Section 1.0: GENERAL REQUIREMENTS FOR STANFORD UNIVERSITY LABORATORIES

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A. Regulations, Standards and References

Regulations:

Federal Code of Regulations (CFR), Title 29, Labor

California Code of Regulations (CCR), Title 8, Cal/OSHA Standards

California Code of Regulations (CCR), Title 24, Part 9, Uniform Fire Code

California Code of Regulations, Title 24, Part 2, Uniform Building Code

CDC Select Agents, Title 42, Chapter I, Part 72 – Interstate Shipment of Etiologic Agents

National Fire Protection Association (NFPA) Handbook 70

National Electric Code

California Radiation Control Regulations, Title 17

Palo Alto Muncipal Code, Title 16, Building Regulations

County of Santa Clara Toxic Gas Ordinance No. NS-517.44

Consensus Standards and References:

American National Standard for Laboratory Ventilation (ANSI/AIHA Z9.5-1992)

American National Standard for Thermal Environmental Conditions for Human Occupancy (ANSI/ASHRAE 55-1992)

State of California, Department of Health Services, Radiologic Health Branch,

Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)(not formally adopted)

"Safe Handling of Radioactive Materials", National Council on Radiation Protection (NBS Handbook 92)

"Safe Handling of Radionuclides", International Atomic Energy Agency, Safety Series No. 1,

(1973 ed. is still current as of 1999) (IAEA)

CDC-NIH Biosafety in Microbiological and Biomedical Laboratories, 3rd Edition

Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines), January 1997

Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide, Federal Emergency Management Agency: FEMA-74, 1994

B. Scope

The primary objective in laboratory design is to provide a safe environment for laboratory personnel to conduct their work. A secondary objective is to allow for the maximum flexibility for safe research use. Undergraduate teaching laboratories require other specific design considerations. Therefore, all health and safety hazards must be anticipated and carefully evaluated so that protective measures can be incorporated into the design. *No matter how well designed a laboratory is, improper usage of its facilities will always defeat the engineered safety features. Proper education of the facility users is essential.*

The General Requirements listed in this section illustrate some of the basic health and safety elements to include in all new and remodeled laboratories at Stanford. Variations from these guidelines need approval from SU Environmental Health and Safety (EH&S). The subsections of Section 1.0 provide specific guidance on additional critical features of a general laboratory (e.g., fume hoods, hazardous materials storage, and compressed gases.)

C. Building Requirements

1. Designer Qualifications- The designer must have the appropriate professional license in his/her area of expertise.

   Good Practice

2. Building Occupancy Classification- Occupancy classification is to be based upon an assessment of a projected chemical inventory of the building. Prior to the final design, the campus fire safety organization will need to assign an occupancy class to insure compliance with the building codes.

   24 CCR, Part 2 (California Building Code)
   24 CCR, Part 9 (California Fire Code)

3. Environmental Permits- Project managers must consult with SU EH&S to identify permitting and pollution abatement engineering requirements for the building. This should be done well before key resource allocation decisions are made.

D. Building Design Issues

Note:

Because the handling and storage of hazardous materials inherently carries a higher risk of exposure and injury, it is important to segregate laboratory and non-laboratory activities. In an academic setting, the potential for students to need access to laboratory personnel, such as

instructors and assistants, is great. A greater degree of safety will result when nonlaboratory work and interaction is conducted in a space separated from the laboratory.

1. Special consideration should be given to the choice of fireproof construction for the buildings. The selection of the site shall be such to minimize the risk of landslide or flood damage.

   Safe Handling of Radionuclides 1973 Edition Section 3.3.1
   Good practice

2. Provide separate office spaces for laboratory employees.

   Prudent Practice in the Laboratory 4.E.2
   California Radioactive Material License, 0676-43
   Good Practice

   It is prohibited to store, consume food, apply make-up or chew gum in areas where hazardous materials are used and/or stored.

3. Public access to laboratory personnel in office rooms with separate corridor access is highly desirable.

   Prudent Practices in the Laboratory 1.D
   Good Practice

4. An automatically triggered main gas shutoff valve for the building shall be provided for use in a seismic event. In addition, interior manual shutoff valves shall be provided for both research and teaching areas.

   Good Practice

5. Large sections of glass shall be shatter resistant.

   Good Practice

   In the event of a severe earthquake, as the glass in cabinets and windows breaks, the shards need to be retained to prevent injury.

E. Laboratory Design Considerations

- ***Walls/Doors/Security***

  1. The laboratory shall be completely separated from outside areas (i.e., must be bound by four walls).

  California Radiation Control Regulations, Title 17
  State of California, Department of Health Services, Radiologic Health Branch,
  Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)

Having enclosed laboratories will help contain spills, keep unauthorized personnel from entering areas where hazardous operations are performed, etc. These regulations apply specifically to laboratories containing radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

2. The laboratory shall have means of securing specifically regulated materials such as DEA (Drug Enforcement Administration) controlled substances and CDC (Center for Diseases Control) select agents and radioactive materials (i.e., lockable doors, lockable cabinets, etc.).

CDC Select Agents
Controlled Substances Act, Section 803
California Radiation Control Regulations, Title 17
State of California, Department of Health Services, Radiologic Health Branch,
Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)

Having secured hazardous materials storage will keep unauthorized personnel from gaining access to them. These regulations apply specifically to laboratories containing radioactive materials and CDC Select Agents; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

- ***Windows***

3. If the laboratory has windows that open, they must be fitted with insect screens.

CDC-NIH Biosafety in Microbiological and Biomedical Laboratories (BSL 2, D.5)
Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines) App. G-II-B-4-e

Insects, particularly flies, are known to be a potential carrier of disease. To keep insects out of the lab, the doors must be closed while an experiment is in progress, and windows shall be screened if they are capable of being opened. These references apply specifically to laboratories containing biological materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

- ***Flooring***

4. The floor must be non-pervious, one piece, and with covings to the wall. This can be achieved by use of glue, heat welded vinyl flooring, epoxy coated concrete slab, etc.

NBS Handbook 92
IAEA, Safe Handling of Radionuclides
Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)

Floors should be coved up walls and cabinets to ensure spills cannot penetrate underneath floors/cabinets. Tiles and wooden planks are not appropriate because liquids can seep through the small gaps between them. These references apply specifically to laboratories containing biological and radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry, electronics, etc.).

5. Floors in storage areas for corrosive liquids shall be of liquid tight construction.

CCR, Title 24, Part 9, Sections 8003.1.7.2, 8003.14.1.2

- ***Sinks***

6. Each laboratory must contain a sink for handwashing.

CDC-NIH Biosafety in Microbiological and Biomedical Laboratories (BSL 2, D.1)
Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines) App. G-II-B-4-d
NBS Handbook 92
IAEA, Safe Handling of Radionuclides

Exposure to hazardous materials and/or pathogenic organisms can occur by hand-to-mouth transmission. It is extremely important that hands are washed prior to leaving the laboratory. For this very reason, the sink should be located close to the egress. These references apply specifically to laboratories containing biological and radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

7. Laboratory sinks shall have lips that protect sink drains from spills.

P.A. Ordinance. 16.09.032(b)(13)

Sink lips or berms should be >= 0.25 inches and designed to completely separate the lab bench or fume hood work area from the sink drain.

- ***Chemical/Waste Storage***

8. Chemical storage shelves shall not be placed above laboratory sinks.

P.A. Ordinance, 16.09.091

9. Sufficient space or facilities (e.g., storage cabinets with partitions) shall be provided so that incompatible chemicals/gases (waste and non-waste) can be physically separated and stored. This will be based on the chemical inventory and use projection provided by the Principal Investigator to the project and EH&S. If the project scope cannot provide sufficient storage the user must develop a written management control plan to include as part of their local Chemical Hygiene Plan.

Good Practice per Stanford University EH&S
CCR, Title 24, Part 9, Section 8001.9.8

Materials which in combination with other substances may cause a fire or explosion, or may liberate a flammable or poisonous gas, must be kept separate. When designing the shelves, it is important to factor in enough space for secondary containers. Recommend that solvent storage not be located under the laboratory fume hood, as this is a location

where fires are most likely to occur in laboratories.

All labs should be designed to conveniently and safely accommodate the temporary storage of biological, radiological, and chemicals (non-waste and waste) based on laboratory use projections. Wastes are generally stored in the lab in which they are generated, not in centralized accumulation areas.

- ***Furniture Design, Location, and Exit Paths***

10. All furniture must be sturdy. All work surfaces (e.g., bench tops and counters) must be impervious to the chemicals used. The counter top should incorporate a lip to help prevent run-off onto the floor.

NBS Handbook 92
IAEA, Safe Handling of Radionuclides
Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)
CDC-NIH Biosafety in Microbiological and Biomedical Laboratories (BSL 2, D.3)
Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines) App. G-II-B-4-b

For example, many microbiological manipulations involve concurrent use of chemical solvents such as formaldehyde, phenol, and ethanol as well as corrosives. The lab bench must be resistant to the chemical actions of these substances and disinfectants. Wooden bench tops are not appropriate because an unfinished wood surface can absorb liquids. Also, wood burns rapidly in the event of a fire. Fiberglass is inappropriate since it can degrade when strong disinfectants are applied. Fiberglass also releases toxic smoke when burned. These references apply specifically to laboratories containing biological and radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

11. Vented cabinets with electrical receptacles and sound insulation should be provided for the placement of individual vacuum pumps where their use is anticipated. A one- to two-inch hole for the vacuum line hose from the cabinet to the bench top should be provided.

Good Practice

12. The lab shall have a minimum aisle clearance of at least 24 inches. Main aisles used for emergency egress must have a clearance width of at least 36 inches.

CCR Title 8, 3272(b)
NFPA 45, Standard on Fire Protection for Laboratories

Clear aisles and exits are necessary to facilitate departure in the event of an emergency. In practice, lab aisles must be designed wider than 24" so that even with the presence of lab stools and other miscellaneous items, a clearance of 24" is always maintained.

13. A pathway clearance of 36 inches must be maintained at the face of the access/exit door.

Good Practice per Stanford University EH&S

Lab benches must not impede emergency access to an exit. This is also applicable to placement of other furniture and appliances such as chairs, stools, refrigerators, etc.

14. Designated storage space should be provided for lab carts. Location must not reduce width of corridors or aisles to less than code-required widths. Lab carts should be secured with earthquake restraints when not in use.

Good practice per Stanford University EH&S. see also information on "Earthquake Restraints" below.

15. Furniture design must comply with basic ergonomic specifications referenced in the SU Facilities Design and Construction Standards (Section 01310, Part A - 1.04)

Good Practice

Lack of properly designed workstations can increase safety and ergonomic risks for occupants.

16. Laboratory shelving should NOT be installed at heights and distances which require workers to reach 30 centimeters above shoulder height and extend arms greater than 30 centimeters while holding objects 16 kg or less when standing on the floor or on a 12" step stool.

ACGIH Threshold Limit Values for Chemicals Substances and Physical Agents & Biological Agents
Good practice per Stanford University EH&S.

Installation of high shelving, above laboratory benches in particular, can create several potential hazards, including, but not limited to ergonomic issues (over reaching above shoulders and across lab benches); spill and exposures to chemical, radiological or biological agents (e.g., dropping containers when accessing them at high levels). If high shelving were installed, administrative controls, which are often burdensome, would be required. A system for ensuring safe access would include prohibition on the materials stored on shelves, limitations on the frequency of use, availability of ladders or ladders stands, training on ladders, etc. (See also #15 and "Earthquake Restraint" information below.)

17. The space between adjacent workstations and laboratory benches should be 5 ft. or greater to provide ease of access. In a teaching laboratory, the desired spacing is 6 ft. Bench spacing shall be considered and included in specifications and plans.

Americans with Disabilities Act of 1990 (ADA)
Title I, "Employment," Sec. 101, "Definitions," 42 USC 12111 9(A)
Title III, "Public Accommodations and Services Operated by Private Entities," Sec. 303, New Construction and Alterations in Public Accommodations and Commercial Facilities," 42 USC 12183.
NFPA 45, Chapters 2 and 3

18. The laboratory doors shall be automatically self-closing. Such self-closing doors are to be able to be opened with a minimum of effort as to allow access and egress for physically challenged individuals.

24 CCR, Part 2, Chap. 10
24 CCR, Part 9 1007.4.4
Americans with Disabilities Act of 1990 (ADA)
Title III, "Public Accommodations and Services Operated by Private Entities," Sec. 303, New Construction and Alterations in Public Accommodations and Commercial Facilities," Pt. 36, App.A
Prudent Practices in the Laboratory, 5.C

19. Doors in H-occupancy laboratories shall have doors which swing in the direction of egress. Doors serving B-occupancy shall swing in the direction of egress if the occupant load is 50 or more. Where possible, all B-occupancy lab doors should swing out.

1997 California Building Code

Doors which swing in the direction of egress will facilitate occupant departures from laboratories during emergencies.

20. Lab desks should be located near exit ways and in the path of fresh make up air.

Good practice per Stanford University EH&S

Will ensure that, in the event of an emergency, employees working in "clean" areas (i.e., their desk) do not have to pass through more hazardous areas to exit the laboratory.

- ***Illumination***

21. Laboratory areas shall be provided adequate natural or artificial illumination to ensure sufficient visibility for operational safety.

NUREG 1556 Vol. 7 Appendix L
Safe Handling of Radionuclides, Section 3.3.5 (1973 ed.)
State of California, Department of Health Services, Radiologic Health Branch, Guide for the Preparation of Applications for Medical Programs (RH 2010 4/90)
Title 8, 3317, Illumination

- ***Earthquake Restraints***

22. All equipment requiring anchoring shall be anchored, supported and braced to the building structure in accordance with CCR Title 24, Part 2, Table 16A-O. For example, any equipment, including but not limited to, appliances and shelving that are 48 inches or higher and have the potential for falling over during an earthquake, shall be permanently braced or anchored to the wall and/or floor.

CCR, Title 24, Part 2, Table 16A-OCCR. Title 8, 3241

This practice keeps these items from falling in the event of an earthquake and assures that safety while exiting is not compromised.

23. **A channeled anchoring station for seismic bracing of equipment, named the Universal Restraining Bar, shall be installed along all bench top/counters in laboratories and other horizontal surfaces that house equipment. These bars shall be installed at the back edge of the bench to minimize bench space used. Examples and guidance are provided on the ProtectSU website protectsu.stanford.edu. This system will allow a bracing point for all bench top equipment and will provide standard bracing locations for all benchtop equipment. This bar allows for bracing of items in a way that allows them to be moved to another location when needed, and re-braced after moving. The bar should be adhered to the benchtop with very high bond adhesive so that no holes are drilled.**

ProtectSU, Stanford's Seismic Mitigation Initiative, protectsu.stanford.edu

24. **All shelves must have a passive restraining system to adequately prevent shelf contents from toppling over. Seismic shelf lips (3/4 inch or greater), sliding doors, or mesh nets are examples. The shelves themselves must be firmly fixed so they cannot be vibrated out of place and allow shelf contents to fall.**

Prudent Practices in the Laboratory (2011 edition), 3.B.1.4 and 5.E.2
Good Practice per Stanford University EH&S

Installation of seismic lips on shelving areas will prevent stored items from falling during a seismic event. For bookshelves, friction matting may be substituted upon consultation with EH&S.

25. **All equipment requiring anchoring, whether installed by a contractor or the University, shall be anchored, supported, and braced to the building structure in accordance with 24 CCR Part 2, Table 16A-O.**

CCR, Title 24, Part 2 Table 16A-O

26. **Cabinets must be equipped with positive locking door latches.**

FEMA, Reducing the Risks of Nonstructural Earthquake Damage

Examples include barrel bolts, safety hasps, and child proof locks. These latches will not allow the cabinet door to open unless the locking mechanism is triggered. Magnetic or pinch grip catches are not considered "positive locking" and hence should not be used.

- ***Cleanability***

27. **The laboratory shall be designed so that it can be easily cleaned. Bench tops must**

be a seamless one-piece design to prevent contamination. Laminate bench tops are not suitable. Penetrations for electrical, plumbing, and other considerations must be completely and permanently sealed. If the bench abuts a wall, it must be coved or have a backsplash against the wall. Walls should be painted with washable, hard non-porous paints.

CDC-NIH Biosafety in Microbiological and Biomedical Laboratories, (BSL 2, D.2)
Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines) App. G-II-B-4-a
NBS Handbook 92
IAEA, Safe Handling of Radionuclides

Wooden and wood finish walls or floors are not appropriate because they can absorb hazardous and/or potentially infectious material, particularly liquids, making decontamination/remediation virtually impossible. These references apply specifically to laboratories containing biological and radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

28. Spaces between benches, cabinets, and equipment must be accessible for cleaning and allow for servicing of equipment.

CDC-NIH Biosafety in Microbiological and Biomedical Laboratories (BSL 2, D.4)
Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines) App. G-II-B-4-c
NIH Biosafety in Microbiological and Biomedical Laboratories, BSL 2, D.4
NIH Guidelines for Research Involving Recombinant DNA Molecules, App. G11-B-4-c

Laboratory furniture must have smooth, non-porous surfaces so as to resist the absorption of liquids and the harsh effects of disinfectants. Furniture must not be positioned in such a manner that makes it difficult to clean spilled liquids or conduct routine maintenance. For example, positioning a Class II biosafety cabinet in a limited concave space might not allow the biosafety cabinet certifier to remove panels of the cabinet when recertifying the unit. These references apply specifically to laboratories containing biological and radioactive materials; however, Stanford University EH&S interprets this to include all laboratories (e.g., general chemistry and electronics).

- ***Breakrooms***

29. The design of the laboratory building must incorporate adequate additional facilities for food storage/consumption and personal hygiene tasks.

California Radioactive Material License, 0676-43
State of California, Department of Health Services, Radiologic Health Branch – DOHS 2010
Stanford University Radiation Safety Manual

Per 8 CCR 3368(b), 5193(d)(2), the storage and consumption of food, application of cosmetics or lip balm, or handling of contact lens in areas they may be contaminated by any toxic material or bloodborne pathogen is prohibited.

F. Mechanical Considerations

- ***Electrical***

30. Shall provide GFI protection to electrical receptacles above counter tops and within 6 feet of sinks. Receptacles that are not readily accessible or receptacles for appliances occupying dedicated space, which are cord-and-plug connected in accordance with NEC Section 400-7A(6-8), are exempted.

NFPA 70, Chapter 2, 210-8

31. The lab should be fitted with an adequate number of electrical outlets, which can accommodate electrical current requirements with an additional 20-40% capacity.

Good Practice per Stanford University

The lab may have several pieces of equipment, which require large amounts of electrical current. Such items include freezers, biosafety cabinets, centrifuges, and incubators. The room design must take into consideration concerns such as electrical demand prior to occupancy to avoid a potential power failure.

32. Circuit breakers should be located outside the lab, but not in rated corridors.

Good Practice per Stanford University EH&S

In the event of an emergency, the laboratory may be unsafe to enter. Hence, the circuit breakers for key electrical appliances should be located outside the lab. ICBO recommends not putting electrical panels in rated corridors.

- ***Plumbing***

33. Auxiliary valves for gas and vacuum lines should be located outside the lab.

Good Practice per Stanford University EH&S

In the event of an emergency, the laboratory may be unsafe to enter. Hence, the valves for gas and vacuum lines should be located outside the lab.

34. Flexible connections should be used for connecting gas and other plumbed utilities to any freestanding device, including but not limited to biosafety cabinets, incubators, and liquid nitrogen freezers. Flexible connections should be appropriate for the pressure requirements and should be constructed of material compatible with the transport gas. A shutoff valve should be located within sight of the connection and clearly marked.

Good Practice per Stanford University EH&S

Seismic activity may cause gas and other utility connections to break off. A flexible

connection will minimize this potential considerably.

35. Sink drains traps shall be transparent (e.g., made of glass) and easy to inspect or have drain plugs to facilitate mercury spill control.

P.A. Ordinance, 16.09.032(b)(14)

If mercury-containing products or compounds will not be used, an exemption may be requested in writing to; Stanford University Environmental Quality Manager, Stanford Utilities Department, Mail Code 7270.

36. Lab waste water lines shall be separate from domestic sewage, and a sampling point shall be installed in an easily accessible location outside the building.

P.A. Ordinance, 16.09.060

The sampling point shall be installed at a location where all building lab wastes are discharged, before the lab waste line connects to the domestic waste line. The sampling point shall be designed so that it is perpendicular to the lab waste line, has a minimum 4 inch diameter, has a cleanout screw on cap and is protected by a christie box. The sampling point should not be located in an area where water from irrigation or flow from stormwater runoff can accumulate.