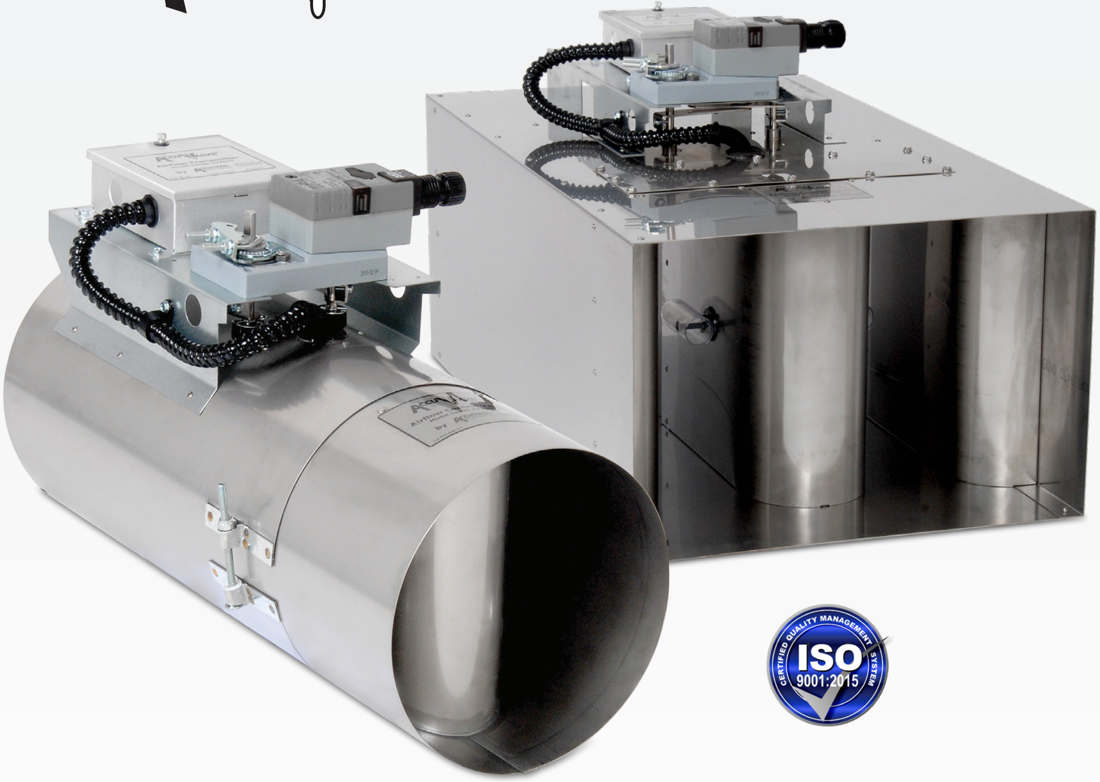
Demand Based Static Pressure Reset Control for Laboratories



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Laboratories are generally the largest users of energy in any facility. Whether in a pharmaceutical research facility, a university or a research facility, laboratories use much larger amounts of energy than other operations.

The industry has looked at ways to save on energy use by using VAV fume hood control systems as well as low flow fume hoods. These systems took a big bite out of energy use in labs.

In continuing efforts to reduce energy costs and make buildings "greener" and sustainable, Labs21 has recommended reducing the static pressure drop of the devices in the airstream for both supply and exhaust systems in labs.

The goal of this paper is to show the advantages of Demand Based Static Pressure Reset Control for use in laboratories and how it can reduce the system static pressure that the mechanical systems operate at, thus reducing the operating cost and lowering the carbon footprint of the building. Reducing the operating static pressure gives the added benefit of lowering the noise levels in the duct making the lab environment more pleasant to work in.

ASHRAE Standard 90.1

The ASHRAE Standard 90.1-6.5.3.2.3 states: "For multiple-zone VAV systems…with DDC of individual zones reporting to the central control panel, static pressure set point shall be reset based on the zone requiring the most pressure; i.e., the set point is reset lower until one zone damper is nearly wide open."

This standard simply states that through network communications the Building Automation System (BAS) should:

- Survey all of the valve positions for a given AHU
- Determine which valve is most open
- Adjust static pressure setpoint until the most open valve approaches wide open

These steps will insure that the fan is operating at the lowest possible static pressure while enabling the airflow control valves to maintain the laboratories in a safe manner for the people working in the labs. This simple control scheme provides the minimum brake horsepower for the fans which uses the minimum electrical energy.

The theme of the I2SL conference in 2006 was lowering pressure drop in mechanical systems in labs. Fig. 1 (pg.6) shows where the emphasis was placed for these systems. Lower static pressure systems have the potential for large savings, a strategy which has quite often been overlooked. I2SL, sponsored by the EPA and US Department of Energy Efficiency and Renewable Energy Federal Energy management Program, has put together a best practices guide called "Low Pressure-Drop HVAC Design for Laboratories". The guide offers suggestions for obtaining lower pressure systems in laboratories. In the guide they list among other things, lower pressure drop VAV control devices.

Another important point regarding Fig.1 is that by reducing the static pressure of the system, noise from the VAV control devices is reduced and silencers can potentially be eliminated thereby reducing the pressure in the system even further.

Low Pressure Drop Valve

In order to maximize the energy savings available it is important to use an airflow control valve that is designed to operate in a low pressure system. A word of caution is warranted here. Different valve manufacturers designate pressure drop differently. For example, mechanical type venturi airflow valve manufacturers show pressure drop between 0.6" and 3.0". This indicates the operating range of the device not the minimum operating pressure. In other words a venturi requires a minimum of 0.6" to operate and generally would require 1.5" to 2.0" of static pressure to ensure operation over the full range of the device. This is because a mechanical venturi valve uses the static pressure in the duct to become pressure independent. In essence it is powered by the fan system wasting considerable energy.

On the other hand the AccuValve® static pressure specification is less than 0.3" pressure drop at the full scale CFM for the valve. The AccuValve does not require duct static pressure to operate. It instead uses a digital airflow sensor to maintain proper airflow rates which enables it to operate at significantly lower duct pressures. This also means that if the maximum design airflow is less than the full scale CFM of the unit, the required static pressure would be even less than 0.3". If for example, the design maximum CFM is 20% less than the full scale CFM for the AccuValve than the static pressure at design flow would be less than 0.2" of drop across the valve.

System Description

The goal of **Demand Based Static Pressure Reset Control** is to operate the mechanical system at the minimum static pressure while allowing the controls to maintain a safe environment in the lab. According to the article "Increasing Efficiency with VAV system static pressure setpoint reset" by Steven T. Taylor in June 2007 ASHRAE Journal, utilizing these controls in a commercial building can provide fan savings of 30%-50%. When comparing this approach to the commonly used venturi valve, savings can easily reach these levels or greater in laboratories.

Figure 2 shows a typical lab supply system layout. The static pressure sensor is located about 2/3 of the way down the duct in both the supply and exhaust ducts. During startup the static pressure setpoints are set at a relatively high setpoint for system balance. The system operates to maintain the fume hoods at a constant face velocity and tracking control in each laboratory to maintain the supply at a fixed differential from the exhaust.

The BAS monitors the position of each airflow control valve and determines which valves are most open (i.e. the largest control output). If the control output of the valves that are most open is below 80%, the BAS reduces the duct static pressure setpoint then again looks at the position of each valve determining the valve(s) that are most open. This continues until the most open valve is approximately 80% open. This ensures that the system is operating at the minimum pressure while ensuring that there is enough pressure in the system to allow the controls to operate to maintain a safe lab environment.

Mechanically Operated Pressure Independant Valves Cannot Be Used

It is worth noting at this time that this control scheme cannot be used with a mechanical venturi-type airflow control valve. A venturi derives its pressure independence from a spring and plunger in the airstream. The spring and plunger combination is used to compensate for changes in static pressure in the duct. The shaft is "commanded" to a position where it is calibrated for a given flow. The spring/plunger then compensate for static pressure changes in the system. Therefore, regardless of the static pressure in the duct (between 0.6" and 3.0") the valve will always be "commanded" to the same position for a given CFM. Control output or valve position is not indicative of static pressure in the system, so this signal cannot be used to reduce the duct static pressure.

Therefore, the safest design for a high pressure drop venturi-type valve is to set the system to a relatively high static pressure to ensure that all valves in the system will operate properly regardless of their location in the duct and the changes in the system as fume hoods open and close. It is also important not to operate close to the minimum allowable static pressure of 0.6" because the friction coefficient of the plunger riding over the cone will change as the shaft becomes coated with exhaust particles thus affecting its responsiveness and accuracy in low static pressure conditions.

AccuValve® Can Be Used

The AccuValve provides "Ready" Demand Based Static Pressure Reset without the need for additional hardware. Since the AccuValve is not a mechanical device and actually measures airflow the valve will modulate to whatever position that is required providing the desired airflow. If the static pressure in the system is high it will modulate to a more closed position and if the static pressure in the system is lower it will modulate to a more open position. Because of this the AccuValve can be used with ASHRAE Standard 90.1-6.5.3.2.3 without additional hardware to provide the minimum operating pressure in the duct for maximum savings.

Savings

The savings that can be achieved using Demand Based Static Pressure Control compared to a fixed static pressure setpoint will vary based on a number of conditions including:

- Lowest operating pressure drop of the valve
- Duct conditions such as straight runs into the valve
- Whether the valve actually measures airflow
- Electric utility rates
- CFM of the system
- Efficiency of the selected fan system

Lowest Operating Pressure Drop

An airflow valve that is capable of operating at a lower static pressure returns the largest energy savings. The AccuValve offers the lowest pressure drop of any critical environment airflow control valve on the market. Venturi valves can easily require an ***additional*** 0.75" to 1.25" to operate safely in a lab.

Duct Conditions

While a number of valves on the market state that no straight runs of ductwork upstream and downstream of the valve are required, it is important for the design engineer to attempt to use best engineering practices in locating airflow control valves in order to reduce operating pressure. There is a penalty incurred when mounting any valve in ducts right after an elbow or similar conditions. System effect of the valve being located in these types of locations cause static pressure losses. This is true for any type of airflow control valve. When mounted in these locations the system will need to operate at higher system static pressures which of course relates to higher operating costs.

Where possible, straight duct runs should be designed into the ductwork before and after the airflow control valve to minimize system effect and static pressure losses. Where that is not possible, the inherent design of the AccuValve which does not require straight runs ***and*** operates at a much lower pressure than the venturi valve is the best engineering design choice. Reference Accutrol paper "Airflow Measurement without Straight Runs – By Design."

True Airflow Measurement

While it would not appear that measuring airflow would have an impact on static pressure in a duct system, there are hidden costs of not measuring airflow. Through the measurement of true airflow, the valve will go to whatever position is necessary to achieve the airflow that is required. This will occur regardless of the static pressure in the duct. On the other hand, a venturi valve which relies on a calibrated spring and plunger only "knows" to drive to a specific valve position and relies on the spring to compensate for pressure changes. If the pressure is too low, the spring will seat against a stop and will no longer control. If the pressure is low and the shaft/plunger has accumulated particulate, the increase in friction may not allow the spring/plunger to overcome the static pressure changes and the valve will not control properly. Because of these issues with the venturi design, static pressures in the duct are required to be higher than in a duct where true airflow measurement is the basis of control. In addition, where safety is important, true airflow measurement gives the user the knowledge that their critical environment is being controlled and monitored for "actual" conditions, not "assumed" conditions.

Calculating Static Pressure & Cost Savings

Savings based on static pressure in the system is based on the following equation:

$$\frac{\text{CFM} \times \Delta\text{SP}}{6345 \times \text{EFF}_f} = \text{HP}$$

Where…

CFM = Airflow in duct (CFM)

ΔSP = Reduction in system air pressure drop by using a low pressure duct device ("wc)

EFF_f = Fan efficiency (%)

HP = Fan brake horsepower (BHP)

Assumptions…

EFF_f = 62%

ΔSP = 0.75"wc

CFM = 50,000 (supply)

Based on the above equation we would see a reduction of 9.53 BHP.

To determine the savings that can be seen for this system the following equation would be:

$$\frac{\text{HP} \times .746 \times \text{Hrs} \times \text{Yrs} \times \$/\text{KWH}}{\text{EFF}_m} = \text{HP}$$

Where…

HP = Fan brake horsepower (BHP)

Hrs = Hours of operation per year (Hours)

Yrs = Years of operation (Years)

KWH = Cost of electricity (KWH)

EFF_m = Motor efficiency

Assumptions…

Hrs = 8760

Yrs = 20

KWH = $0.12/KWH

EFF_m = 0.92%

Based on the above equation, the building owner would see a savings of $162,465 over the 20 year life of the system for the supply fan. He could expect similar savings for the exhaust, giving a savings of $324,930 for the entire system.

These savings are quite significant. Designing a laboratory as VAV gives the owner savings by reducing the CFM thereby reducing operating cost and lessening the impact on the environment. It would be counter productive to give some of that energy savings back by using a high pressure duct device such as a venturi valve instead of a low pressure device such as the AccuValve.

With the lower pressure drop afforded by using Demand Based Static Pressure Reset Control and low pressure drop airflow control valves, it is possible that silencers can be eliminated thereby reducing the static pressure in the system even further giving even greater savings in energy.

To obtain a spreadsheet which calculates energy savings for your application please contact your Accutrol representative.

Closed Loop System

As stated above, Demand Based Static Pressure Reset Control, as described in Standard 90.1-6.5.3.2.3, can only be achieved with a closed loop feedback control approach. An open loop system merely moves a valve to a preset position based on a factory calibrated flow rate and a spring compensates for static pressure changes. In an open loop system, merely knowing the valve position does not help to determine whether the static pressure in the duct is high, low or at the optimized setpoint.

By measuring airflow with a digital airflow system like vortex shedding and using that flow signal for feedback to control to an airflow setpoint, valve positions can be surveyed to determine if the static in the duct is too high. The BAS can now optimize the overall building system to operate at the lowest static pressure while maintaining a safe laboratory environment.

Also of importance is the type of airflow control valve being used since there are different designs in the marketplace.

While a single blade damper does measure airflow the airflow measuring device that is typically used is very non-linear and operates best over about a 3:1 turndown in the center of the control output. It is most non-linear when in the upper or lower 30% of the device (near open or closed), which is the most important area when utilizing static pressure reset control. Demand Based Static Pressure Reset Control is designed to make the valve operate near its open position. A single blade damper is non-linear and because of this, is subject to continual position hunting creating a dangerous situation in the lab and shorter lifespan of the actuator.

Summary

Through such organizations such as I2SL, the EPA, US Department of Energy Efficiency, Green Building Council and many others, owners and designers have been brought to the forefront of sustainable issues.

Laboratories are generally the largest users of energy in any facility. Many owners and engineers adopted VAV control systems for energy savings and are now looking at ways to save additional energy.

As stated above, lower static pressure system design can contribute greatly to sustainability goals and give the building owner a tremendous opportunity towards saving a large amount of energy dollars every year that the system is in operation.

The ISO 9001:2015 certified AccuValve is a low pressure drop VAV control device. Its inherent design allows it to be utilized with Demand Based Static Pressure Control further reducing the static pressure in the system and maximizing energy efficiency.

The utilization of these airflow control valve technologies with the combined approach of Demand Based Static Pressure Control, offers the safest airflow control system (closed loop control) with the lowest operating cost.

Figure 1 – Low Pressure Drop Design Summary (Labs21)

Component	Standard	Good	Better
Air handler face velocity	500 fpm	400 fpm	300 fpm
Air handler pressure drop	2.7 in. w.g.	1.7 in. w.g.	1.0 in. w.g.
Energy recovery device pressure drop	1.0 in. w.g.	0.6 in. w.g.	0.35 in. w.g.
VAV control device pressure drop	Constant volume, n/a	0.6 - 0.3 in. w.g.	0.1 in. w.g.
Zone temperature control coils pressure drop	0.42 in. w.g.	0.2 in. w.g.	0.0 in. w.g.
Total Supply and exhaust ductwork pressure drop	4.5 in. w.g.	2.25 in. w.g.	1.1 in. w.g.
Exhaust Stack Pressure drop	0.7 in. w.g. full design flow through entire CV exhaust system	0.7 in. w.g. full design flow through fan and stack only, VAV system with bypass	0.75 in. w.g., averaging half the designflow, VAV system with multiple stacks
Noise control (silencers)	1.0 in. w.g.	0.25 in. w.g.	0.0 in. w.g.
Total	10.32 in. w.g.	6.15 in. w.g.	3.3 in. w.g.
Approximate fan power requirement	2.0 (W/cfm)[2]	1.2 (W/cfm)[2]	0.6 (W/cfm)[2]

[1] Good Practice corresponds to the use of low-pressure-drop sound attenuators. Better practice corresponds to eliminating the need for sound attenuators by appropriate duct design and layout.

[2] To convert pressure drop values into the commonly used metric W/cfm, these assumptions were used in the fan power equation: 0.62 fan system efficiency (70% efficient fan, 90% efficient motor, 98% efficient drive).

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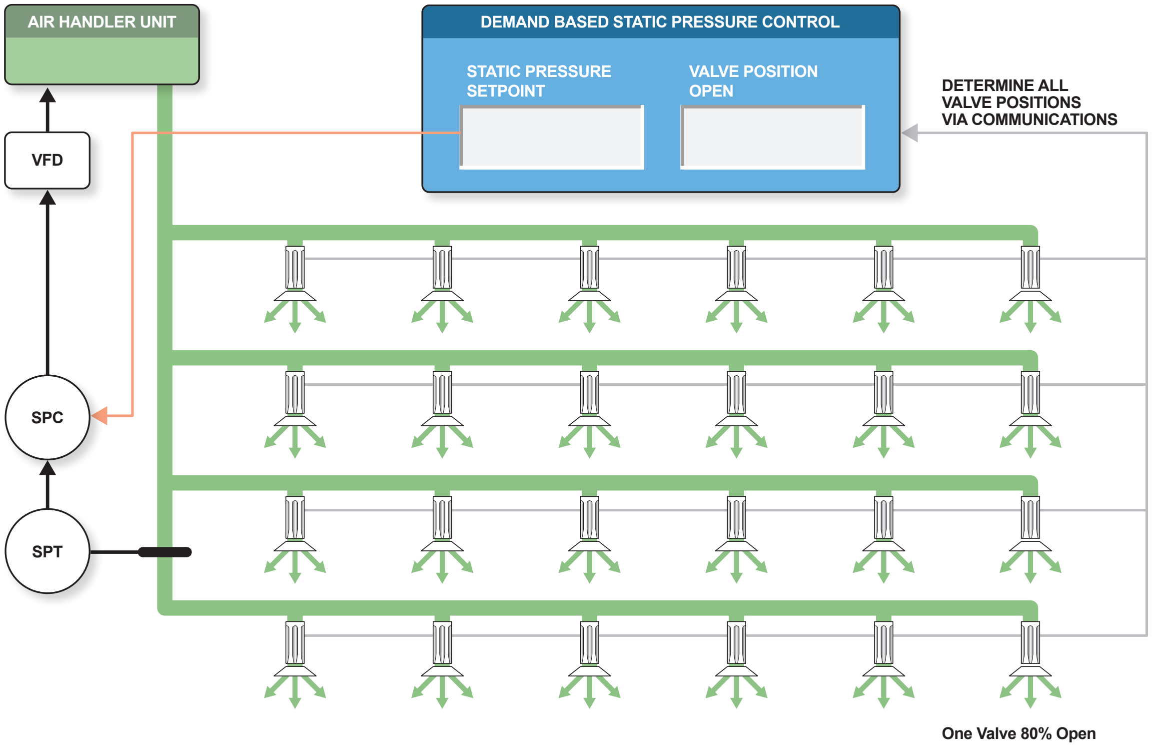
Figure 2 – Demand Based Static Pressure Reset Control Schematic



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