PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

Variable Volume Laboratory Systems, an Overview

On a variable volume laboratory exhaust systems; air is exhausted through fume hoods, as well as a through general exhaust grille(s), using a laboratory exhaust fan system.

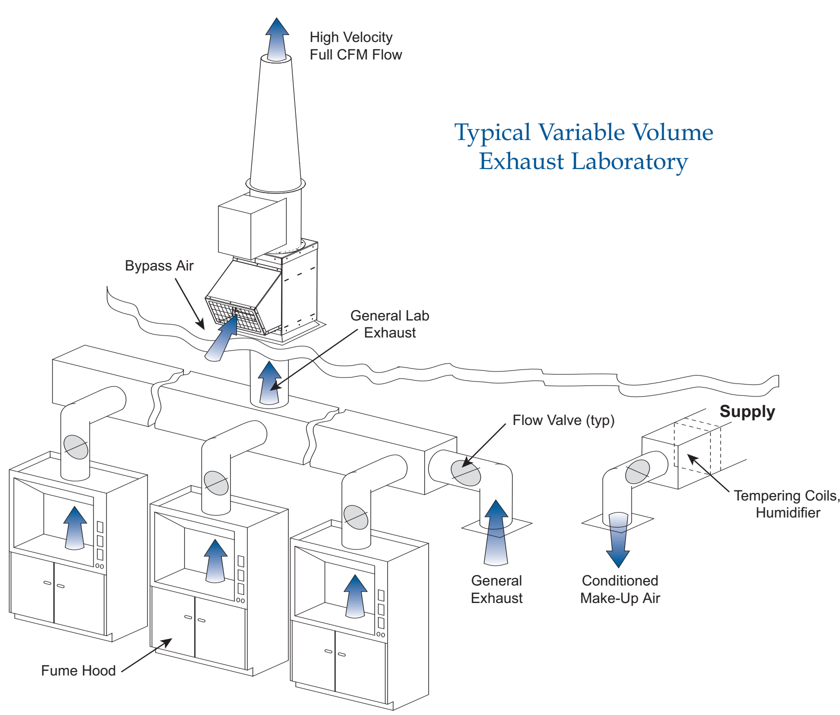
One of the goals of the exhaust fan system is to maintain a minimum effluent discharge velocity or plume height. Therefore a minimum volumetric flow (cfm) must pass through the fan. To maintain this minimum cfm, a bypass air damper is provided with the exhaust fan system to bleed unconditioned air to mix with the reduced lab exhaust volume. This allows the exhaust fan to maintain the desired discharge velocity.

In a typical system as shown, conditioned air is supplied to the space to "make-up" the air that is exhausted through the fume hoods and the general exhaust grille. This make-up air is typically supplied at a volumetric flow rate slightly less than that which is exhausted. This keeps the laboratory at a negative pressure with respect to adjacent spaces. In the event there is a chemical spill or biological release outside of the fume hood, *infiltration into the lab will occur instead of ex-filtration out of the lab.*

Controls

There are three separate control systems that make up the overall control system in a variable volume laboratory:

1. A control system for each fume hood to control the flow into the fume hood to assure capture and containment by the fume hood (to maintain a constant sash opening velocity).
2. A control system for the bypass air damper on the exhaust fan system. Allowing the proper amount of bypass air into the exhaust fan can be challenging. The most successful strategy is to use a constant static pressure control system, which maintains a constant static pressure in the exhaust riser, by opening and closing the bypass air damper as the lab exhaust volume varies. The



Typical Variable Volume Exhaust Laboratory

GREENHECK
Building Value in Air.
P.O. Box 410 • Schofield, WI 54476 • 715.359.6171 • Fax 715.355.2399
Copyright © 2005 Greenheck Fan Corp.

location of the static pressure sensor is critical. In many cases, high velocities are present in the exhaust duct that disrupt the static pressure measurement. It is also a common problem to oversize the bypass air damper, believing that "more is better". This is far from the truth, and typically results in unsatisfactory system performance. The exhaust fan system manufacturer needs to apply "damper expertise" and "specialized lab VAV system knowledge" to properly size and select the bypass air damper.

3. A room ventilation control system which maintains room pressurization, a minimum number of air changes, and comfort levels within the laboratory.

   Room pressurization. Room pressurization may be positive or negative. Negative is the most common and is generally the case for laboratories with heavy chemistry. However, much research now involves tissue culture, or clean spaces, where the rooms need to be positive. Regardless of whether the room is positive or negative, the supply airflow tracks the exhaust airflow so the net pressurization is maintained. This is accomplished by maintaining a fixed cfm differential between supply and exhaust. This control method is called "cfm Tracking" or "Flow Tracking".

   A minimum number of air changes. An air change is the volume amount of air required to replace the air in a given space. The number of air changes is calculated by dividing the volume of the space by the amount of air entering the space per unit of time. The minimum air change rate will normally be in the range of 6-12 Air Changes per Hour (ACH) during occupied periods, and may be lower during periods when the lab is not occupied.

   Comfort levels within the laboratory. The cooling demand for the room may also require an increase in the minimum air change rate. As temperatures in the space rise above the cooling set point, the minimum air change rate may be increased to provide additional cooling.

It is easy to conclude that the supply volume into the space either tracks the demands from the fume hood, from the minimum required air change rate or cooling load.

If the minimum air change or cooling load varies the supply volume, the exhaust system tracks the supply flow increase to maintain the required room pressurization.

The speed of these control systems is critical to maintain containment and safety in the laboratory. The speed of the fume hood and the lab make-up air systems are the most important. The speed of the bypass air damper control system is less critical, and is a function of the number and status of fume hoods in operation.

Items that drive conditioned air into the lab space are:

1 Fume hood exhaust air volume.

2. Air change rate (usually a minimum of 6-12 air changes per hour).

3. Cooling ventilation, which typically exceeds fume hood exhaust demand.

An important function performed by the bypass air damper is to significantly reduce the quantity of conditioned exhaust air from the lab space when the sashes on the fume hoods are lowered or closed. The general exhaust from the lab could be used in place of the bypass air damper, however, large quantities of conditioned air would be exhausted from the space, wasting energy and increasing operating costs.

Energy Use

Although this varies from geographic location to location, for moderate annual climate conditions, the breakdown of energy usage in a laboratory is approximately:

33% Supply Air Cooling

33% Supply Fan Energy

17% Supply Air Reheating

17% Exhaust Fan Energy

The cooling component would be higher in areas of the country with high humidity, and the heating component would be higher in areas with lower ambient temperatures.

Given the high cost of conditioning the air in a lab space it is prudent to decrease the supply into the space whenever possible, and to provide make-up air (bypass air) to the exhaust system to maintain minimum volume or stack velocity. Using bypass air preserves the bulk of the savings provided with the variable air volume (VAV) system.

Variable volume flow from laboratories is typically controlled using the bypass damper & plenum as described above. The use of variable frequency drives (VFD) on lab exhaust fans to modulate lab exhaust flow is typically avoided for two reasons:

1. Slowing the fan down to reduce flow results in a drop of stack discharge velocity and exit mass flow (reduced momentum) reducing system plume rise, and
2. On large blowers, the mass momentum inertia of the fan wheel requires time to accelerate or decelerate, which can result in poor containment control of the laboratory.

There are a number of schemes to provide reduced exhaust fan energy as loads vary, including staging fans on and off (using equally sized fans) and by using VFDs for night set back or unoccupied laboratory conditions. Care should be taken, however, when applying VFDs to laboratory exhaust fan systems to insure that the minimum acceptable effluent discharge velocity or minimum acceptable plume height is maintained.

Manifolded fume hood systems offer the following advantages:

1. Centralized exhaust fan system on the roof.
2. Elimination of one fan per fume hood (less fans to be maintained).
3. Increased fume hood reliability (connected to a manifolded fan system).
4. Additional dilution of exhaust from manifolded fume hoods.
5. Additional momentum (greater plume rise) at fans discharge (more cfm @ discharge velocity).
6. Reliability of the exhaust system is created by the addition of a redundant (standby, or N+1) fan.

Obtaining answers to the following items will assist in the selection, design and specification of the required lab exhaust system:

- General or specialized fume hoods
- Chemical and /or biological exhausts
- Excessive concentrations
- Exhaust orientation with respect to other campus buildings & HVAC intakes
- Constant or variable volume exhaust
- Heat recovery or HEPA filters
- Economics including operating, maintenance and replacement costs
- Materials of construction
- Fan / blower type
- Utilize a “system” design approach
- Architectural considerations
- Acoustic considerations.

Designing a laboratory exhaust system can be a complex process and it may be beneficial to consult with the fan manufacturer to select a product that best meets your application. Greenheck has a team of dedicated technical experts and application engineers on staff to assist with any laboratory exhaust design questions.

P.O. Box 410 • Schofield, WI 54476-0410 • 715.359.6171 • greenheck.com