23 00 10 Systems Selection and Application

Add new *subsection .12 in its entirety in Section 23 00 10* per the following new text. Remainder of section is unchanged.

.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 direction.

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 accommodate 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 simplified 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 numbers) with easily recognizable tags for any room that is not neutral pressurization. The tag would indicate airflow direction (e.g. + and – or POS and NEG) and airflow (cfm).

   b. The drawing would also have a table indicating system level summaries of airflows per floor. (i.e. System SA(max/min), RA (max/min), General Lab Exhaust (max/min), Fume Hood Exhaust (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 following 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, Lab Safety Requirements:

1. Coordinate and review all laboratory designs with PSU Environmental Health and Safety, **Laboratory Safety Program,** http://www.ehs.psu.edu/occhealth/labsafety.cfm

2. Work with representatives of University's scientific staff and PSU EH&S to perform a hazard assessment to determine risk level for each lab application.

3. Use definitions and associated occupied/unoccupied minimum lab ventilation rates being developed within PSU Environmental Health and Safety "Lab Banding" guidelines. Minimum ventilation rates shall be established and clearly defined/scheduled on the construction documents on a room-by-room basis considering the hazard level of materials expected to be used in the room and the operation and procedures to be performed.

4. Be advised that the company EH&S has retained to develop methodology for laboratory hazard assessment and associated ventilation rates (i.e. lab banding) is also developing a *Laboratory Ventilation Management Plan*, based on ANS/AIHA Z9.5. Contact EH&S to request current document.

5. Comply with the following fume hood guidelines from EH&S.

    a. Review and confirm most current requirements with EH&S during the Design Phase.

    b. The following shall be included with regards to low flow/high performance hoods.

        1. Low Flow or Velocity Hoods - At a 12" vertical sash height, the minimum face velocity should be 60 fpm.

        2. Existing hoods shall not be adapted to function as low flow/high performance hoods. Low flow/velocity hoods shall be purchased as hoods designed for high performance at low flow operation.

    c. Other considerations for fume hoods:

1. Fume hoods should not be situated directly opposite normally occupied work stations.

2. Air distribution devices shall be carefully located within the laboratory to avoid turbulence and cross currents at the fume hood face that can negatively affect the fume capturing performance of the fume hood.

3. Note: 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 U.S. Compliance to the DRM, which promulgates minimum performance design standards for NIH owned and leased new buildings and renovated facilities, ensures that those facilities will be of the highest quality to support Biomedical research.

4. The DRM requirement that fume hood face velocity never falls below 80 feet per minute applied to buildings that are constructed using NIH funding, and also applied to NIH funded renovations if the entire building is renovated, or if more than 50% of the building is renovated.

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

END of revision

Update Commentary:

Section was updated primarily for the following reasons:

1) *Add new subsection defining OPP Laboratory Ventilation system requirements.*

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