23 00 10_12 Lab Ventilation Systems - Revision Request

Delete the following current section 23 00 10.12 in its entirety (deletions are shown struck through).

.12 Laboratory Ventilation Systems

~~A. General:~~

~~1. Comply with other general requirements of Section 23 00 10.~~

~~2. Ensure needs of scientific research and life safety are satisfactorily met.~~

~~a. Review all design parameters with the scientific staff and PSU Environmental Health and Safety.~~

~~b. Establish the desirable operating conditions (temperature, humidity, rate of change, pressure relationships, air quality) and determine limits that should not be exceeded. These characteristics shall be clearly defined in the construction documents so contractors, Commissioning Agency and operating staff clearly understand intent and initial settings on room-by-room basis.~~

~~c. For areas requiring variable temperature or humidity, these parameters must be carefully reviewed with the users to establish a clear understanding of expected operating conditions and system performance.~~

~~d. Determine need for standby equipment and emergency power to achieve system reliability and life safety.~~ ~~***Note: In general, EH&S recommends that ventilation systems (exhaust and adequate makeup) serving fume hoods be on emergency power. A major concern is about toxic gas and flammable vapor build-up in the event of a power outage. This has already caused a fire on campus. However, it is not an absolute requirement for all cases. Each project specific application shall be assessed among the scientific staff, EH&S and the capabilities of and/or implications to the electrical infrastructure.***~~

~~e. Determine and define alarming requirements.~~

~~3. Operable window systems are prohibited for use in laboratory spaces due to loss of proper pressurization control in the facility.~~

~~a. Operable windows in fully conditioned, pressure controlled laboratory spaces have the potential to cause serious life safety and energy issues, as well has having a negative impact on research. All laboratory air should be controlled and discharged in a safe manner. Operable windows inhibit our ability to achieve that goal.~~

~~b. Life Safety Issues:~~

~~1. Random crossflows (drafts) in a space, created by wind, adversely affect a hood's ability to capture, resulting in an unsafe working environment.~~

~~2. A windward (positively pressurized) opening in a laboratory space has the potential to over-pressurize an individual room, reversing pressures and forcing laboratory air into the egress~~

corridor in lieu of being safely managed and exhausted at the designated discharge points.

3. A leeward open window can draw a significant quantity of air out of a lab. This causes multiple issues: reduced hood capture, "stealing" of pressurization air through one location which causes adjacent labs to be positive in respect to the corridor, and affecting pedestrians outside the building.

c. Energy Consequences:

1. Air in or out of a window reduces the energy recovery capability of the exhaust system.
2. A window left open might (and often does) arbitrarily drive the HVAC system to extremes, increasing energy usages, and potentially adversely affecting adjacent spaces.
3. Window seals break down over time, leading to leakage and comfort issues.

d. Research - Loss of controlled conditions:

1. HEPA filters installed in most research AHUs filter to 99%, catching viruses, bacteria and pollen. An open window allows all these things into the airspace, completely circumventing the filtration system, and essentially corrupting all research in the space.
2. Accurate temperature and humidity control cannot operate properly with a "rogue zone". Therefore, systems may not be able to operate within the user's tolerances for temperature and humidity.
3. Humidity cannot be controlled with an open window. Vapor pressure will always equalize, and quickly, regardless of wind directions.

4. Mechanical infrastructure serving laboratory spaces shall be flexible and adaptable.

a. Research objectives frequently require changes in laboratory operations and programs. Thus, laboratories must be flexible and adaptable, able to accomodate these changes without significant modifications to the infrastructure.

b. Therefore the utilities and distribution infrastructure system design shall be flexible enough to supply ample cooling to support the addition of heat producing equipment without requiring modifications to the central HVAC system.

c. Adaptable designs shall allow programmatic research changes that require modifications to the laboratory's infrastructure within the limits of the individual laboratory area and/or interstitial and utility corridors.

5. Design Professionals shall include plans in the construction set of drawings showing simplifieid pressure relationships and tabular summaries of overall air balance for each pressure controlled space and summaries of system airflows.

a. These plans shall be the basic floor plan (clearly identifying all room names/use-not just mumbers) with easily recognizable tags for any room that is not neutral pressurization. The tag would indicate airflow direction (e.g. + or - or POS and NEG) and airflow (cfm).

b. The drawing would also have a table indication system level summaries of airflows per floor. (i.e. System SA(max/min), General Exhaust, Transfer Air (including intended source - adjacent system), and any other special exhaust systems.

c. The purpose is to have easy to follow summaries to help everybody involved understand the design intent during all phases of the project and for the record set for future operation and maintenance reference. Showing transfer air on a complicated duct drawing does not work well. The concept is similar to having simple Life Safety Plans for accurate and quick understanding.

B. Codes, Standards and Guidelines:

1. In addition to minimum requirements of the Building Code, laboratory ventilation systems shall be designed in accordance with the followng current editions of industry standards and design guidelines.

   a. The basic design of laboratory spaces shall be in accordance with the guidelines in the current edition of the **ASHRAE Applications Handbook** including, but not necessarily limited to, the chapters for Educational Facilities and Laboratories.

   b. Comply with ANSI/AIHA Z9.5-(current) Laboratory Ventilation.

2. Other Laboratory Design Resources:

   a. National Institute of Building Sciences (NIBS) - Whole Building Design Guide - Research Facilities

   b. A **Design Guide for Energy-Efficient Research Laboratories** - Version 4.0, http://ateam.lbl.gov/Design-Guide/Index.htm

C. PSU Environmental Health and Safety Requirements:

1. ***NOTE – Part C. is Under Revision:***

2. ***For any project scope that includes new or renovated laboratory ventilation systems, consult EH&S for requirements and guidance, including but not necessarily limited to:***

   Design Phase Collaboration

   Hazard/Risk Assessments

   Operating parameters and testing criteria for fume hoods and other containment devices

3. ***EH&S Office Phone: 814-865-6391***

D. Energy Saving Strategies and OPP Preferences:

1. Laboratory spaces typically use far more energy and water than most typical office or classroom spaces. Therefore, as part of meeting the Performance Requirements and Sustainability goals of the University, careful attention must be given to the design, construction and continued operation of Laboratory spaces. Refer to the U.S. EPA and DOE sponsored Labs for the 21st Century (Labs21) Tool Kit, including the Best Practices Guides. Apply them to best fit each specific project scope giving consideration to the University's local operating staff to achieve high performance and the lowest long term total life cycle costs.

2. Be careful to define and segregate non-hazard type spaces (i.e. offices, non-lab workspaces, classroom-use "teaching labs" or "dry labs" – those that contain primarily physics and/or electronic equipment) that could otherwise be recirculated because they do not have hazardous or noxious contaminants and thus do not require fume hoods from actual "wet lab" spaces that do have requirements for fume hoods that require 100% exhaust and 100% outside air makeup.
3. Maintaining the proper pressure relationships for laboratory spaces shall not require the continuous operation of mechanical systems serving non-laboratory spaces when they could otherwise be scheduled off during unoccupied periods. For instance, an air handling system serving adjacent regular office spaces and/or corridors shall not be required to run 24/7/365 in order to provide makeup /transfer air into the lab spaces. That does not preclude the mutually beneficial transfer of air when it can be used beneficially during shared occupied periods. Rather, it may require alternately serving the transfer zone/corridor with the lab system makeup air during unoccupied periods.
4. The architectural and engineering design of labs shall segregate equipment and process cooling loads wherever possible from the ventilation requirements so that the heat gain from the equipment can be cooled separately with process cooling systems and/or recirculating space cooling equipment in lieu of 100% makeup air systems. Consult with scientific staff to inform and guide them to select water-cooled process equipment in lieu of air-cooled units that reject heat to lab space whenever possible.
5. Work with representatives of scientific staff to minimize use of hoods while still meeting their needs. Eliminate/decommission unnecessary existing hoods wherever practical. Use local / snorkel exhaust devices strategically to capture applicable noxious, non-hazardous odors as close to source as possible to maintain overall high indoor air quality while keeping general lab ventilation rates as low as practical.
6. The design of lab ventilation and fume hood systems shall be carefully integrated to strive to continuously and optimally match the general minimum ventilation rates (during occupied and unoccupied periods wherever applicable) and specific exhaust hood and makeup air and pressure relationships needed to maintain a healthy and safe work environment for the occupants. Refer to Labs 21 Best Practice Guides Optimizing Laboratory Ventilation Rates.
7. Apply variable air volume to exhaust and supply air makeup systems to the fullest extent practical within the project constraints.
   a. When considering fume exhaust systems and related equipment or changes to an existing system, the designer should first consider whether the labs served are fume hood driven or air change driven with respect to airflow. There may be little or no energy saving advantage for applying low flow hoods in a lab that is driven by minimum air change rates.
   b. Also, consider whether the project specific location will have the commitment to have the adequate training and staff available to keep more sophisticated systems operating as designed.
   c. Applying variable geometry discharge dampers to fume hood exhaust fans can be a value-added option that allows modulating the fan speed

to control exhaust duct static pressure and to maintain constant stack velocity / effective plume discharge height rather than requiring modulating a bypass damper on a constant speed fan assembly. This technology should be evaluated and applied where it offers the lowest life cycle cost. Consider developing as an additional energy conservation measure alternate bid option with an estimated payback analysis as appropriate.

8. Apply space occupancy sensors to achieve demand based minimum ventilation strategies applicable to laboratories. Disable in control settings of individual lab spaces defined to not allow reductions due to risk type.
9. In applications with multiple exhaust devices, generally connect into a common manifold exhaust system with the recommended better multiple fan lead/lag/standby assembly (3 fans each @ 50% maximum capacity) to achieve the benefits listed below (see Labs 21 Toolkit, Manifolding Laboratory Exhaust Systems):
    a. Ability to take advantage of exhaust system diversity and fume dilution
    b. Ability to provide a redundant exhaust system by adding one spare fan per manifold and thus increasing personnel safety (lab user's and maintenance staff)
    c. Opportunity for energy recovery
    d. Design Flexibility and adaptability
    e. Fewer pieces of equipment to operate and maintain
    f. Centralized locations for exhaust discharge
    g. Fewer roof penetrations and exhaust stacks
    h. Lower ductwork cost
10. Laboratory exhaust air systems shall be designed to minimize pressure drops through each component, fitting, and the total system to minimize associated fan energy. This is especially important for manifolded systems. Refer to Labs 21 Best Practice Guides Low-Pressure-Drop HVAC Design for Laboratories.
    a. Review and optimize exhaust device selection for lowest pressure drop with lab consultant (as applicable). Be careful to not allow hoods or snorkels with high individual pressure drops that end up causing the whole system to have to operate at the higher pressure, which can have a huge impact on the fan energy.
    b. Minimize length of duct runs and number of elbows, transitions, fittings and abrupt changes and combinations of all of the above that contribute to high pressure drops.
11. Apply Air to Air Energy Recovery equipment in safest and most cost-effective manner:
    a. General lab exhaust: Enthalpy wheels are typically recommended to maximize total energy recovery from non-contaminated/non-hazardous general lab exhaust airstreams. Non-recirculated air drawn from general lab spaces (not through fume hoods) may be treated as spill/relief air in the sense that regular VAV exhaust fans and discharge louvers at normal velocities located far enough away from other intakes are acceptable and preferred rather than forcing all that air through the more energy-intensive high-plume type fume hood exhaust fans.

b. Fume Hood Exhaust: In general, in teaching or research laboratories with fume exhaust devices manifolded together, the concentration levels of potentially hazardous materials at the main header/discharge point are typically below the threshold that the Mechanical Code would prohibit the application of heat recovery. Therefore, Glycol Runaround coil systems (in separated airstreams so no chance of cross contamination) are recommended where applicable and cost effective depending on capacity and frequency of use. All associated aspects of the design and construction shall include special emphasis for specifying materials of construction of coils and filters/housing and provisions for safe inspection, cleaning and maintenance of these systems.

c. Any special purpose containment devices dedicated to toxic or flammable hazardous exhaust systems classified as such, shall be prohibited from applying heat recovery, per the Mechanical Code.

d. Air Filtration: Appropriate particle filtration shall be included at the entering sides of all air to air heat recovery equipment to keep surfaces free of dirt and debris to extend cleaning periods as long as practical. Filter housings shall be convenient and safe to routinely access to inspect and change filters.

E. Laboratory fume hoods:

1. Shall be the current state of the art, high-performance designs to achieve optimal fume capture with minimal airflow requirements. This requirement shall supersede other, older references in 11 53 13 Laboratory Fume Hoods to constant volume, bypass type hoods until that section is updated in the future.
2. Generally, in applications with multiple hoods, fume hoods shall be variable air flow type, based on sash position. Some exceptions may apply but review with OPP Engineering Services and EH&S.
3. The operating mechanisms for vertical and horizontal sashes shall be high quality and well-engineered so the sashes can easily be adjusted by users.
    a. Hoods with poor quality cables, pulleys, and sliding mechanisms that allow the sashes to bind up and require a lot of effort to move them are prohibited. If such conditions are encountered on a project, hoods must be repaired or replaced at no additional cost to the University.
4. The sash positioners should be "non-contact" type for reliable long service life when using VAV hood systems.
    a. Variable resistance pressure activated type shall be prohibited.
5. Specify protective screens at lower exhaust inlets of fume hoods to prevent pulling debris such as paper towels or lab wipes into the exhaust system and cause clogging problems on VAV airflow stations, duct turning vanes and fan blades.
    a. Recommending something like 1/2"x1/2" stainless steel welded wire mesh covering inlet slots that would be prone to sucking in materials from the working surfaces within the hood. This would be preferable as a factory-installed option for best fit and finish.
6. Consider proximity occupancy sensors at each hood that could allow reduced airflows when nobody is working in front of the hood. Review with EH&S.
7. If the hood is VAV then some device measures the face area for air flow control. Not all hood face velocity monitor/alarms are equal. In the VAV case

~~the face velocity monitor/alarm can use that info and other control data to report FPM and alarms. If a constant volume hood, then the face velocity monitor/alarm is typically a stand-alone device. Currently we do not have a recommendation regarding who makes a high-quality, long-term reliable device, but this needs to be looked at closely.~~

~~F. Laboratory Controls:~~

~~1. For specialized lab ventilation system controls, avoid use of independent LONworks LAB controller that requires a gateway interface to BACnet BAS. Preference is for the lab controls to be part of the overall BAS Contract responsibilities and shall be fully integrated into the BAS system. Installation shall be by the BAS vendor.~~

~~2. At this time, our BAS Department approves Phoenix, Siemens and Waddell as Lab Control Manufacturers.~~

~~3. Review and confirm most current requirements with OPP Environmental Systems, Building Automation System (BAS) Application Engineering. Clearly specifying adequate instrumentation, sensors and the ability to trend data will improve the odds that the system will be successful.~~

~~G. Specialized Commissioning:~~

~~1. In order to ensure all lab spaces are constructed and operating effectively, laboratory ventilation systems shall include detailed specifications for specialized commissioned according to industry best practice guides for laboratories.~~

~~2. Refer to Labs 21 Toolkit Commissioning Ventilated Containment Systems in the Laboratory. Complicated systems must be commissioned per the above guidelines prior to turnover to owner. They also need to be recommissioned over the life of the system to assure that they are still operating safely and saving energy. Those recommendations and requirements shall be included in the Operating and Maintenance manuals and Owner Training at turnover.~~

~~H. Facility Asset Management System:~~

~~1. The University has a computerized facility asset management and preventive maintenance system. All laboratory ventilation system equipment shall be planned and fully coordinated with the University's Preventive Maintenance (PM) Group to be included in the asset database with recommended operating and maintenance procedures defined for each component to ensure continued safe and effective operation. Contact: Richard L. Phillips, rlp163@psu.edu - PM Quality Assurance Coordinator, Phone: (814) 865-4837.~~

Replace with following text.

.12 Laboratory Ventilation Systems

A. General:

1. Laboratory HVAC systems shall be designed to satisfy the specific parameters for each laboratory to provide a safe working environment for all personnel, maintain the necessary indoor environmental conditions to conduct the teaching and/or

research within each laboratory, and meet the high-performance requirements in Division 1 of the Design and Construction Standards.

2. The Design Professional shall collaborate with the University representatives in order to understand the function and associated parameters for each laboratory application and thus determine the most appropriate HVAC system selection and design.
    a. Ascertain as early in the design process as possible all HVAC design parameters with the laboratory supervisor, college/department safety staff, OPP Engineering Services, OPP Facility Automation Services, and Environmental Health and Safety.
    b. For areas or processes requiring user-controlled variable parameters, all such variable operating ranges must be carefully reviewed with the users to establish a clear understanding of expected operating conditions and system performance.
    c. All parameters shall be fully tabulated on the construction documents for each laboratory.
    d. Parameters shall include:
        1) Temperature range and allowable rate of change
        2) Humidity range and allowable rate of change,
        3) Minimum occupied/unoccupied ventilation rates for type of lab and associated hazard assessment
        4) Room pressure relationships
        5) Specific type(s) of laboratory containment/exhaust equipment with associated performance parameters. The identifying nomenclature of the type shall conform to the OPP Equipment Acronym List / Facility Asset Management Database.
        6) Application-specific alarming requirements, in coordination with the laboratory supervisor/safety staff, EHS, and OPP Facility Automation Services. Detailed requirements shall include:
            a) Alarm set points,
            b) Alarm notification class (General, Critical, Preventive Maintenance, Diagnostic, Life Safety, or other specialty if needed)
            c) For Critical, Life Safety or other specialty alarms, define the distribution list and preferred method (email, text, or voice message) of associated alarm notifications to key recipients,
        7) Air treatment requirements for process and safety, which can include any combination of particulate, HEPA, gas-phase filtration, and other air purification/sanitizing treatment of supply and/or exhaust.
        8) Defined spare capacities and/or control operating range allowances that can cost-effectively accommodate anticipated, potential changes.
        9) Specific requirements for standby equipment and emergency power to achieve system reliability and life safety.
            a) In general, EH&S recommends that ventilation systems (exhaust and adequate make-up air) serving fume hoods be connected to emergency power, to prevent toxic and/or flammable gas/vapor build-up in the event of a power outage, which has previously been related to a fire on campus.

    b) Emergency power is not an absolute requirement for all cases. Each project-specific application shall be assessed among the Design Professional, scientific staff, EHS, and OPP; and the capabilities and/or implications to the electrical infrastructure shall be determined.

3. Operable window systems are prohibited in conditioned, pressure-controlled laboratory spaces due to the following reasons.
   a. Life Safety Consequences: Loss of proper air pressurization control
      1) Random crossflows (drafts) in a space, created by wind, adversely affect a hood's ability to capture, resulting in an unsafe working environment.
      2) A windward (positively pressurized) opening in a laboratory space has the potential to over-pressurize an individual room, reversing pressures and forcing laboratory air into the egress corridor rather than safely collecting/exhausting air at the designated discharge points.
      3) A leeward open window can draw a significant quantity of air out of a lab, causing multiple consequences: reduced hood capture, "stealing" pressurized air from one location causing adjacent labs to be positive in respect to the corridor, and permitting exhaust effluent to potentially affect pedestrian areas outside the building.
   b. Energy Consequences:
      1) Uncontrolled airflow into or out of a window reduces the energy recovery capability of the exhaust system.
      2) An open window can arbitrarily drive the HVAC system to extremes, thereby increasing energy usages, and potentially causing adverse effect to adjacent spaces.
      3) Window seals break down over time, leading to leakage and comfort issues.
   c. Research Consequences (loss of controlled conditions):
      1) An open window can allow various biological, physical, and chemical constituents into the airspace, completely circumventing the air filtration or other air treatment systems, and thus adversely impact research in the space.
      2) Accurate temperature and humidity control cannot operate properly with a "rogue zone". Therefore, systems may not be able to operate within the user's tolerances for temperature and humidity.
      3) Laboratory space humidity cannot be controlled with an open window. Vapor pressure will always equalize, and quickly, regardless of wind direction.
4. HVAC infrastructure serving laboratory spaces shall be flexible and adaptable. Research objectives frequently require changes in laboratory operations and programs. Therefore laboratory ventilation systems must be designed to be able to accommodate reasonably anticipated changes without significant modifications.
   a. The utilities, distribution and terminal equipment system design shall be flexible enough to supply ample cooling to support the addition of heat producing equipment without requiring modifications to the central HVAC system. Apply a minimum 10% safety factor to sensible cooling loads. Consult with OPP if higher factors are requested by laboratory users for more specific anticipated needs.
   b. Ventilation system infrastructure design shall be easily adaptable to allow programmatic research changes with associated modifications to the

laboratory's ventilation system infrastructure to be kept within the confines of the individual laboratory area, and/or interstitial and utility corridors.

5. HVAC construction document sets shall include drawings showing simplified pressure relationships and air flow summaries complying with requirements in Section 23 00 01 Owner General Requirements and Design Intent, .01 HVAC Design General Requirements.
6. Maintain generous, safe, convenient service access to all laboratory HVAC system components serving and/or within laboratory spaces, including but not necessarily limited to, air terminal units, laboratory supply and exhaust air terminals, and BAS controllers, valves, actuators, terminal humidifiers, etc.
   a. Equipment must be readily accessible by ladder, without special accommodations.
   b. Equipment must be able to be removed without interrupting water, power, data, or fire protection services, or dismantling building general construction or fixed laboratory furniture.
   c. Avoid creating “confined spaces” for regular maintenance access, as defined by the Penn State Confined Space Program, and the OPP Confined Space Policy 05-005.
   d. Equipment installed in a prohibited or inaccessible location shall be relocated at no additional expense to the University.

B. Codes, Standards and Guidelines:
   1. In addition to minimum requirements of the Building Code, laboratory ventilation systems shall be designed in accordance with the following (or current) editions of industry standards and design guidelines.
      a. **ANSI/AIHA Z9.5: Laboratory Ventilation (2012)**
      b. **ACGIH Industrial Ventilation: A Manual of Recommended Practice (2013 edition, or current)**
      c. **ASHRAE 62.1: Ventilation for Acceptable Indoor Air Quality (2010 or current)**
         1) This standard shall supersede the associated portion of the International Mechanical Code for mechanical ventilation rates in Breathable Zone and associated procedures, Air Classifications, Recirculation and Outside Air Intake criteria.
      d. **ASHRAE Standard 110-1995 (or current) -- Method of Testing Performance of Laboratory Fume Hoods**
      e. **ASHRAE Applications Handbook** including, but not necessarily limited to, the chapters for Educational Facilities and Laboratories.
      f. **NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals (2015)**
   2. OPP Design and Construction Standards: Including but not necessarily limited to the following:
      a. 01 81 13 Sustainable Design Requirements
      b. 23 00 00 HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)
   3. Other Laboratory Design Resources:
      a. National Institute of Building Sciences (NIBS) - Whole Building Design Guide - Research Facilities
      b. I^{2}SL, Labs21 Tool Kit, Best Practices Guides
      c. A **Design Guide for Energy-Efficient Research Laboratories** - Version 4.0, http://ateam.lbl.gov/Design-Guide/Index.htm

C. PSU Environmental Health and Safety Requirements:

1. The Design Professional shall consult and collaborate with each department's laboratory/research liaison, Facility Coordinator/Safety Officer, and EHS to determine optimized ventilation requirements for each application.
   a. Laboratory hazard/ risk level – EHS has piloted an assessment tool (lab banding tool) supporting determination of a relative risk/hazard level for laboratories, with the objective of deriving occupied and unoccupied minimum laboratory ventilation (exhaust) rates for all EXCEPT high hazard laboratories. High hazard laboratories may include such spaces as Clean Rooms and ABSL-rated laboratories. Contact EH&S for assistance in determining current relative hazard/ risk levels, and/or current recommended laboratory exhaust ventilation rates.
   b. Laboratory exhaust ventilation rates are influenced by several factors, and laboratory-specific design requirements. These factors may include, but are not limited to:
      1) The quantity of low flow/high efficiency exhaust hoods specified for use in a given space, and the available make-up air system demands,
      2) The type of laboratory work employed (research vs. academic), impacting necessary safety factors,
      3) Research activities, hazardous chemicals or agents used, and whether part of continuous or discreet processes,
      4) Outdoor fresh make-up air requirements to meet spatial indoor air quality requirements (ASHRAE 62.1),
      5) Air classification/recirculation demands (ASHRAE 62.1).
2. EH&S has drafted a Laboratory Ventilation Management Plan as recommended by and based upon ANSI Z9.5. This document will be developed in collaboration with applicable Penn State stakeholders. Contact EH&S to discuss other recommended laboratory ventilation management practices, or for a current copy of the draft document. EH&S Office Phone: 814-865-6391
3. Refer to the subsequent section, Laboratory Fume Hoods and Other Containment Devices for other EHS requirements regarding fume hood performance testing criteria.
4. Outside air intakes shall be located according to guidelines established by AIHA/ANSI Z9.5-2012 (Section 5.3.3), and ASHRAE 62.1.

D. High-Performance Laboratory HVAC Design Requirements:

1. Follow Best Practices for Sustainable Design. As part of meeting the Performance Requirements and Sustainability goals of the University, careful attention must be given to the design, construction and continued operation of Laboratory spaces. Refer to the U.S. EPA and DOE sponsored Labs for the 21st Century (Labs21) Tool Kit, including the Best Practices Guides. Apply them to best fit each specific project scope giving consideration to the University's local operating staff to achieve high performance and the lowest long term total life cycle costs.
2. Segregate spaces according to function and associated air recirculation criteria. Segregate non-hazard type spaces (i.e. offices, non-lab workspaces, classroom-use "teaching labs" or "dry labs" – those that are limited to physics, physical testing, and/or electronic equipment, which do not include volatile or hazardous

constituents) from more hazardous, “wet” laboratory spaces. Air from non-hazardous spaces may be recirculated within other design considerations. Air from hazardous laboratories, i.e. wet labs or those that generate hazardous or noxious contaminants require fume hoods with 100% exhaust and 100% outside air make-up. Consult EHS for assistance.

3. Design for energy-effective makeup air transfer in both occupied/unoccupied periods. Maintenance of proper pressure relationships in non-hazardous laboratory spaces should permit design of mechanical ventilation setback adjustments during unoccupied use periods. For instance, an air handling system serving adjacent regular office spaces and/or corridors shall not be required to run 24/7/365 in order to provide make-up /transfer air into the lab spaces. This should not prohibit the use of mutually beneficial transfer of air when it can be used during shared occupied periods. Such use may require alternately serving the transfer zone/corridor with the lab system make-up air during unoccupied periods.
4. Segregate energy-intensive operations, areas and associated systems. The architectural and engineered systems design of labs shall segregate equipment and process cooling loads wherever possible to avoid forcing overall central systems into greatly multiplied, energy-intensive, inefficient operating conditions in order to meet some relatively small but specialized, highly- concentrated or critical processes.
   a. Segregate areas that require very tightly controlled temperature and humidity or air treatment conditions from spaces that are simply providing typical ventilation requirements and/or human comfort.
   b. Similar load profile areas and their associated zone controls and air handling systems shall be grouped appropriately to meet the intent of maximizing energy-savings during all operating modes (occupied, unoccupied, demand-limiting, and holiday break modes).
   c. Use “mini-environments” to isolate energy-intensive operations to fullest extent practical.
   d. Collaborate with scientific staff to inform and guide them to select water-cooled process equipment in lieu of air-cooled units that reject heat to lab space whenever possible.
5. Safely Reduce Unnecessary Exhaust Hood Use. Work with representatives of scientific staff to minimize use of exhaust ventilation hoods, where practicable, and within EHS requirements, while still meeting their needs.
   a. Eliminate/decommission unnecessary existing exhaust hoods wherever practical.
   b. Use local / snorkel exhaust devices strategically to capture applicable noxious, or non-hazardous odors as close to the source as possible to maintain overall high indoor air quality while keeping general lab ventilation rates as low as practical.
6. Optimize Ventilation Rates for all operating conditions. The design of lab ventilation and fume hood systems shall be carefully integrated to strive to continuously and optimally match the general minimum ventilation rates (during occupied and unoccupied periods wherever applicable) and specific exhaust hood and makeup air and pressure relationships needed to maintain a healthy and safe work environment for the occupants.
   a. Refer to Labs 21 Best Practice Guides Optimizing Laboratory Ventilation Rates.

b. Consult with PSU Environmental Health and Safety as indicated in section (C.) above.

7. Optimize use of Variable Air Volume Technology. Apply variable air volume to exhaust and supply air makeup systems to the fullest extent practical within the project constraints.
   a. When considering fume exhaust systems and related equipment or changes to an existing system, the designer should first consider whether the labs served are fume hood- driven or air-exchange-driven with respect to airflow. For example, there may be little or no energy saving advantage to utilizing low flow/ high efficiency hoods in a lab that is otherwise driven by minimum air change rates.
   b. In coordination with the department, consideration must be given to whether the department/ locale will have the commitment of resources necessary to ensure that adequate staff, training and preventive maintenance are available for continued operation of sophisticated ventilation systems, as designed.
8. Evaluate Variable Geometry Discharge Dampers. Applying variable geometry discharge dampers to fume hood exhaust fans can be a value-added option that allows modulating the fan speed to control exhaust duct static pressure and to maintain constant stack velocity / effective plume discharge height rather than requiring modulating a bypass damper on a constant speed fan assembly.
   a. This technology should be evaluated and applied where it offers the lowest life cycle cost.
   b. Consider developing as an additional energy conservation measure alternate bid option with an estimated payback analysis as appropriate.
9. Include Provisions for Demand Controlled Ventilation. Laboratory control systems shall include capability to apply space occupancy sensors to achieve demand based minimum ventilation strategies applicable to laboratories.
   a. This feature shall be capable of being disabled in specific control settings of individual lab spaces.
   b. For example, occupancy sensors would not be permitted to set back ventilation rates in laboratories designated with a higher risk level/ hazard band that required constant rates.
10. Optimize Use of Manifolded Laboratory Exhaust Systems – In applications with multiple ventilated containment devices, generally connect into a common manifold exhaust system with the recommended multiple fan lead/lag/standby assembly (3 fans each @ 50% maximum capacity).
    a. The intent is to achieve the benefits listed below (see Labs 21 Toolkit, Manifolding Laboratory Exhaust Systems):
       1) Ability to take advantage of exhaust system diversity and fume dilution
       2) Ability to provide a redundant exhaust system by adding one spare fan per manifold and thus increasing personnel safety (lab user's and maintenance staff)
       3) Opportunity for energy recovery
       4) Design Flexibility and adaptability
       5) Fewer pieces of equipment to operate and maintain
       6) Centralized locations for exhaust discharge
       7) Fewer roof penetrations and exhaust stacks
       8) Lower ductwork cost

b. **Note: Caution!** Carefully review specific building and fire codes and standards prior to manifolding ventilation systems, to ensure that containment systems exhausting toxic, corrosive, flammable, explosive and other related hazards are kept segregated by design. Consult EHS, OPP Engineering, and the Code AHJ during design to ensure safe compliance.

11. Design for Minimal Pressure Losses – Laboratory exhaust air systems shall be designed to minimize pressure drops through each component, fitting, and the total system to minimize associated fan energy requirements. This is especially important for manifold systems.
    a. Refer to Labs 21 Best Practice Guides Low-Pressure-Drop HVAC Design for Laboratories.
    b. Review and optimize exhaust device selection for lowest pressure drop with lab consultant (as applicable). Be careful to not allow hoods or snorkels with high individual pressure drops that end up causing the whole system to have to operate at the higher pressure, which can have a huge impact on the fan energy.
    c. Minimize length of duct runs and number of elbows, transitions, fittings and abrupt changes and combinations of all of the above that contribute to high pressure requirements.
12. Optimize Use of Air-to-Air Energy Recovery. Apply Air to Air Energy Recovery equipment in safest and most cost-effective manner. Evaluate and select the option(s) that offer the lowest total cost of ownership, and/or comply with the criteria as indicated in 01 81 13 Sustainable Design Requirements, .05 Owner's Additional Energy Conservation Options - Alternate Bid Requirements, as most appropriate for the scope of the project.
    a. General Lab (Room Air) Exhaust: Enthalpy wheels are typically recommended to maximize total energy recovery from non-contaminated/non-hazardous general lab exhaust airstreams. It is acceptable and preferable for non-recirculated air drawn from general lab spaces (not fume hood exhaust) to be exhausted by typical variable air volume (VAV) HVAC exhaust fans and discharge louvers at normal velocities, when this exhaust is located at appropriate distances from other building air intakes (refer to ASHRAE 62.1 Section 5.5, Table 5-1Air Intake Minimum Separation Distance), as opposed to forcing all laboratory air through the more energy-intensive high-plume type fume hood exhaust fans.
    b. Fume Exhaust: Where heat recovery systems are not prohibited for laboratory fume exhaust systems, glycol runaround coil systems are typically recommended to segregate air stream to prevent cross contamination. Where used, all associated aspects of the design and construction shall include:
        1) Special emphasis for specifying materials of construction of coils and protective filters/ housing, and
        2) Provisions for safe inspection, cleaning and maintenance of these systems.
        3) Note: The application of heat recovery shall be subject to complying with the requirements and exceptions for laboratories in which chemical use is on a nonproduction rather than in a manufacturing process as described in the Mechanical Code.
    c. Special Purpose Containment Devices – Devices dedicated to toxic or flammable or other specialty hazardous exhaust systems, and classified as such, shall not be installed with heat recovery systems, per the Mechanical Code.

d. Air Filtration – Appropriate particulate filtration shall be included in the design for all air entry sides to heat recovery equipment, in order to keep surfaces free of dirt and debris, and to extend cleaning periods as long as practical. Filter housings shall be the most appropriate type and located in a convenient and safe manner, to permit routine access for inspection and safe filter change-out maintenance.
    1) Air filter maintenance must be considered in the design of the system. The design engineer is required to coordinate with OPP Engineering, and EHS, to achieve acceptable solutions for the protection and life safety of maintenance personnel.

E. Laboratory Fume Hoods and Other Containment Devices:
1. The design, construction, installation and operation of laboratory fume hoods and other containment devices shall conform to applicable sections in AIHA/ANSI Z9.5 (2012). All ventilated containment devices shall be the current state of the art, high-performance designs, applied in a manner to sufficiently contain the hazards for which they are selected and as generated under as-used conditions with minimal airflow and pressure drop requirements. This requirement shall supersede other, older references in 11 53 13 Laboratory Fume Hoods of these OPP Design & Construction Standards, with regard to constant volume, bypass- type hoods, until that section is updated in the future.
2. Laboratory ventilation systems shall be designed to achieve the following requirements and chemical fume hood operating performance test criteria, established by EHS.
    a. NOTE: According to the AIHA/ANSI Z9.5 standard, studies indicate face velocity criteria alone is an inadequate indicator of overall containment performance, and shall not be used as the only performance indictor for designing or verifying ventilated containment systems. However, the containment systems must be capable of operating within the minimum face velocity criteria, as defined in this D&C standard, and as established by EHS.
    b. Review and confirm current requirements with EHS during the design phase.
    c. Conventional or Low Flow High Efficiency (LFHE) fume hoods shall be selected for use from those manufactured to minimally meet ANSI/ASHRAE 110-1995 “As Manufactured” test criteria, and with containment tests over the range of possible design configurations.
    d. The following parameters shall be included with regards to design, construction, installation, and operation of LFHE hoods:
        1) Consult EHS for guidance during major projects involving LFHE hood installations, until such time that EHS develops a separate standard for selection, installation, commissioning, preventive maintenance, and monitoring of LFHE fume hoods.
        2) LFHE hoods, regardless of whether VAV or other type flow controllers are installed, shall not be operated at less than 80 fpm at 18” open sash height, during occupied mode, unless otherwise approved by EHS.
            a) NOTE: **Caution!** Though low flow hood manufacturers indicate low flow/high efficiency hoods may operate safely at low face velocities, i.e. $\leq$ 60 feet per minute (60 FPM), Penn State EHS does not permit the installation and operation of LFHE hoods at this operating parameter, to

ensure safety margin is applied. Refer to subsequent sections of this D&C standard for clarification.

3) Existing conventional, auxiliary or by-pass hoods shall not be adapted to function as low flow/high efficiency hoods.
4) Low flow/ high efficiency (LFHE) hoods shall be purchased and utilized for the intended design purpose.

e. All other types of chemical fume hoods shall be installed to minimally operate at 100 fpm at 18” open sash height.
f. Chemical fume hoods shall not be permitted to operate at greater than 150 fpm at operating sash height. Chemical fume hoods, whether conventional or LFHE, should not be operated outside the range as prescribed or recommended by the hood manufacturer.
g. Chemical fume hoods (also including LFHE hoods) may not continuously operate outside a deviation exceeding 25% commissioned average face velocity at operating sash height, and such cases, shall be referred to the pertinent local maintenance authority, and/or to OPP/ Engineering Services for immediate corrective action.
h. Minimum face velocity requirements shall be posted on the front of the hood at the time of installation, as established by the project requirements. Contact EHS for assistance and clarification with hood labeling.
i. Unoccupied face velocity setback controls shall not be programmed for hood operation at face velocities less than 60 fpm, and with the hood sash in designated closed/lowered position.
j. Controls shall not permit unoccupied setback mode operation with the hood sash in other than designated closed position.

3. Generally, in applications with multiple hoods, fume hoods shall be of the VAV airflow control type, with respect to sash position. Some exceptions may apply; however, review with OPP Engineering Services and EHS is required.
4. The operating mechanisms for vertical and horizontal sashes shall be high quality and well-engineered so the sashes can easily be adjusted by users.
   a. Hoods with poor quality cables, pulleys, and sliding mechanisms that allow the sashes to bind up and require excessive effort to move them are prohibited.
   b. The force shall not exceed the criteria in ANSI Z9.5, 3.1.1 Sashes. <u>If such conditions are encountered on a project, hoods must be repaired or replaced at no additional cost to the University</u>.
5. The sash position sensors should be “non-contact” type for reliable, long service life when using VAV hood systems.
   a. <u>Variable resistance pressure activated type are prohibited</u>.
6. Specify corrosion-resistant screens (approximately 1/2-inch x 1/2-inch mesh) at exhaust inlets of fume hoods.
   a. Screens shall be designed and installed to prevent suction of materials such as paper towels or lab wipes into the exhaust system that can cause airflow sensing or clogging problems at VAV airflow stations, duct turning vanes, and fan blades.
   b. Factory-installed screens are preferable for best fit and finish.
7. Laboratory hood controllers shall have provisions to allow for the present or future use of proximity sensors.
   a. Consult/ review specific laboratory operating conditions with EHS.

b. Where the laboratory application allows for fume hoods to be reduced to UNOCCUPIED airflow rates, the hood-occupant proximity sensors shall be used to return fume hood airflow exhaust rates from UNOCCUPIED to OCCUPIED mode/conditions when an occupant is sensed near the hood during those scheduled unoccupied hours of the laboratory.
   1) Proximity sensors shall not be used to intermittently reduce fume hood flow and/or associated face velocities to unoccupied rates during the scheduled occupied hours of the laboratory.
   2) NOTE: Proximity sensors shall not be enabled in continuous required chemical fume hood use, such as in continuous research process applications.

8. Hood flow/velocity sensors shall be selected and prescribed, according to fume hood type, to be a high quality assembly to achieve long-term reliability and effective communication with the building automation system (BAS), AND the pertinent fire and/or smoke alarm (life safety) systems.
9. Other Considerations and Requirements
   a. Fume hoods should not be situated directly opposite normally occupied work stations.
   b. All air distribution devices shall be carefully located within the laboratory to avoid turbulence and cross currents near the fume hood face, which can negatively affect the fume capturing performance of the fume hood.
   c. <u>Biological Containment Devices</u> – The 2008 National Institutes of Health (NIH) Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities (DRM), formerly called the NIH Design Policy and Guidelines, is the only detailed design requirements and guidance manual for biomedical research laboratory and animal research facilities in the United States. Compliance to the DRM, which promulgates minimum performance design standards for NIH-owned and NIH-leased new buildings and renovated facilities, ensures that those facilities will be of the highest quality to support biomedical research.
   d. The DRM requirement that fume hood face velocity never falls below 80 feet per minute shall be applicable to buildings that are constructed using NIH funding, and/or building renovations conducted using NIH funding, whether the entire building is renovated, or if more than 50% of the building is renovated.
10. Anatomy Laboratory and Specialty Containment Exhaust Systems
   a. <u>General:</u> Shall comply with AIHA/ANSI Z9.5-2012, Section 2.1.1 (or current), "Adequate laboratory fume hoods, special purpose hoods, or other engineering controls shall be used when there is a possibility of employee overexposure to air contaminants generated by a laboratory activity."
   b. <u>Anatomy/cadaver laboratories:</u> Shall be designed and constructed according to industry current best practice guidelines using most current recommended containment/ local exhaust ventilation types, such as side slot collection tables, to achieve effective exposure control.
      1) Design Resources:
         a) Refer to American Association of Anatomists **Gross Anatomy Laboratory Design**.
         b) ACGIH Industrial Ventilation: A Manual of Recommended Practice (Current Ed.), Specific Operations, "Mortuary Table".

2) For renovations of existing anatomy laboratories/cadaver dissection rooms, not fitted with the recommended type of collection tables or other source capture ventilation, hazardous vapor or aerosol contaminants (e.g. formaldehyde-containing agents), other mechanical ventilation shall ensure user exposure control is maintained less than the applicable exposure criteria presented subsequently at item 4.
3) HVAC systems, including energy recovery options, shall be selected from types that do not permit seal leakage or cross contamination, nor subsequent recirculation of anatomy/cadaver room air (i.e. ASHRAE 62.1 Class 4 airstream).

c. Requirements for all other containment/exposure control devices include:
1) Laboratory hoods and other containment devices must be designed and installed to meet current laboratory performance guides, and function properly and adequately to control air contaminant exposure levels, at a minimum, to less than the applicable OSHA Permissible Exposure Limits (PEL's). Where measurement is required, and in the absence of PEL's, other exposure standards or criteria shall be identified, selected and used to assess adequate control, in consultation with EHS.
2) Where air contaminant levels are measured for OSHA compliance, or to evaluate exposure levels in comparison with other exposure criteria, validated OSHA, NIOSH, or equivalent methods shall be used.
3) Air contaminant monitoring to assess effectiveness of ventilation controls shall meet OSHA and/or other selected exposure criteria. Determine such requirements in consultation with EHS.

F. Laboratory HVAC System Controls

1. Laboratory controls and associated acceptable manufacturers shall be coordinated and reviewed with OPP Facility Automation Services and shall conform with their requirements. Refer also to the requirements in OPP Design and Construction Standards - Division 25 - Integrated Automation.
   a. OPP Facility Automation Services shall be consulted in all matters related to laboratory ventilation system controls.
   b. For specialized lab ventilation system controls, avoid use of independent LONworks LAB controller that requires a gateway interface to BACnet BAS.
   c. Laboratory controls should be part of the overall BAS contract responsibilities, and shall be fully integrated into the BAS system. Installation shall be by the BAS Vendor.
2. Clearly specify adequate instrumentation, sensors, application-specific alarming/notification requirements, and the ability to trend and store data as required for each laboratory application.
3. **Full functional performance testing (FPT) of all laboratory HVAC system controls within the project's extent of work is essential to verify and record the controls are operating in a safe, energy-efficient, tuned, and reliable manner. Full FPT shall be clearly defined and shall be specified as a mandatory requirement of the construction phase laboratory HVAC checkout procedures/commissioning process**.

G. Laboratory HVAC System Commissioning and Functional Performance Testing

1. For new or renovated laboratories, in order to ensure all lab spaces are constructed and operating effectively, laboratory ventilation systems shall include detailed specifications for specialized laboratory HVAC commissioning according to industry best practice guides for laboratories.
   a. Related Standards, Guides, and Resources:
      1) AIHA/ANSI Z9.5-2012 Laboratory Ventilation Standard, Section 6, Commissioning and Routine Performance Testing.
      2) Labs 21 Toolkit Commissioning Ventilated Containment Systems in the Laboratory.
   b. Specifications shall include requirements for a detailed written commissioning plan, to be approved by the Owner in advance of related construction activities.
2. Laboratory HVAC Testing, Adjusting, and Balancing; and Commissioning Requirements
   a. General
      1) Laboratory ventilation system Testing, Adjusting, and Balancing (including hood/containment device performance) shall be conducted and a certified Balance Report provided for the following conditions:
         a) New construction
         b) Laboratory renovations that involve necessary changes to general mechanical ventilation systems,
         c) Ventilation system components or controls that have failed, and must be repaired or replaced,
         d) Laboratory use / configuration changes that require alterations to or replacement of terminal equipment and/or operating parameters and settings.
      2) Scope shall include ALL components that drive and control and/or monitor the HVAC-related conditions in laboratory spaces that include ventilated containment devices and/or require continuously maintaining associated air pressure relationships for indoor air quality and safety. Typically that includes:
         a) Laboratory supply air valves and supply diffusers
         b) Laboratory general exhaust air valves and room exhaust air distribution devices
         c) Laboratory fume exhaust ventilated containment devices and associated fume exhaust air valves
         d) Fans (supply and exhaust)
         e) All associated BAS Controllers, sequences, trending, and alarms
         f) Any other related items integral to this equipment.
      3) Wherever general mechanical ventilation systems must be balanced or re-balanced, laboratory hoods shall be functionally performance tested/commissioned according to ANSI/ASHRAE 110 protocol, to include: airflow visualization, auxiliary air velocity (only for auxiliary air hoods), cross drafts velocity, exhaust flow, face velocity, hood static pressure, and tracer gas containment.
      4) Project specifications shall include requirements that the TAB agent (or other party responsible for functional performance testing of laboratory hoods) visibly labels each performance tested laboratory exhaust hood with the correct hood average face velocity setting at sash operating height,

specified for the correct hood operation and certify to the OPP Project Leader when complete. The OPP Project Leader shall then notify EH&S/Lab Safety Officer to confirm and co-certify this has been completed as part of the project turnover process.

a) Where applicable, other containment devices, such as cadaver tables, shall be similarly labeled with the appropriate minimum performance measurement criteria.

b. Specific
   1) Commissioning, where required, shall address the following:
      a) Commissioning requirements shall be determined in coordination with EHS and Engineering Services.
      b) Commissioning shall be overseen by a responsible person/ commissioning authority, who shall engage pertinent parties as identified in this laboratory ventilation standard.
      c) Commissioning shall be conducted prior to turnover to owner.
      d) Commissioning recommendations and requirements shall be included in the Operating and Maintenance manuals and Owner Training at time of turnover.

3. Periodic Performance Testing
   a. Periodic performance testing of laboratory hoods and containment systems is generally advised by current standards and codes to ensure continued safe and energy-efficient operation.
   b. EHS shall conduct or arrange face velocity testing on an annual basis in coordination with pertinent OPP or campus maintenance authorities as a “pass/fail” stop-gap test to verify average fume hood face velocities exceed minimum acceptable requirements.
   c. Specific Requirements
      1) For laboratory ventilation systems including cadaver tables, and other containment devices, manufacturer performance criteria, including but not limited to face velocities, must be provided to the Owner for subsequent periodic performance testing of the tables, hoods, fume collection boxes, and containment devices, as recommended by the manufacturer.
      2) Periodic Performance criteria must be discussed with the Owner during project design and prior to installation.
      3) Periodic performance testing recommendations and requirements shall be included in the Operating and Maintenance manuals and Owner Training at time of turnover.
   d. Periodic performance testing should verify:
      1) Room exhaust provisions are within specifications,
      2) Room differential is within specifications,
      3) Room differential airflow is within specification,
      4) Hoods are operating with respect to recommended tolerances of commissioned parameters.

H. Facility Asset Management System
   1. The University has a computerized facility asset management and preventive maintenance system. All laboratory ventilation system equipment shall be planned

and fully coordinated with the OPP's Maintenance Engineering (ME) Group to be included in the asset database.

a. The asset database information shall include identification, description, location, performance characteristics and recommended operating and maintenance procedures defined for each component to ensure continued safe and effective operation.
b. Maintenance Engineering Office Phone: (814) 865-4837

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *To make various additions and revisions throughout the entire section including, but not limited to, PSU Environmental Health and Safety Requirements, Laboratory Fume Hoods and Other Containment Devices, Anatomy Laboratory and Specialty Containment Exhaust Systems*