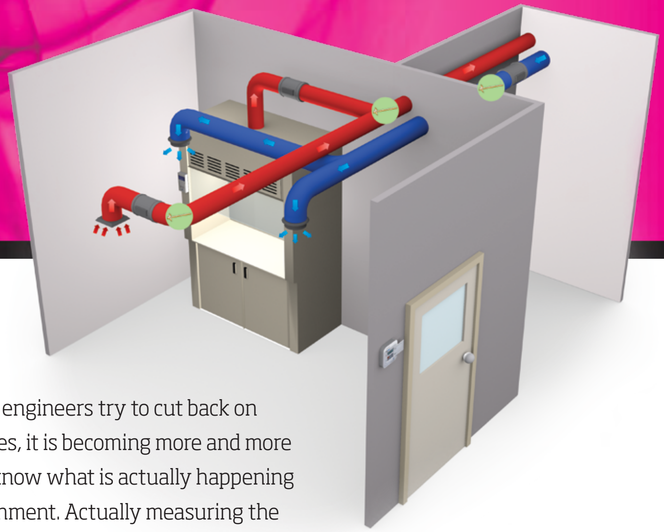
LABORATORY CONTROLS: MYTHS VS. REALITY

BY RYAN THOMPSON
APPLICATIONS ENGINEER - CRITICAL ENVIRONMENTS



Introduction

A key objective in laboratory design is to protect users inside the lab space from exposure to hazardous materials, as well as protect those outside of the lab. HVAC systems must be designed appropriately to minimize risks and keep people in the lab safe. Fume hoods in the lab space are a very critical part of containing fumes, and measuring and controlling the face velocity of a fume hood is the first line of defense in containment. The second line of defense, and just as important as the fume hood control, is the room control system. These systems must work together to maintain proper fume hood face velocity and the correct directional airflow, as well as air change rates in the critical space. To be sure these spaces are performing at optimum levels, closed-loop control systems using direct measurements are used to ascertain the room's and fume hood's ability to contain and safely exhaust harmful vapors.

As facilities owners and engineers try to cut back on energy use in laboratories, it is becoming more and more critical to measure and know what is actually happening in the laboratory environment. Actually measuring the critical items in a lab, like room pressure differential and fume hood velocity, is paramount. The days of making assumptions that safety is intact simply because no alarms are sounding are coming to an end. Technology has dramatically advanced from the era of pneumatic controls with flow-metering and open-loop control, to now where we can accurately measure airflow and react to the reading precisely with closed-loop control. These measurements enable facility operators to recognize a problem with their laboratory system, diagnose the cause and correct it. Ultimately, taking measurements makes critical spaces safer for users.

With that in mind, let's examine some of the myths and realities that surround room and fume hood control in laboratories.

LABORATORY CONTROLS:

MYTHS VS. REALITY

Myth #1:
Sash sensing gives an accurate measurement of face velocity.

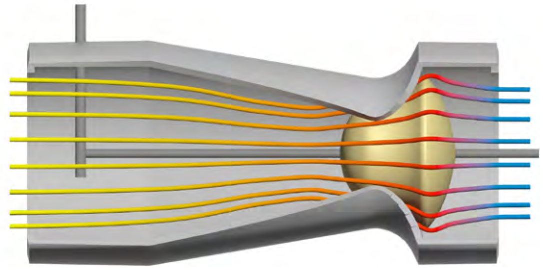
Reality:
Sash sensing is an open-loop control system that only measures the height of the sash and then guesses at the face velocity at the sash by using a flow estimation from a venturi valve metering device to "calculate" the sash face velocity. The face velocity "calculation" is just an assumption as to what is happening at the sash opening, and is not a true depiction of what the fume hood user is seeing. Conversely, a sidewall sensor is part of a closed-loop control system and actually measures the air velocity entering the hood and controls the face velocity based on this calibrated measurement.

The face velocity across the open sash of a fume hood is affected by many factors, including the amount of air exhausted from the hood, the height of the sash, the amount of infiltration into the hood, lab equipment near the sash and the hood users. A person standing in front of a fume hood will affect the air flow in the hood by impeding the airflow, thus changing the face velocity of the fume hood. When using a sash sensor, a change in the face velocity is not detected since the only measurement being taken is the sash height. The sash sensor is clueless as to what is actually happening near the hood and most importantly, right in front of the hood in the user's breathing zone. The impact could be a loss of containment! Conversely, with a side-wall sensor taking a measurement of airflow any change to the airflow will be recognized immediately and the fume hood controller will adjust to maintain that critical face velocity set point. When it comes to user safety, measurements are critical and assumptions of proper face velocity should not be made.

By using a sidewall sensor paired with a fume hood controller, you can gauge a fume hood's ability to contain and exhaust harmful vapors, leading to a higher level of fume hood safety and energy efficiency.

Myth #2:
Venturi valves are the only option when designing a laboratory ventilation system.

Reality:
Back in the days of pneumatic controls and low accuracy pressure transducers, the venturi valve was the popular option for laboratory control systems. With advancements in flow measurement, DDC controls and high-speed actuators, technology has surpassed the venturi valve.



The venturi valve is merely a flow metering device, with no actual measurement being taken. To accomplish this metering, a venturi valve creates a restriction in the air stream, which incurs a large pressure drop, and then a plunger slides along the shaft while using a spring to compensate for with the pressure in the ductwork. This means fan energy is wasted to achieve the high static pressure needed for the valve to operate. This waste of energy is one of the reasons why the EPA and DOE* have classified designing a lab with venturi valves as just a step above a constant volume system in terms of saving energy. The airflow restriction also creates more noise in the ductwork, meaning a sound attenuator might be needed as well, increasing the pressure drop even further.

Flow sensing technology has also dramatically improved since the use of pneumatic controls. Thermal flow stations offer higher accuracy than venturi valves, while providing the additional benefits of an actual reading and more precise control. When applying a thermal flow station with a simple damper, there is no longer a venturi restriction, resulting in a vastly smaller pressure drop. This results in immediate fan energy savings and possible AHU savings. It is also dramatically quieter – all for less upfront and long-term costs.

In a fume hood application, a 3:1 turn down on the airflow is common, and a damper exceeds this with 6:1. While a venturi valve has a 16:1 turn-down ratio, it is rarely ever needed.

	Venturi Valve	Damper and Thermal Flow Station
Pressure Drop	1"-3"	0.01" -0.1"
Sound	NC upper 30s	NC lower 20s
Cost	High	Low
Pressure Independence	Yes, via an internal spring	Yes, via a flow measurement
Measurement Accuracy	No flow measurement	±3%
Metering Accuracy	±5%	±3%
Device Length	24"-30"	24"-30" includes straight run
Turn down ratio	16:1	6:1

* Reference is "Laboratories for the 21st Century: Best Practices"

LABORATORY CONTROLS:

MYTHS VS. REALITY

Myth #3:
Offset control is the "best" and only way to control a lab space.

Reality:
Offset control is just one of three ways to control room pressure in a lab. Direct pressure and adaptive offset methods are commonly used as well. Each method has specific strengths and weaknesses, and when to use a specific method depends on the individual lab design and what is important to the owner.

Care must be taken to ensure that fumes escaping into the laboratory area do not migrate to other regions of the building. Laboratory room controls are the second line of defense.

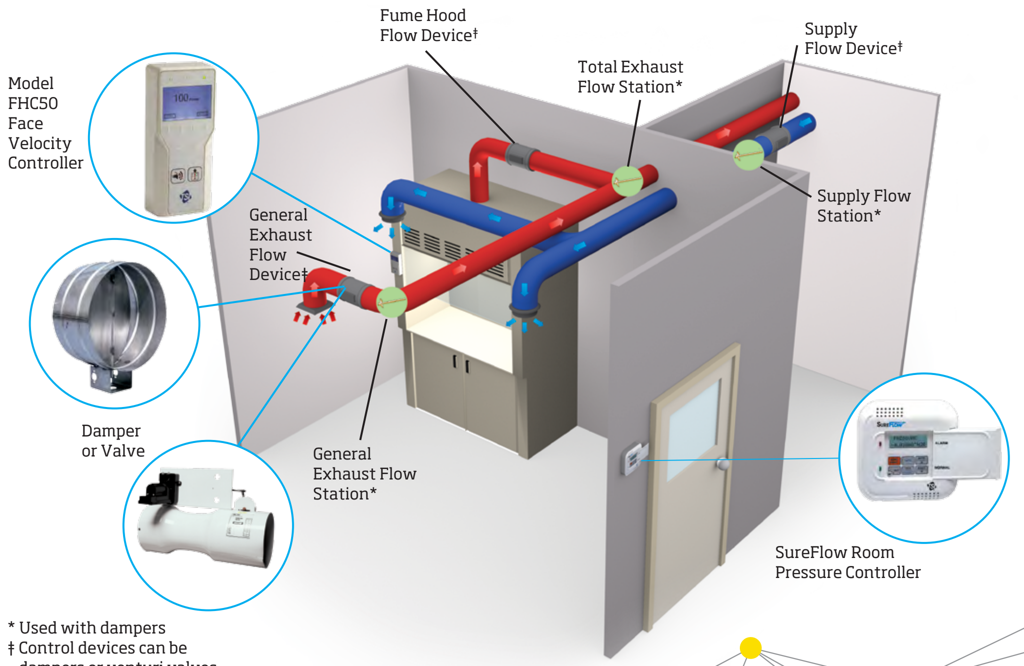
ANSI guidelines stipulate the need to maintain a small negative pressure in the lab relative to surrounding areas. In practice, negative pressure is achieved by exhausting more air than is supplied. The extra air must infiltrate into the lab from adjacent areas, helping to ensure chemical vapors do not escape out of the laboratory.

Offset control means that a fixed volumetric difference, or offset, is maintained between the supply and exhaust flows. Because no room pressure measurement is taken, offset control does not account for changing room pressure differentials in adjoining spaces. Offset is the design of choice for open architecture laboratories, and is used in areas where uninterrupted containment is not critical. An open lab using offset control still requires the lab to be well sealed, otherwise the offset needs to increase to maintain directional airflow.

Direct Pressure control maintains a measured pressure differential between the lab and neighboring space. This means room controls are able to modulate the supply and exhaust dampers in order to manage the room pressure differential between the two spaces. The advantage of direct pressure control is that room pressure is constantly measured and maintained, therefore ensuring room containment as well. All control adjustments are based on actual room pressure measurements, not assumptions. If any change in the room pressure measurement in relation to the reference space is detected, the controls make necessary adjustments to get the room pressure back to the desired set point. This is crucial for rooms that house hazardous or airborne substances that need to stay contained.

However, direct pressure controls have their limitations as well. Direct pressure controls will modulate supply and general exhaust dampers to any change in room pressure differential; if the pressure in the reference space is not stable, the HVAC system will react accordingly. Also, with a direct pressure system, since you are reading the pressure differential between two separate spaces, you must have a proper envelope for your lab.

Adaptive Offset control combines the safety of Direct Pressure control gained from a having a pressure measurement, along with the airflow stability from Offset control. Adaptive Offset control adjusts quickly to preserve directional airflow by upholding the offset, and the room pressure differential then slowly resets the offset set point to maximize energy savings, while maintaining safety.



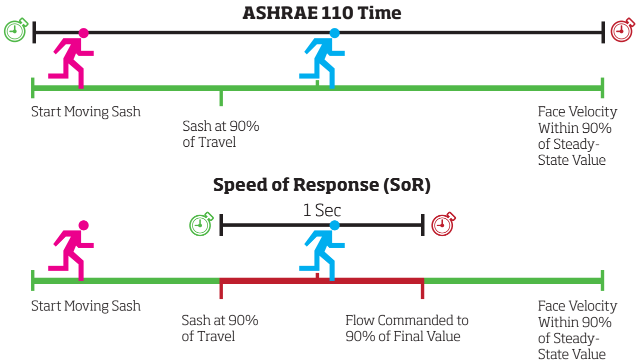
* Used with dampers
‡ Control devices can be
dampers or venturi valves

Myth #4:
"Speed-of-response" should be one second for a fume hood control system.

Reality:
The 1-Second Speed-of-Response theory most Mechanical Engineers are familiar with is a marketing tactic used to create an illusion of safety due to an arbitrary measurement of time. As you open the fume hood sash, the face velocity changes and the fume hood controller responds by bringing the face velocity back within an acceptable range. The 1-Second Speed-of-Response theory starts its timing after a sash has been moved to 90% of its total travel, and concludes timing when flow is commanded (not achieved) to 90% of the final value. The theory states this should all take place in less than 1 second. For example, if you are going to move a sash a distance of 18 inches, the moment the sash height is at 16.2 inches, the clock starts. Once the flow-control device is commanded to go to 90% of the final flow value, the clock stops.

The industry standard for testing Fume Hoods, ASHRAE 110, defines the VAV Speed of Response as "the time, measured from the first movement of the sash for the VAV system to restore the slot velocity or airflow to 90% of the average steady-state value". The clock starts the moment the sash moves (typically at a rate of 1 to 1.5 ft/sec), and stops once the face velocity is within 10% of the desired face velocity. For example, if you move a sash from fully closed to an operating height of 18 inches, at the recommended rate for sash movement, it will take 1-1.5 seconds to just move the sash. The face velocity will be fluctuating as the fume hood controller brings it to within 90% of the starting value. ASHRAE 110 does not define a set time in which this all should occur. As you can see, these methods are different and not comparable.

Think of it in terms of a relay race with two legs; the first leg of the race is the sash movement, and the second leg is the face velocity of the fume hood. Team ASHRAE 110 vs Team 1-Second Speed-of -Response (SOR). The pistol sounds, both the ASHRAE 110 and SOR runners jump out of the blocks, but the clock only starts for one of them, the ASHRAE 110 runner. Once the SOR runner completes 90% of his leg, his clock finally starts. Both runners pass the baton to the second leg of the race, the face velocity portion. The ASHRAE 110 runner continues on his path until he gets to the finish line of 90% of the steady-state face velocity, to stop his clock. At the same time, the second SOR runner takes off on his leg of the race, but stops his clock arbitrarily before he gets to the finish line.



Obviously the ASHRAE 110 team time will be higher, but we know exactly the race they ran and how long it took them to complete the race, which is to bring the face velocity back to within 90% of the desired face velocity after moving the fume hood sash. In the meantime, the SOR team time looks great, but really means nothing since they didn't start the clock until after the first leg was nearly complete and stopped the clock before the finish line.

	ANSI Z9.5	1-Second Speed-of-Response Theory
Start Time	When the sash starts moving	Once the sash movement is 90% complete
Stop Time	When face velocity is within 90% of steady-state (typically 90 to 110 FPM)	Flow is commanded to 90% of final value
Response time	Less than 3 seconds	1 second

Conclusion:
Understanding controls strategies and control devices in a laboratory is crucial for building occupants' safety. From isolated spaces like a fume hood, to entire laboratory rooms, control methods should be based on actual measurements, not assumptions. Carefully assessing your laboratory environment, and selecting the proper flow control devices and control strategy, will help maximize safety and energy efficiency.

UNDERSTANDING, ACCELERATED

TSI Incorporated - Visit our website **www.tsi.com** for more information.

USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 1 41 19 21 99	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

P/N 5001901 Rev A

Printed in U.S.A.