Laboratory Design: Chemical and bio-research laboratories where hazardous materials will be handled or stored shall be designed to safely accommodate the research and/or instruction to be conducted therein. They shall be designed in compliance with all applicable federal, state and local codes and regulations, including the *Illinois Plumbing Code, OSHA Standard #29CFR1910.151, and ANSI Standard #Z358.1.* They shall also be designed in compliance with all of the requirements of these *University of Illinois at Urbana-Champaign Facilities Standards*. *Prudent Practices in the Laboratory*, and *Laboratory Design, Construction and Renovation-Participants, Process and Products* are recommended as additional sources of guidance on safety issues where regulations are not detailed regarding laboratory applications.

Special Review: New construction or remodeling that involves or impacts chemical or bio-research laboratories may require review by the Division of Research Safety (DRS) and the Division of Safety and Compliance.

Bio-Research Laboratories: Bio-research laboratories where pathogens, recombinant DNA materials, biotoxins, oncogenic viruses, or chemical carcinogens will be handled or stored shall be designed according to the level of risk associated with the research and/or instruction to be conducted therein, as classified by the Centers for Disease Control and Prevention (CDC), National Institutes of Health (NIH), and the National Cancer Institute (NCI). More information regarding design specifications can be obtained by consulting the most recent edition of *Biosafety in Microbiological and Biomedical Laboratories*, CDC/NIH (available online at http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm) and contacting DRS.

Risk Level: Prior to design, each bio-research laboratory shall be evaluated to determine which of the three following "risk level" classifications shall be applied. This determination shall be made with DRS concurrence:

1. Low Risk Research / Biosafety Level 1
2. Moderate Risk Research / Biosafety Level 2
3. High Risk Research / Biosafety Level 3

Low Risk Research / Biosafety Level 1: Conventional biological laboratory design requirements apply. Safety requirements for this classification are mostly procedural / operational. However, laboratory design shall provide controlled access and promote easy "cleanability". A hand-washing sink shall be present in the laboratory. Windows that open to the exterior shall be fitted with screens.

Moderate Risk Research / Biosafety Level 2: All design requirements for "Low Risk Research / Biosafety Level 1" apply. In addition to these requirements, any biological safety cabinets installed shall be appropriately placed. Also, the ventilation system that serves the laboratory shall maintain a negative air pressure within the lab relative to adjacent spaces, such that air flows into the lab from these spaces, not vice versa. A hand-washing sink and an eyewash shall be present in the laboratory. Doors shall be self-closing and have locks.

High Risk Research / Biosafety Level 3: All design requirements for "Moderate Risk Research / Biosafety Level 2" apply. In addition, compliance with all design / operational requirements shall be reviewed / tested, verified, and documented prior to placing the laboratory into service.

Each laboratory shall then be designed in compliance with the specific requirements for its risk level classification. For the design of any Moderate or High Risk / Biosafety Level 2 or 3 laboratories, the Biological Safety Section, DRS shall be consulted (333-2755 or bss@illinois.edu).

Hazardous Production Materials: DRS and Fire Safety and Code Compliance shall be consulted for facilities using "hazardous production materials" (HPMs) for semiconductor fabrication and comparable research. These facilities must comply with Article 9 of the latest edition of the Uniform Building Code concerning "Requirements for Group H Occupancies." For each proposed facility, the U of I will conduct a risk assessment which will evaluate the value in

decreasing the exemption quantities of HPMs and/or limiting the total quantities of HPMs permitted in any one facility, area or building.

Production, pre-manufacturing or Pilot Plant scale: Any research area that plans to run reactions larger than laboratory scale (up to 20L), or that will receive, use, or store ≥ 55 gallon containers of flammable solvents shall consult with DRS and Fire Safety / Code Compliance before operations commence.

Emergency Showers and Eyewash: Shall be installed inside all labs or areas where hazardous chemicals are used or stored. The installation shall meet the requirements of the applicable standards. See *Drawing 22 45 00-1, Emergency Eyewash & Safety Shower Installation* for proper installation requirements.

Emergency Power Off (EPO): An approved means shall be provided for emergency switching of any part of a laboratory electrical installation where it may be necessary to control the supply to remove unexpected danger. The arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger. The electrical circuits serving the bench top receptacles are an example of the areas to be covered by the EPO. The laboratory lighting and required exhaust systems shall not be disconnected by the EPO. The control for these disconnecting means shall be grouped and identified and shall be readily accessible at principle exit doors.

Ventilation: Chemical laboratories where hazardous materials will be handled or stored shall comply with all of the requirements of the current revision of the *American National Standard for Laboratory Ventilation (ANSI/AIAH Standard #Z9.5),* a publication of the American Industrial Hygiene Association. The air distribution system that serves each chemical laboratory shall be a "once through" system that supplies 100% outdoor air. Supply air quantities shall be as required to satisfy the temperature requirements or the makeup air requirements of each space, whichever is greater. When the supply air quantity that is required to serve a space is greater than the quantity of contaminated exhaust air (e.g. through fume hoods and storage cabinets), the difference shall be removed from the space through a "general exhaust" system. This system may be connected to the contaminated exhaust system to increase dilution and reduce corrosiveness within this system. The supply air diffusers / grilles that serve a laboratory shall be located / oriented such that supply airflow is introduced into the lab without creating turbulence at or near the face of any fume hood.

Humidity Control: Humidification / humidity control capability shall not be provided unless it is absolutely necessary. Most types of equipment in chemical laboratories have humidity requirements that are no more stringent than that of humans. The HVAC systems required to support humidification / humidity control consume large amounts of energy as compared to standard systems. If humidification capability is required, a dedicated HVAC system shall be provided.

Energy Conservation: The conditioning of outdoor air is the most significant energy consumer on campus. Therefore, exhaust airflow and associated outdoor air makeup airflow shall be minimized to conserve energy as feasible. Energy conservation by reduction of exhaust airflow and associated outdoor air makeup airflow shall not be applied to laboratories where regulated carcinogens, highly toxic chemicals, nanomaterials of unknown toxicity, or other compounds of unknown (and suspect) toxicity are used. Fume hoods and other equipment that require large quantities of exhaust / makeup air to support their proper operation shall be installed with discretion and restraint by not over-sizing the number of air changes and / or overestimating the quantity of hoods, outside air volume, and subsequently, cooling capacity needed now or for the future. Energy recovery systems shall be carefully considered, especially with respect to possible recirculation or bleed-over of hazardous components.

Fume Exhaust Systems: The laboratory fume hoods, chemical storage cabinets, etc.

within a building shall be served by one or more manifolded exhaust systems. Each manifolded system shall be served by a minimum of two exhaust fans, one of which is a 100% standby unit. Each exhaust fan shall be sized, configured and controlled such that full system design capacity is maintained when any one fan fails or is taken out of service. Isolation dampers shall be provided that allow each fan to be taken out of service for maintenance, repair or replacement while allowing the exhaust system to remain in operation at full capacity. A dedicated exhaust duct / discharge stack shall be provided downstream of each fume exhaust fan. Each fume exhaust stack shall be located and configured such that contaminated air is discharged vertically upward at an appropriate velocity (3,000 FPM minimum) and distance above the roof level of the building (10' minimum stack height) to prevent the recirculation of contaminated air back into an intake air opening. For more complicated, critical and/or larger scale applications, intensive studies and even scale model simulations shall be performed as required to ensure a design that minimizes fume exhaust reentrainment.

Exhaust Filtration: Final filtration shall not be installed in exhaust systems, with the possible exception of systems in which high-hazard biological contaminants or highly radioactive isotopes are used. In these cases, DRS shall be contacted for guidance.

Manifolded vs. Dedicated Systems: Chemical fumes from dissimilar service fume hoods, storage cabinets, etc, such as acid fumes, solvent vapors, and fumes may be exhausted through a common manifolded exhaust system as long as adequate dilution is achieved prior to the mixing of potentially reactive substances. Vapors from hoods in which highly concentrated volatile acids or radioactive isotopes are used at elevated temperatures shall not be exhausted through a common manifolded exhaust system that also serves other dissimilar service hoods without first obtaining approval from DRS and the Division of Safety and Compliance. The same is true of vapors from biological safety cabinets. Fume hoods in which perchloric acid, highly toxic vapors, or pyrophoric gases (i.e., gases that spontaneously ignite in air) are used shall always be served by a dedicated exhaust system with special features as appropriate (e.g., a scrubber or wash-down system). Contact the Division of Safety and Compliance for guidance. As required by *NFPA Standard #45*, any hood that is protected by a gaseous fire extinguishing system shall be provided with an independent duct system and a fan that is interlocked to shut down on actuation of the extinguishing system, or the protected hood shall be isolated by a damper actuated by the extinguishing system.

Chemical Fume Hoods and Other Laboratory Exhaust Systems: Chemical fume hoods and other laboratory exhaust systems shall be in compliance with the following requirements established by Safety and Compliance:

1. ASHRAE 110 "as-installed" testing shall be performed on all new installations and recommissioning (installation of new exhaust fan) of chemical fume hoods to verify containment.
2. Each perchloric acid fume hood and its associated exhaust system requires specialized design, which shall be in full compliance with chemical fume hood guidelines established by the Division of Safety and Compliance.
3. Lead shall not be contained in the materials of construction or paint of any fume hood or associated casework.
4. The design of "local" (i.e., point-of-use) exhaust systems shall conform to the recommendations provided within the latest edition of *"Industrial Ventilation"*, published by ACGIH.

Ductless Fume Hoods*:* Ductless fume hoods shall not be installed in laboratories as a substitute for a chemical fume hood or other local exhaust system to remove hazardous or flammable vapors from a laboratory.

Storage Cabinets: It is preferable that each flammable liquid (a.k.a. solvent) storage cabinet not be ventilated unless vapors from the solvents stored within the cabinet pose a hazard to the room occupants or to those who directly access the cabinet. If it is determined that a flammable liquid storage cabinet requires ventilation it may be vented

into a fume hood exhaust duct. A flammable liquid storage cabinet that is located under a fume hood shall not be vented into the fume hood above it. It shall be served by a dedicated exhaust duct which may be connected to the fume hood exhaust branch duct downstream (i.e., above) the fume hood. This is done to prevent a fire which begins in a fume hood (a relatively common occurrence) from propagating into a flammable-liquid storage cabinet that is directly vented into that fume hood. In such cases, the vent duct shall be constructed of the same material as the fume hood exhaust duct (i.e., welded type 316L stainless steel, 18 gauge minimum) and that provides no less fire protection than the cabinet itself. Additional detailed information regarding flammable liquid storage cabinets can be obtained from DRS. Each cabinet that is not designed for the storage of flammable liquids but that requires venting in order to minimize odors from stored chemicals may also be vented into a fume hood exhaust duct. In such cases the vent duct may be constructed of either the same material as the fume hood exhaust duct or of rigid plastic piping (e.g., PVC).

Odor Control: Air distribution systems that serve chemical laboratories shall be designed so as to minimize odor and airborne contamination problems. This can be accomplished to a large extent by maintaining appropriate relative air pressurization between each laboratory and the adjacent corridor and between the corridor system and any adjacent non-laboratory area. For non-critical applications, this shall be accomplished by means of static air balancing of the air distribution system(s) serving these areas. For more critical applications, where more positive differential pressure control is required, a more sophisticated pressure differential control system may be utilized.

Flexible Design: Each chemical laboratory shall be designed / configured so as to maximize future flexibility of usage. For example, consideration shall be given to bring all utilities that may be needed in the future into the lab, either overhead above the ceiling or in the utility service area between the benches (or in a utility chase) with the appropriate capping (and valves when necessary) during initial construction / remodeling.

Compatible Construction: The finishes, cabinetry, fixtures, etc, used in each laboratory shall be compatible with the use of the lab (including the specific chemicals to be used within the lab).

Casework: All casework work surfaces within a chemical laboratory shall be of acid resistant construction even if the use of acids is not immediately anticipated. All casework shall incorporate sufficient utility space and provision for access to utilities to facilitate maintenance. Casework located adjacent to exterior walls shall also incorporate adequate access to perimeter heating units and utilities.

Flooring: Special flooring shall be installed as required to provide appropriate chemical resistance and/or waterproofing.

Electrical: All receptacles located on or in a fume hood or storage cabinet shall have Ground-Fault Circuit protection.

Voice / Data Jacks: Voice / data jacks shall be installed in appropriate numbers and locations in each chemical laboratory.

UPS: Consideration shall be given to providing a UPS to serve individual or multiple lab(s) as required to serve specialty laboratory equipment.

Sterilizing Equipment: Glassware washers and other sterilizing equipment that release concentrated heat and humidity shall be provided with an exhaust system and associated makeup air system that is designed to quickly remove the heat and humidity that is intermittently released by this type of equipment. A direct duct connection shall be made between each unit and an exhaust system that is designed to handle supersaturated exhaust airflow and is dedicated to such applications. If a unit is not designed for a direct duct connection, a canopy or capture type exhaust hood shall be provided. Where applicable, the exhaust system shall operate only for an appropriate length of time after the completion of each wash cycle. Special consideration shall be given to providing waterproof / humidity-

resistant construction in areas that house this type of equipment.

Paper Towel Cabinets: C-fold paper towel cabinets that satisfy the requirements of *Technical Section 10 20 01 – Laboratory Accessories* shall be installed in appropriate numbers and locations in each chemical laboratory. The campus has standardized on a single make and model to be installed within all buildings. This prevents the unnecessary purchase and stocking of unique supply items to accommodate various styles of dispensers. C-fold type paper towel cabinets shall be installed in laboratories and roll type paper towel dispensers shall be installed in restrooms.

Laser Laboratories: Spaces designed for use of Class 3b or Class 4 laser systems shall include the following engineering controls: (1) visible warning lights that are illuminated when the laser system(s) are energized; (2) baffles, partition walls, or other barriers that prevent the laser radiation from leaving the laser controlled areas (as an alternative, interlocks may be installed on entrances to the laser control area that will interrupt the laser beam when the door is opened); (3) remote firing locations and/or viewing systems when practicable.

Maintenance Responsibility: Maintenance of chemical laboratories, including furnishings, equipment and the systems that serve them will not be provided by the F&S Division, but will be the responsibility of the using department / campus unit.

Communications: Voice and data outlets shall be provided for all laboratories. Power outlets shall also be provided at each communication outlet. The location of the communication outlets shall be coordinated with the furniture and casework plans. A permanent wire management system shall be incorporated within the furniture. Consideration shall be given to installing wireless access connections.