performance, the ASHRAE-110 tests must be repeated. These hoods must pass the As-Installed (AI) testing criteria with tracer gas flow rates increased from 4.0 to 8.0 lpm and they shall not exceed an average release concentration of 0.05 ppm or exceed a peak concentration of 0.5 ppm. Any system modifications or upgrades necessary to achieve the AI ratings shall also be paid for by the fume hood supplier.
- Fume hoods shall be designed and manufactured in accordance with industry standards with chemically resistant materials. They should be able to contain small spills with some assurance that these will not cause degradation of the fume hood and shall be easy to decontaminate. Standard resins and composites that are currently utilized for construction of these units should be adequate. Stainless steel interiors are not required for the radioisotope work that is performed at FSU and shall not be specified for this purpose. Likewise, HEPA filtration, scrubbers or other special exhaust components should not be necessary for anything other than dedicated perchloric acid use hoods. Please consult with EH&S staff, if researchers report or design professionals feel that these types of additional criteria will be needed.
- Visual and audible low flow alarms shall be provided for each fume hood. These shall be calibrated when installed, visible to users at the hood, and have a means for the users to temporarily silence the alarm. They shall also be capable of set point adjustments by trained FSU Utilities personnel that have been provided any necessary equipment.

<u>Other Local Exhaust Devices</u>

- Gloveboxes, downdraft tables and other such equipment can be used effectively as adjuncts or replacements for chemical fume hoods. These shall be ducted to appropriate exhaust systems whenever ventilation is required to control hazardous emissions. Recirculation or filtration type devices shall not be specified unless they will only be utilized to control non-hazardous emissions.
- Snorkels, canopy hoods and other such ducted devices that cannot be sufficiently tested for containment performance shall not be installed with the intention of controlling hazardous exposures. These devices may be utilized for heat removal or the control of non-hazardous emissions.

Safety Showers and Eyewashes

- Install plumbed devices in sufficient locations for the anticipated use of the facility in accordance with ANSI Z358.1. In areas where chemicals may be expected to be handled in the future, but these devices are not currently specified, consider installing blanked tees on cold potable water lines under sinks to facilitate future installation of countertop mounted eyewashes.
- Self-contained safety shower or eyewash stations shall never be used in lieu of plumbed devices.
- These units are to be connected to cold potable water supply lines only. For typical indoor installations, hot water supplies and thermal mixing valves are not required and should not be

installed. The added complexity can negatively impact reliability without benefit in our Florida climate. Thermal mixing is not required by code.

- Plumb these devices such that they are not on the ends of long dead end branch lines or otherwise situated within the plumbing system to allow for stagnation of supplied potable water. This will aid in maintaining chlorination levels sufficiently high to inhibit growth of microorganisms that may be hazardous to users.
- Eyewash units shall have two nozzles, one for each eye. Do not install single nozzle drench hoses or other multiple nozzle devices.
- Safety shower and eyewash stations should be rugged and simple in their operation in order to promote ease of use and long-term reliability. Extra accessories such as alarms, floor mounted activator pedals attached with chains, eyewash bowl covers, etc. that do not enhance these properties should be avoided.
- The safety shower activator shall be installed so that it can be activated by a person standing directly under the spray from the shower head.
- Consideration should be given to flooring installed below this type of equipment to ensure that it will not pose an atypical slip hazard when wet.
- Do not hang any signage or posting that comes with this equipment, forward it to FSU EH&S personnel and they will ensure that appropriate signs are installed per current regulations.
- Drains do not need to be installed below these devices but are desired in most locations to assist with routine testing and cleanup after emergency activation. When floor drains are installed, they should be provided with self-priming traps. Do not install floor drains in chemical or hazardous waste storage rooms.

Other Plumbing Considerations

- No drains should be directed to the stormwater system except for stormwater runoff.
- All floor drains, except those for stormwater runoff, shall be directed to the sanitary sewage system, unless otherwise approved by the appropriate municipal authorities having jurisdiction.
- Sanitary sewage system drains installed in areas expected to be infrequently utilized shall have self-priming traps to prevent loss of the water seal due to evaporation.
- No holdup tanks are to be installed for any type of drainage collection.
- Acid neutralization tanks are not warranted. Neither are they required by federal or state laws; and they shall not be installed unless municipal Authorities Having jurisdiction mandate such installations in areas that are not covered under an existing Campus Master Plan or similar development agreement.
- Access ports should be provided for obtaining liquid samples of building effluents for each laboratory drain system installed in any new facility and when feasible for major renovations of existing facilities.
- At least one floor level sink or drain, plumbed to sanitary sewage, and capable of receiving fluids from floor cleaning machines or similar equipment, shall be installed in each facility within appropriate service areas such as the janitorial closets.
- Corrosion resistant piping shall be installed on drains originating from laboratory sinks or equipment in order to protect the initial portions of the waste system from degradation due to

trace chemicals that may be found during operations such as the routine washing of empty laboratory glassware. Minimize horizontal runs of downstream laboratory drains to prevent chemicals from pooling and/or upgrade the piping to protect them in a similar manner.

- Plumbing vents from laboratory drains should be directed to building roofs whenever possible. When installing alternative systems, ensure that all special adapters, such as air admittance valves, are rated appropriately for chemical and industrial use for the types of chemicals used within that laboratory or facility.

Biological Hazards

Biological Safety Laboratories, Levels 2 through 4 (BSL-2, 3, or 4)

- Eyewash stations shall be accessible to users within any BSL2, BSL3 or BSL4 facility, such that they do not have to leave the containment area in order to access them.
- Viewing windows shall be installed so that personnel working within BSL3 or 4 (optional for BSL2) containment areas can be observed by personnel outside of the containment area.
- Separate HEPA filtered exhaust shall be used in all BSL3 or 4 facilities to provide the negative pressure differentials required by the BMBL.
- BSL3 or 4 areas must have visual indication that a sufficiently negative relative pressure is being maintained. These indicators must be able to function without power.
- BSL3 or 4 facilities must be commissioned by a qualified and independent testing company or agent before use and annually thereafter.
- BSL2 facilities must be reviewed by the Biological Safety Officer before use and annually thereafter.

Biological Safety Cabinets

- Biological safety cabinets should be Class II Type A1 or A2 recirculating cabinets. They shall not be ducted or thimble connected to the building ventilation system and shall never be used to provide the negative pressure differential required within the containment area.
- If volatile or toxic chemicals will be used and a chemical BSC may be necessary for the project, please consult with the University Biological Safety Officer.
- These devices must be certified as part of the project and before use. Whoever purchased them is responsible for the cost of initial certification and any repairs or modifications that are required.
- Gas lines shall not be plumbed into any BSC.

Autoclaves

- Sufficient space should be provided around autoclaves to allow for easy service access to filters, drains, and exhausts.
- Safety valve discharge outlets must also be located so that they will drain and exhaust safely.
- Drain lines and joints shall be capable of withstanding temperatures and pressures that may be expected during operation of the autoclave.
- The autoclave room shall be of adequate size for the device and the resultant heat generated during its operation.

- Autoclaves should be tested after installation to ensure that they are working properly. The University Biological Safety Officer can assist by performing these tests or recommending a qualified and independent inspection agent or company.

Radiation Hazards

Any facility design involving the use of regulated ionizing (radioactive materials, x-ray machines or accelerators) or non-ionizing (LASERS, high magnetic fields, radio-frequency transmitters, etc.) radiation hazards shall be submitted for approval to the FSU Radiation Safety Office. The types, quantities, strengths and any other relevant data for the hazard(s) involved shall also be furnished. The RSO will specify the minimum controls necessary and will assist in obtaining any approval required from regulatory agencies. Specialty signage may be required; the Radiation Safety Office can provide some specialty signage for radiation hazards that have been identified or installed.

Flammable Liquids Storage

- Cabinets that are not permanently installed shall not be ventilated unless other options to control fugitive emissions are not feasible. If it is determined that ventilation will be necessary, the University Chemical or Laboratory Safety Officer should be consulted and all of the requirements of NFPA-30 and 45 shall be met.
- Bulk containers (larger than 10 gallons size) shall be kept out of laboratory areas. Large total quantities of chemicals should also be kept out of these areas. Where this type and quantity of chemical use is expected, provisions should be made to provide suitably designed storage areas near laboratory or use areas.
- Chemical storage rooms shall also meet the safety and environmental compliance requirements outlined for chemical waste storage areas as described in 40CFR (specifically 262.34 or 265.31,265.32a-c, and 265.176)

Corrosive Liquids Storage

- Provide sufficient space for the segregated storage of acid and base liquids with provisions made to allow separation of organic acids from mineral acids, as warranted based on quantities. As a general rule, if the chemical usage expectations are not identified, provide at least 2 cabinets (with 6 sq. ft. each of shelf space and capable of storing up to 4 liter size bottles) or an amount equivalent to one-third that which is provided for flammable storage, whichever is greater.
- Chemical storage cabinets for corrosives must be lined or constructed with chemically resistant materials.

Compressed Gases and Cryogenic Fluids

The specifications required by NFPA-55 shall be complied with and incorporated into all new designs and renovations. Particular attention should be given to the following historical problem areas to assist with code compliance by the ultimate users of the facility.

- Storage should be provided for one in-use and one spare cylinder of each type of gas needed within individual laboratory units. Permanently installed storage locations or spaces should be allocated that will allow securing individual cylinders out of high traffic areas that will not interfere with egress. Sufficient distance or fire-rated walls shall be provided to allow for segregation of non-compatible gases.

- When constructing piping systems from remote compressed gas or cryogen storage locations that are not entirely visible to users, ensure that piping is compatible with the gas that will be carried, is labeled at the ends and along the path identifying the gas or gas type being utilized, and is adequately protected.
- Most compressed gas cylinders are not owned by FSU. Vendors frequently deliver large shipments of these products to University exchange locations typically found by facility loading docks. Design professionals can help foster user safety by providing sufficient cylinder storage rack or cage capacity in these locations such that the cylinders:
    - Can be secured vertically
    - Are prevented from tipping or theft
    - Will not require more than four cylinders to be ganged together at one time
    - Are protected from direct sunlight, rain, pools or water, extreme temperatures or other such hazards
    - Are able to have non-compatible classes segregated by distance and/or fire rated walls
    - Are not stored near elevated surfaces greater than half of the shortest cylinder height or in any location that interferes with building egress or presents any unsafe condition

Noise Levels

Ensure that ambient laboratory noise levels emanating from installed systems and associated equipment will not preclude effective communication at normal voice levels. Generally, this means that 55 dBA throughout the area, or 60 dBA immediately adjacent to noisy equipment such as fume hoods, should not be exceeded. Simple measures such as the installation of flexible ducting to fans, sound isolation of ducts and motor mount attachments, proper location of HVAC equipment and the operation of systems within efficient load ranges should alleviate this potential concern.

Personal and Office Spaces

Space should be provided which is separate from laboratory work areas for students, staff and faculty to perform their non-laboratory duties. Break areas for eating and drinking should be provided in each facility and shall always be located outside of laboratories or other chemical storage areas.

If all laboratory work performed in the room is comprised of activities that carry a very low risk of exposure to hazardous materials, researchers may contact EH&S to determine if non-laboratory activities, including eating and drinking, may safely be conducted.

General Considerations

Accessibility

Teaching laboratories and other research spaces that are not used strictly as employee work areas shall be fully compliant with the Accessibility section of the Florida Building Code.

FSU considers research laboratories and spaces, which are not designated for general academic coursework or public assembly, to be work spaces. Beyond the basic requirement to provide accessibility for approach, entry and exit in these spaces, it is desirable to provide accessible laboratory work areas wherever this can reasonably be accomplished. Five percent, and at least one, of the laboratories within each building shall have a fully accessible laboratory work area including desks, benches, countertops, fume hoods, sinks, eyewash stations, safety showers and other equipment

necessary equipment, all collocated within the same vicinity. For teaching laboratories, this applies to each individual laboratory work area.

ADA fume hoods shall have 34" working surface heights, horizontal sliding sashes, adequate knee space and controls designed to allow for forward reach access by users. Specify base cabinets for chemical storage that are designed for this purpose, such as those with sliding drawers that are easy to move out of the knee space area.

Do not attempt to globally apply ADA design elements that might negatively impact all users. For instance, non-ADA fume hoods generally have standard 36" working surface heights and permanent base cabinets installed below them. Simply specifying 34" heights for these fume hoods with traditional vertical sliding sashes can require standing users to expose at least 2" more of their bodies or stoop, placing their faces closer to the opening, in order to reach into the fume hood. Assuming they meet the ADA side reach access requirements is also impractical because it necessitates awkward ergonomic body positioning. It is safer and more ideal to have a designated and fully functional ADA hood and work area available within a laboratory or building while ensuring other equipment remains ergonomic and equally functional for more typical users.

Do not use adjustable height tables to reposition fume hoods that would require flexible ducting to be utilized in lieu of welded stainless steel ductwork. This arrangement is more prone to flow perturbations that could cause loss of containment, is less resistant to chemical degradation and more susceptible to internal contaminant deposition.

A code compliant barrier free eyewash station must be provided near enough to accessible work areas that it can be reached in 10 seconds or less travel time. Avoid locating barrier free devices where they may be more prone to damage or may interfere with egress pathways due to their longer length profiles.

Laboratory Furnishing and Flooring

All laboratory work surfaces, including stools and chairs, must be non-porous and easy to clean and decontaminate. Permanent casework, countertops, and flooring must be rugged and chemically resistant to the products that will be used. The flooring shall be a non-pervious type to allow for spill containment and cleanup, such as seamless heat welded vinyl flooring, durable epoxy coatings, etc. Temporary flooring such as anti-fatigue should have similar properties with an emphasis placed on non-slip characteristics.

Ergonomics must be taken into consideration for all laboratory work stations. Countertop and fume hood depths should be limited, with equipment such as lattices (monkey-bars) installed and positioned such that personnel do not have to contact potentially contaminated surfaces or breathe hazardous emissions in order to adjust instruments or conduct their experiments. Knee space should be provided under bench tops so that chairs and stools can be used comfortably. All seated bench top work areas shall have marine edges (raised edges) or similar features to minimize the likelihood of accidental spills onto laboratory personnel. ADA compliant surfaces shall be recessed sufficiently and/or have sills or collection troughs that are able to contain at least two liters of liquids, more if there is a greater potential for larger size spills.

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duct silencers, sound isolation of duct and motor mount attachments, proper location of HVAC equipment and the operation of systems within efficient load ranges can help alleviate this concern.

Moving a Lab

Additional Information and Resources

- OSHA Standards
    - 29 CFR 1910.1000, Air Contaminants
    - 29 CFR 1910.1000 Table Z-1, Table Z-1 Limits for Air Contaminants
    - 29 CFR 1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories
    - 29 CFR 1910.1450 App A, National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)
    - 29 CFR 1910.1450 App B, References (Non-Mandatory)
    - Laboratory Ventilation
- Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) Standards
- Department of Health and Human Services, Centers for Disease Control and Prevention and National Institutes of Health - Biosafety in Microbiological and Biomedical Laboratories (BMBL)
- WHO Laboratory Biosafety, 3rd edition
- ANSI Z358.1—Emergency Eyewash and Shower Equipment (contact EH&S for copy)
- National Institutes of Health
    - https://www.orf.od.nih.gov/TechnicalResources/Pages/DesignRequirementsManual2016.aspx
- NFPA
    - NFPA 30—Flammable and Combustible Liquids Code (contact EH&S for copy)
    - NFPA 45—Fire Protection for Laboratories using Chemical: This standard applies to laboratories in which hazardous chemicals are handled or stored. (contact EH&S for copy)
- Resources:
    - CRC Handbook of Laboratory Safety, 5th ed. by A. K. Furr. Boca Raton, FL: CRC Press, 2000. Guidelines Laboratory Design: Health and Safety Considerations, 3rd Edition by Louis J. DiBerardinis, et al. New York, NY: John Wiley & Sons, Inc., 2001.
    - "Security and Safety in Laboratories" by Daniel Watch and Deepa Tolat (2010). National Institute of Building Sciences
    - Laboratories for the 21st Century (Labs21)—Sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Energy, Labs21 is a voluntary program dedicated to improving the environmental performance of U.S. laboratories.