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. They shall also be designed in compliance with all of the requirements of these Design Guidelines.
All “wet” labs, including any laboratory space containing fume hood(s), gas storage and delivery systems, or the potential for the use of hazardous materials, chemicals or gasses, shall be design to meet, at minimum, NFPA 45 Class “B” construction requirements.
All labs and/or workrooms that are equipped with natural gas delivery systems, regardless of the number of outlets, shall be equipped with an emergency shut off valve located adjacent to an exit from the area.
Break areas and office desks are to be physically segregated from laboratory spaces. (No desks in the back of the lab.)

An emergency shower and eyewash station shall be located within 10 seconds of every chemical fume hood. This must be a direct pathway with no equipment or doors blocking the path and no changes in elevation.

A floor drain shall be installed near emergency showers to allow the water to drain in a controlled manner. Permanently plumbed eyewash stations shall be plumbed to a drain. Both of these measures will help facilitate the compliance requirement of weekly (eyewash) and monthly (emergency shower) required operational tests and they will reduce potential slip hazards.

At a minimum, a continuously mechanically ventilated gas cabinet is required for the following gases in cylinders that exceed a lecture-bottle sizes:

Gases that have health hazard ratings of 3 or 4.

Gases that have a health hazard rating of 2 without physiological warning properties

Pyrophoric gases.

Flammable storage cabinets will not be vented (unless it is a fume hood base cabinet designed as flammable liquid storage and it is vented with the hood.)

Proper storage areas for compressed gas cylinders will be located away from exits and the restraining brackets should accommodate the different heights of the cylinders that are planned for use in that area.

Each laboratory shall be evaluated for catastrophe potential in terms of the maximum credible accident, involving the properties of the chemicals used and the nature of the operations. Examples of such a catastrophe would be:

- Explosion.
- Violent ejection of life-threatening chemicals into the room.
- Overheating of the exhaust duct.

If it is determined a definite potential for catastrophe is present, special designs to prevent or limit the consequences shall be implemented. Examples of such provisions would be:

- Special hood design.
- Fire or explosion suppression systems.
- Redundant-installed spare exhaust blowers.

- Emergency power supply.

If flammable or hazardous materials are to be dispensed in storage areas from storage containers to smaller containers, the ventilation rates mentioned herein and in ANSI\NFPA 30 might not be adequate. If the amount and frequency of dispensing is sufficient to exceed these requirements, special exhaust hoods shall be provided. If flammable gas, vapor, or combustible dust is present in concentrations above 20% of the Lower Flammable Limit, the fan construction shall be as recommended by AMCA's Classification for Spark Resistant Construction

HVAC Systems, Noise Criteria: All spaces shall meet current ASHRAE Recommended Guidelines for Background Sound in Rooms. (See 2007 ASHRAE Handbook, HVAC Applications, Chapter 47, Table 42.)

Special Review: New construction or remodeling that involves or impacts chemical or bio-research laboratories shall be reviewed and approved by University of Nebraska- Lincoln Environmental Health and Safety (UNL EHS)

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 UNL EHS 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.

Hazardous Production Materials: UNL EHS, UNL Building Code Authority and the State Fire Marshal shall be consulted for facilities using "hazardous production materials" (HPMs) for semiconductor fabrication and comparable research. These facilities must comply with all applicable codes and building safety standards.
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 _containers of flammable solvents shall consult with UNL EHS, the UNL Code Official and the State Fire Marshal before operations commence.

Emergency Showers and Eyewash: Shall be installed in all labs or areas where hazardous chemicals are used or stored. The installation shall meet the requirements of the applicable standards. Floor drains shall be installed under emergency showers.

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. Laboratories shall be designed to be the most energy efficient possible, and air change rates (ACH) shall meet ANSI Standards.

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. Contaminated ductwork, and general exhaust ductwork connected to contaminated ductwork shall be constructed of stainless steel unless alternate materials are approved by UNL EHS, UNL Code Authority and UNL Maintenance. In laboratories where corrosive gasses are vented, a careful review of the appropriateness of ductwork material is required.

Generally laboratory areas shall be maintained at a negative pressure relative to corridors and non-laboratory areas. One possible exception to this criteria is a "clean laboratory" where the processes conducted in the laboratory are not hazardous and where the laboratory must be kept free of uncontrolled contamination.

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 above work zones) to prevent the recirculation of contaminated air back into an intake air opening. The exit velocity from ductwork located on the building roof shall be a minimum of 3,000 feet per minute directed straight up from the exhaust duct or stack for a stack without internal condensation; or a discharge velocity of 2,000 feet per minute or less if internal condensation might occur. 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 re-entrainment.

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, UNL EHS shall be contacted for guidance.

Manifolded vs. Dedicated Systems: Exhaust ducts from two or more hoods may be connected to an exhaust manifold, frequently to avoid a multiplicity of small stacks on the roof of the building or to reduce the pipe chase that would be required in a multi-story laboratory. Such manifolds shall be provided with an exhaust fan or fans and be maintained under negative pressure. The manifold shall be designed as a plenum (i.e. the suction at any point in the manifold will be reasonably constant regardless of the flow into it from individual hoods).Chemical fumes from dissimilar service fume hoods, storage cabinets, etc, such as acid fumes, solvent vapors, and fumes from radioisotope sources shall not be exhausted through a common manifolded-exhaust system without first obtaining approval from UNL EHS, the UNL code Authority and the State Fire Marshal. Exhaust streams that might form explosive compounds, or reaction products that will condense on the walls of the manifold or combine to produce compounds of significantly higher toxicity or lower odor thresholds, shall not be combined into one manifold.. The same is true of vapors from biological safety cabinets. Each fume hood in which perchloric acid is used or stored shall always be served by a dedicated exhaust system with special features as appropriate (e.g. a water wash-down system). Contact the UNL EHS for guidance. 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). 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

Unless the use of all laboratory exhaust hoods connected to a manifold can be stopped completely without creating a hazardous situation, provision shall be made for continuous maintenance of adequate suction in the manifold. This requirement could be satisfied by providing:

- An installed spare manifold exhaust fan that can be put into service rapidly by energizing its motor and switching a damper.

- Emergency power to the manifold exhaust fans.

- Alternative methods of maintaining manifold suction may be utilized, subject to the approval of the Owner's representative.

Chemical Fume Hoods: Chemical fume hoods and their associated exhaust systems shall be in compliance with the following requirements:

1. Fume hood flow rates shall conform to applicable standards and UNL Environmental Health and Safety acceptable guidelines based on type of use. For hoods requiring a face velocity of 100 feet per minute, a maximum duct velocity of 1600 feet per minute shall be provided through ductwork up to the exhaust valves.
2. Utilize one fan of the industrial unitary type (preassembled package unit) for each fume hood. Manifold systems are to be considered as an option for high density lab fume hood applications, except for perchloric hoods. Properly designed variable volume systems are encouraged. Prior approval of manifold systems and variable volume systems by UNL representatives is required. Energy recovery will be required when manifold systems are installed. Fume hoods and their associated base cabinets or stands shall be designed and specified as part of the mechanical designer’s responsibility.
3. Fume hood fan and motor sheaves shall be the continuously adjustable type. Fume hoods shall be provided from the factory without air flow indicator and shall be field fitted with air flow indicator and controls as designed and installed by UNL BSM, unless the air flow indicator is integral to the operation of the fume hood. Fans and air movers shall be selected to provide design flow rates in the hood and duct system. Fan wheels and housings shall be constructed of materials compatible with chemicals being transported in the air through the fan. Types of fans suitable for exhaust systems are flat blade and backwardly curved blade centrifugal.
4. Designer shall coordinate fume hood design with UNL BSM representative.
5. Laboratory ventilation ductwork shall be designed to comply with appropriate Sheet Metal and Air Conditioning Contractor's National Association (SMACNA) standards. Exhaust ductwork shall be designed in accordance with ANSI Z9.2 and the ASHRAE Fundamentals handbook.
6. Small labs or alcoves with hoods shall have make-up air distributed through radial flow diffuser(s) to prevent air velocity disturbance of hood capture.
7. Exhaust fans shall be located outside the building housing the laboratory or in a separate room that is maintained at negative pressure to the rest of the building and provides direct access to the outside for fan discharge ducts. (NOTE: This requirement responds to the fact that, under some operating conditions, centrifugal fans leak small amounts of system gases at the fan shaft hole. Shaft seals are available but are expensive or require frequent maintenance. Fan discharge ducts typically are under positive pressure, therefore, any leakage would be into the area housing the fans.)

8. Provisions shall be included in the system design to notify the user and/or the UNL maintenance staff when a chemical fume hood is not functioning. Remote alarms, where specified, shall be through a dry contact and wired to the nearest mechanical space and terminated on a terminal block for future connection to an annunciation panel.
9. The system shall be energy-efficient within the design criteria.
10. Fume hoods with built-in exhaust fans are not allowed. When relocating or remodeling fan-enclosed fume hoods, they shall be removed and replaced.
11. Direct pressurization controls, which use a sensor to control the pressure differential, are not acceptable. Volumetric tracking, using a constant offset of 100 CFM per fume hood, between supply and exhaust is desirable and predictable.
12. Emergency eyewash and safety shower facilities shall be located inside the laboratory and installed in accordance with the applicable edition of ANSI Z-358.1. See *Drawing 22 45 00-1, Emergency Eyewash & Safety Shower Installation* for proper installation requirements.
13. Each perchloric acid fume hood and its associated exhaust system requires specialized design reviewed and approved by UNL EHS.
14. Lead shall not be contained in the materials of construction or paint of any fume hood or associated casework.
15. 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.

Biological Safety Cabinets: Class II Type A1 and A2 biological safety cabinets may be served by a manifold or dedicated laboratory exhaust system through a canopy connection.

Class II Type B1 and B2 biological safety cabinets shall be served by individual fans and dedicated exhaust ducting.

Ductwork shall run undiminished in size from the cabinet collar to the air valve.

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 UNL EHS. 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.

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.

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 UNL FMP 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.