

LAB VENTILATION DESIGN

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I. Introduction

If you are a Facilities Director at an elementary school, high school, or university and have been tasked with converting a standard classroom to a chemistry lab space, how do you decide what type of ventilation system to use? You may know you will need lab hoods with exhaust fans connected to them, but where should the makeup air come from? You know that protecting users from potentially toxic fumes is your top priority, but do you also need to protect the experiments from contamination? Is a “clean room” environment required? You know laboratory ventilation systems can use lots of fresh air and be expensive to operate, but you also want to use the space as a classroom – can a system be designed to satisfy both requirements?

As you may have already noticed there can be a lot of questions that need answers and decisions that need to be made when working with laboratory ventilation systems. In the following pages, we’ll take an in-depth look at some of the considerations to think about in planning your next laboratory design project.

II. Protecting People and Experiments

Laboratory ventilation is different than most other building types. For renovation projects, where an office, classroom, or other space is being transformed into a lab space, design often involves a significant change to the ventilation system. While all lab ventilation systems are designed to protect people, there are also other end goals in mind, such as the need to separate contaminants and prevent experiments from being compromised. In this respect the ventilation system is intended to maintain clean areas as positive pressure zones and potentially toxic areas as negative pressure zones. When dangerous chemicals are used, the lab ventilation system is essential in helping keep the danger away from the user. A lab will often include a fume hood, a bio safety cabinet, or a similar device specifically designed to allow the safe handling of dangerous chemicals or toxic substances and limit the risk of contamination. In some cases, a lab may require equipment such as a glove box to maintain a very clean and sterile environment.

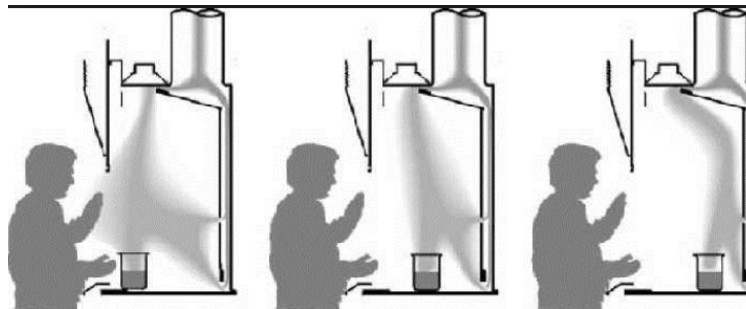


Diagram 1: Biosafety Cabinet and Lab Hoods

III. Under Pressure

Standard ventilation design typically defines positive or negative pressures relative to ambient (outdoor) conditions. However, for a lab, each lab space must be defined at a positive or negative pressure relative to the adjacent areas. But when should a lab be positive, negative, or neutral pressure to adjacent areas? The answer depends on the function of the room and the type of lab.

Lab ventilation may have multiple levels of pressure control. In the example below, Room A is positive pressure compared to Corridor C, while Room B is negative to Corridor C. In this case, the pressure differences may be very slight, but still measurable: 0.05" W.C. to 0.10" W.C.

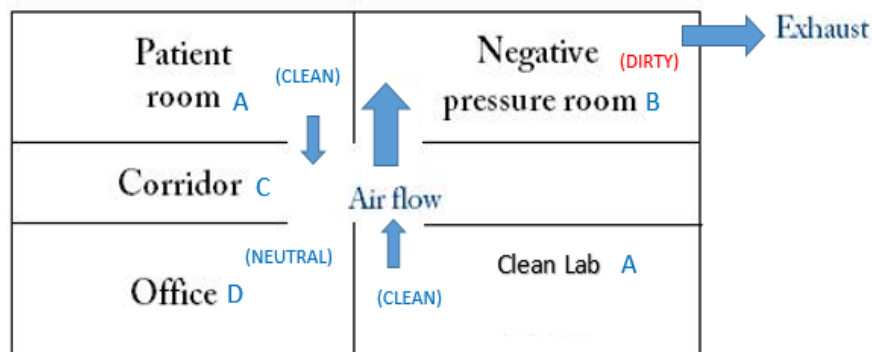


Diagram 2: Typical room pressure relationships

Typically the pressure relationships must be defined by the academic running the lab or owner's lab safety personnel, but the important point here is that the pressure relationships should be identified early in the design process.

IV. Room Construction / Room Layout

Standard buildings are typically constructed with air-tight construction for exterior walls (to maintain the interior space at a positive pressure relative to the outside) with less consideration for interior walls. For lab spaces wherein pressure differentials are to be maintained between rooms, interior walls should be constructed as air-tight as possible. Among the construction features that can be used to enhance air-tightness are door gaskets and door sweeps.

Lab spaces have doors, and lab users use those doors to enter and leave the lab space. When a door to a lab space is opened the pressure relationship to adjacent spaces will be temporarily compromised. To offset this, an anteroom can be designed into the architectural layout. The anteroom is typically maintained at an intermediate pressure relationship between the lab space and the corridor.

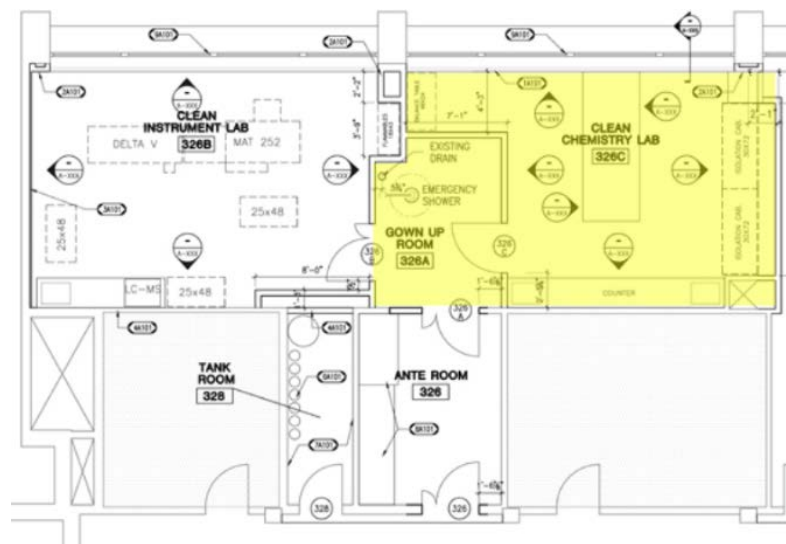


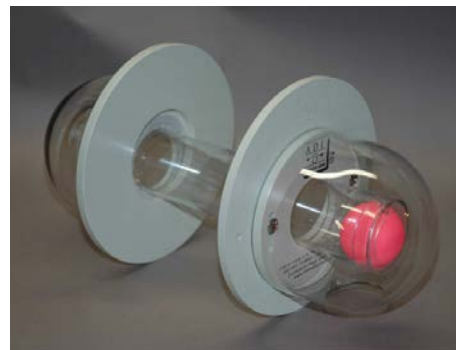
Diagram 3: Lab Space with Anteroom

V. Verifying System Operation

It is also common to have visual and/or digital pressure indicators to let the occupants know that there is a pressure differential or if there is any problem with the ventilation system, which helps to ensure safety. The digital pressure monitor commonly has an audible alarm feature, and some models can monitor multiple room pressures so that when an ante room is used, it can alarm if the ante room or critical room are outside of the pressure tolerance. The visual pressure monitor is a simple local device that does not need calibration or maintenance after it is properly installed.



Digital pressure monitor



Visual pressure monitor

Diagram 4: Pressure monitors

VI. Lab Ventilation System Options

Once the pressure relationships are defined, there are multiple methods to achieve and maintain the pressure differential between spaces. Engineering firms, such as Primera Engineers, can guide you through the process of selecting the right system for your needs and finding the balance point between low first cost and low operating costs. Three lab ventilation systems types are described herein.

A. Constant Air Volume Supply and Exhaust

Constant volume lab ventilation systems are the simplest to install and operate. As expected, they are also the most costly to operate. These systems typically operate in an on/off fashion, and control accuracy is not critical because there are less variables to consider.

Total supply airflow to the space is determined by the greater of the following: exhaust hood's airflow requirement, airflow to satisfy the cooling load or heating load, or minimum code required air. For an all-air system, if the cooling or heating load airflow is higher than the exhaust hood or minimum code requirements, cooling and/or heating can be achieved through non-air means such as radiant cooling or heating systems, thus reducing the supply air required.

When a lab space is small relative to the overall HVAC system, makeup air can come from the air handling unit feeding that general area. Care must be taken that the temperature control system/BAS is programmed to always enable the air handling unit with the required outside air whenever the lab exhaust is operating.

As the overall lab spaces become larger relative to the HVAC system serving that area, a dedicated makeup air system – designed to bring in outside air for the lab spaces – becomes more practical. When lab exhaust and its associated makeup air are matched, energy recovery from the exhaust air can be used to greatly offset the operating cost of lab ventilation system. In fact, energy recovery is now mandated by the International Energy Conservation Code (IECC), with some exceptions.

B. Variable Air Volume – Airflow Differential Control

A variable air volume (VAV) lab ventilation system with airflow differential control is typically designed to vary supply airflow between a minimum and maximum to maintain the space temperature, while the exhaust airflow is modulated to maintain pressure differentials. In a scenario where the lab space is to be maintained at a negative pressure relative to adjacent spaces, as the supply airflow may vary between 500 and 1,000 CFM (for example), the exhaust air from that space will vary between 650 and 1,150 CFM, continuously matching an exhaust airflow of 150 CFM greater than the supply airflow. This guarantees constant infiltration to the lab space from adjacent rooms.

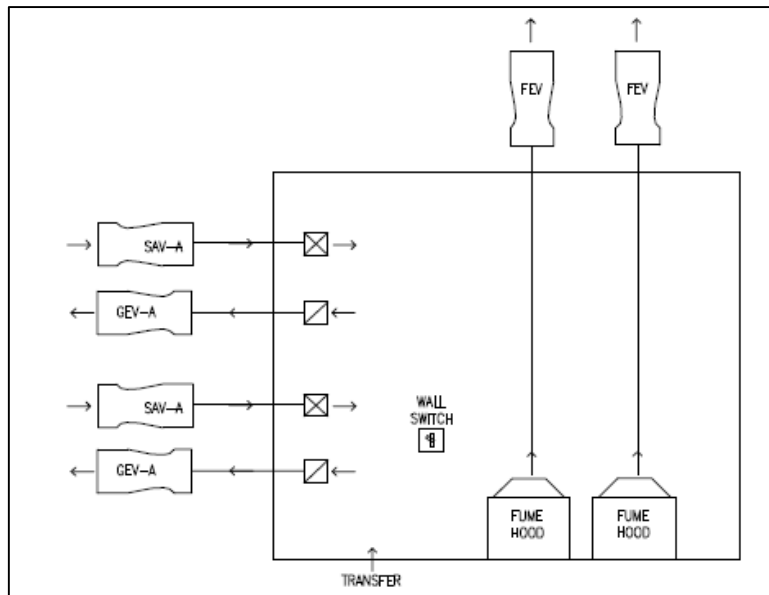


Diagram 5: Lab Ventilation System with Supply and Exhaust Air Valves

To accomplish airflow differential control in a lab ventilation system, air valves are used on both the supply air entering the space and the exhaust air leaving the space. All airflow entering and leaving the space (excluding exfiltration or infiltration) is measured using airflow measuring stations in the air valves. A controller receives the airflow information and adjusts the air valve accordingly to maintain the pressure differential. The supply air valves are usually slow-acting, while the exhaust air valves are fast-acting to adjust airflow to react to pressure fluctuations.

The first cost for equipment and controls is greater than in a constant volume system. However, there are significant energy savings. With less exhaust, less outside air is required to make-up, which means less cooling, less heating, and often longer life on filters and equipment.

C. Variable Air Volume – Space Pressure Control

Another version of the VAV lab ventilation system uses direct differential pressure measurement between adjacent spaces to maintain the pressure relationships. This system is similar to the VAV airflow differential control system in that supply air valves control to maintain space temperature and the exhaust air valves control to maintain pressure relationships between spaces. In lieu of measuring airflow in and out of a room, the exhaust air valve modulates to maintain the actual pressure differential between the lab and an adjacent space.

While this system may seem like the obvious choice with a lower first cost than a VAV-airflow differential control system, it can be difficult to maintain your pressure target if the lab space wall/ceiling/floor construction lacks air-tightness. Depending on conditions, Primera has successfully implemented both VAV control types of lab ventilation systems.

VII. Lab Space or Classroom Space – Why Not Both?

To account for flexibility between lab classrooms, where the teacher spends part of the time lecturing, and part of the time with experiments, Primera has successfully implemented a manually controlled change-over. The control system includes a manual toggle switch which is linked to damper and fan operations that switch the lab from a classroom mode to a lab mode.

- In the classroom (lecture) mode, the room allows return air back to the main air handling system, the exhaust system is off, and the system operates just like a normal classroom varying airflow as needed to meet temperatures.
- In the lab mode, return air isolation dampers close, the dampers and exhaust fans are engaged to a specific airflow and all of the room air is exhausted. During the lab mode, the system can be constant volume or variable volume. This allows these rooms to be safe during lab mode while saving energy during lecture mode.

For a system like this that requires manual intervention, the staff must be trained properly, signs are typically utilized to remind staff and students to adjust the room mode before and after experiments take place, and optional alarms can be set up to sound when needed.

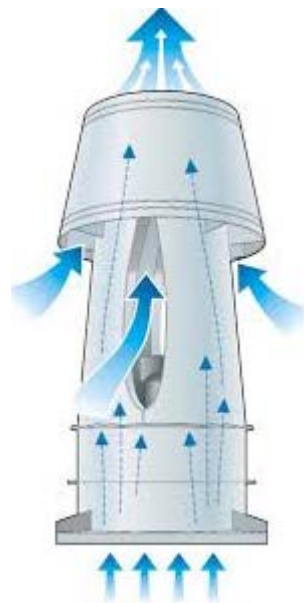
A. Options and Accessories

Supply Air Reheat: Many HVAC systems that use hot water for heating often disable the hot water plant in the summer. Since lab systems use a greater amount of supply air than standard ventilation systems, reheat of that supply air may be required year-round. In these cases, electric reheat may be considered for reheat to lab spaces.

Humidification: In large science buildings with a significant number of lab types, point-of-use humidification of supply air is often used to maintain specific labs at a minimum relative humidity level. At the makeup air unit, central humidification is typically used.

Exhaust Duct Materials: Exhaust duct materials are selected based on the chemicals expected to be used under the lab hoods. Clients are more frequently requesting that labs have versatility and flexibility to allow for a wide variety of experimentation. With versatility comes added first costs. A wide variety of duct materials and coatings are available for use in lab exhaust systems. To contain first costs, Primera coordinates with the owner at the earliest possible stage of design to determine the expected short-term and long-term use of the lab space.

Exhaust Fans: Exhaust fans used for lab exhaust are constructed differently than standard exhaust fans in a number of areas. The materials the fan is constructed with are designed to withstand the chemicals they are expected to encounter. Lab exhaust fans discharge straight up from the roof at a higher velocity than normal fans. They often have dilution dampers that mix the exhaust air with outside air to reduce the concentration of chemicals and add velocity to the exhaust air stream as it leaves the fan. A lab exhaust fan drawing 4,000 CFM (for example) from the lab hoods may draw an additional 6,000 CFM of outside air to create a diluted 10,000 CFM high velocity discharge off the roof.



VIII. Conclusion

In any instance, proper ventilation in laboratories is required to promote and maintain life and property safety, and with as many ventilation choices as there are, each project and budget must be analyzed on a case-by-case basis. For additional information on laboratory ventilation system design please contact John Palasz.