Abstract
In a recent educational seminar, Paul Fuson, Siemens National Business Development Manager for Life Science, explored recent updates to airflow control technologies. This paper summarizes that discussion, including emerging areas that can expand the laboratory airflow control design range and ways laboratory and critical environment managers can prepare for the next generation Smart Lab.

Laboratory airflow conditions and requirements
It’s essential that lab managers understand and address airflow conditions and performance requirements. To briefly outline:

• Flow range, today based on hazard classification: Owners need flexibility to adapt air change rates to a range of operating conditions, from low-risk to high-risk hazards, to occupied vs. unoccupied spaces, and changing space designs.

• Flow accuracy, which affects room pressurization: Different rooms have different requirements, yet a majority of design documents call out 5% as a requirement for airflow measurement accuracy. In practice, however, with that specification, the system might be ventilating spaces higher and maintaining a higher flow differential than what is truly needed in a given space.

Types of airflow control devices used in labs
Several airflow control devices are available to achieve the performance requirements for a given lab:

• Venturi air valve with metering cone
• Damper with a single blade
• Damper with dual blades
• Variable aperture devices (VADs)
Airborne hazards: These are often handled by fume hood or specialized exhaust, but even lint can be a serious problem in certain environments. Exhaust flow sensing solutions need to be robust enough to handle airborne debris.

Speed of response requirement: Many labs don’t require high-speed responses, but there is a trend toward larger, more flexible lab space designs with fewer or smaller “shared” fume hoods. These spaces can be specified with standard speed actuation on supply and general exhaust and high-speed actuation only on the fume hoods.

Modern lab environments require greater flexibility
As lab room airflow design requirements push for larger flow ranges, lower flow errors, and resilience in the face of changing airborne contaminants, they’re really reaching the performance limits of traditional flow control devices. The VADs, however, enable these greater levels of flexibility, are designed for larger turndown and wider operating range, and can help lab managers as they create the concepts and foundation for their smart labs.

How do VADs work?
VADs can provide stable and precise lab airflow control over an incredibly broad range of room requirements. They vary the position of the damper blades and use them as an orifice to change the aperture and measure pressure drop across the damper. At low flows, where the damper is mostly closed, VADs see a high pressure drop like an orifice. At higher flows, where the damper is mostly open, it looks at total pressure at the inlet, and that’s what increases the control signal.

In this way, the VAD measures pressure drop across the damper. The image above illustrates that lower flows create higher differential pressure signals. Higher flows may cause the signal to come down.
In short, VADs are designed to go lower and offer key benefits for lab managers, owners, and designers:

- Lower minimum flows – 100:1 turndown with +/- 3% accuracy
- Lower minimum operating pressure drop, which can save fan energy
- Lower sound power, which may create quieter environments
- Lower complexity – fewer sizes and configurations cover wider flow ranges, which reduces the number and complexity of duct transitions

**Why does it matter?**

This is important for one critical reason: modern lab environments need greater flexibility than ever before. Older buildings and campuses have undergone retrofits and renovations to accommodate today’s innovations. Newer lab spaces are more modular in nature, which enables organizations to adapt to whatever the day’s research may hold.

Traditional airflow control devices simply cannot support this level of flexibility, nor can they support design requirements for larger flow ranges, lower flow errors, and resilience in the face of changing airborne contaminants. But with a VAD, one device can adapt to any lab requirement, instead of constantly redesigning and replacing equipment.

Ultimately, airflow rate is almost always the answer to making places safer, healthier, and more energy efficient. Lab managers need the ability to adapt the air change rate based on what’s happening in the space. Still, a building is built but one time. To avoid the cycle of re-engineering, recommissioning, and retrofitting, these environments need flexibility, which is where VADs play an important role.
The journey to your smart lab

Consider a research lab with an open concept space. In one area of their facility, they installed a machine that mixes chemicals. While the machine is off, there is little to no potential risk to lab workers. While the machine is on, however, there could be a potential risk; that would depend on whether the lid is secured.

Technology advancements mean that nearly any properly equipped device can connect to the internet, which means monitoring can be applied to this lab’s chemical mixing equipment to check for safe or unsafe conditions. That is, the building automation system can extract the details about how the machine works, whether it’s on or off, whether the lid is secured, and other important data points.

The laboratory’s airflow can also be extrapolated and refined to exactly the area where this work gets done. This is important because for the vast majority of the time, workers in lab spaces like this one are not doing something that presents an immediate hazard. They may be setting up an experiment, writing a report, cleaning, etc. But for those occasions when they’re working at a fume hood, dispensing chemicals, opening the cabinet that stores hazardous materials, or transporting those around the lab, the environment will need a flexible, responsive system that can monitor for those changing conditions, adapt the airflow accordingly, and alert people who need that information.

With a smart lab space, lab and critical environment managers have visibility into this information and automatically make the necessary changes to protect people, research, and equipment. Likewise, they can optimize workflows and design the space for how the lab workers actually use it, which may not align with how architects and engineers designed it. Empowered with data about the space, the manager can determine that, for example, moving the solvent cabinet so there are shorter paths for transport, is prudent. Likewise, they can refine airflow controls appropriately, creating a safer workflow.