What is the true cost of static pressure?

Phoenix Controls
Corporation

Printed in USA

What is the true cost of static pressure?

Energy consumption is among the biggest line items in the budget of any facility with a critical environment. That's because higher volumes of energy are required to ensure comfort, health and safety in these spaces. For example, according to the U.S. Environmental Protection Agency, "laboratories typically consume 5 to 10 times more energy per square foot than do office buildings. And some specialty laboratories, such as cleanrooms and labs with large process loads, can consume as much as 100 times the energy of a similarly sized institutional or commercial structure."[1] Hospitals struggle with similar issues in their round-the-clock operations.

Of all of the energy costs in a critical environment, the demands from ventilation tend to be the highest. The ventilation system alone can consume as much as 50% of a building's energy expenses. As a result, energy-efficient designs in ventilation systems are becoming increasingly important. The biggest challenge in these designs is to cut costs without cutting corners, preserving safety while saving energy.

When an engineer is designing a new ventilation system or upgrading an existing one, the total energy input for the system is examined. The total energy input required for an airflow system is dependent on:

- Fan system efficiency
- Airflow (cubic feet per minute, or CFM)
- System pressure

In most cases, fan system efficiency has already been optimized. Therefore, to reduce energy consumption even further, airflow and system pressure requirements must be considered. In variable air volume (VAV) systems, a range of decisions must be made to optimize the design. Of these, the most crucial decision is in selecting devices that will provide the best performance, along with the greatest energy savings.

The true cost of increased system pressure involves understanding how terminal boxes operate and their true static pressure requirements. It also involves understanding the limitations of these devices in terms of reducing airflow. Designers often choose between terminal boxes, which measure airflow, and venturi valves, which typically meter flow. In some cases, they select terminal boxes in order to reduce static pressure requirements. The justification is that terminal boxes consume less energy than venturi valves due to their specifications stating low static pressure requirements. In reality, designers select fans and operate systems at higher than these minimum static pressure requirements to ensure controllability. As a result, the energy savings that a venturi valve can provide far outweigh the potential increase in static pressure requirements.

How is this possible? To answer this question, we need to understand how terminal boxes and venturi valves function. A brief description of how each device works is provided in the next section, followed by a comparison of each device and recommendations for reducing energy consumption in critical and semi-critical airflow control systems.

How Terminal Boxes and Venturi Valves Work

The purpose of the terminal box and venturi valve is to control airflow, but the methods to achieve this are very different for each device. Of particular note is each device's ability to respond to changes in static pressure.

Terminal Boxes

A sensor, typically a pitot tube, measures the velocity pressure at its location (see Figure 1). The airflow is calculated based on this velocity pressure measurement and the duct diameter. This calculation is used by a controller to adjust the damper in the terminal box to maintain the required flow.

Venturi Valves

Venturi valves combine a mechanical pressure-independent regulator with a position/airflow controller to meet the unique requirements of a critical space's airflow (see Figure 2). These valves maintain a fixed flow

Figure 1. Terminal Box

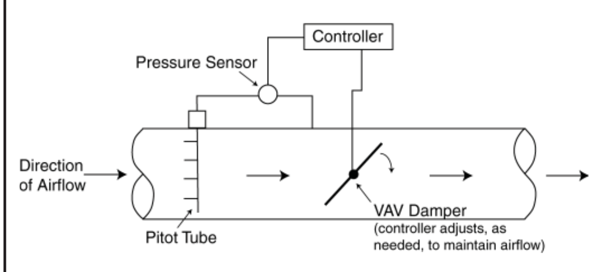
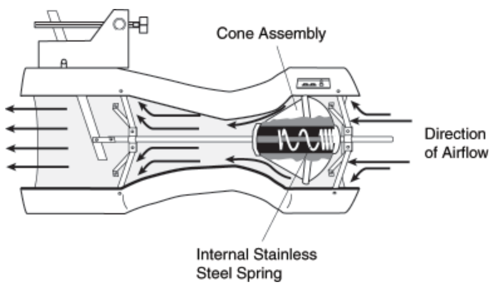


Figure 2. Venturi Valve



of air by adjusting to changes in static pressure. Each valve has a cone assembly with an internal stainless steel spring. The cone assembly adjusts the open area of the venturi to the system pressure so that the flow set point is maintained continuously and instantaneously.

When there is low static pressure, less force is applied to the cone, which causes the spring inside to expand and pull the cone away from the venturi. As static pressure increases force on the cone, the spring compresses and the cone moves into the venturi, reducing the open area.

Some venturi valves measure flow for control, while others, like the Phoenix Controls Accel® II valve, use the flow metering approach. Metered valves are characterized in the factory, which ensures accurate control across a significant range.

A Comparison of Terminal Boxes and Venturi Valves

Terminal Boxes

Although a minimum static pressure is not required by VAV box manufacturers, it is recommended that designers use at least 0.5 to 0.6 in WC to minimize life cycle costs.[2] This solution works well in most buildings, but in critical or semi-critical spaces, accuracy is more important. To ensure sufficient accuracy of the flow sensor, designers generally increase minimum velocity and static pressure to improve the flow sensor's performance. Often designers expect 0.8 inch or more of static pressure for the last device on the system. To increase velocity and meet controllability requirements, VAV boxes are generally selected at the smallest possible size to meet the required airflow. This results in a significant increase in the static pressure required (see Figure 3, where 0.5 inch WC is required to flow 1000 CFM through a 10-inch box).

> "In 18 years of experience, I've never seen boxes set to operate below 0.5 or 0.6 inches of static pressure."
>
> Todd Walter
> TABB Certified Contractor
> Comprehensive Test and Balance, Inc.

Despite claims that terminal boxes can provide stable control at 0.1 inch WC, they generally are designed at a higher static level. "(The fan) must maintain 0.8 to 1.25 inches of water column throughout the system to ensure that the furthest terminal box functions properly," said Wayne Schexnayder of Coastal Air Balance Co., Inc. If boxes fall below 0.5 inch WC, issues with control may arise. "In 18 years of experience, I've never seen boxes set to operate below 0.5 or 0.6 inches of static pressure," said Todd Walter, TABB Certified Contractor at Comprehensive Test and Balance, Inc. "On a recent job, the system pressure degraded, and a box had only 0.5 inch of static pressure and 0.08 inch of velocity pressure available. As a result, the box lost control and was constantly hunting to find the set point."

In addition, the sensor that measures the velocity pressure can "drift," or become dirty, over time. This decreases the measured flow and results in increased room air change rates, improper room pressurization and increased energy costs.

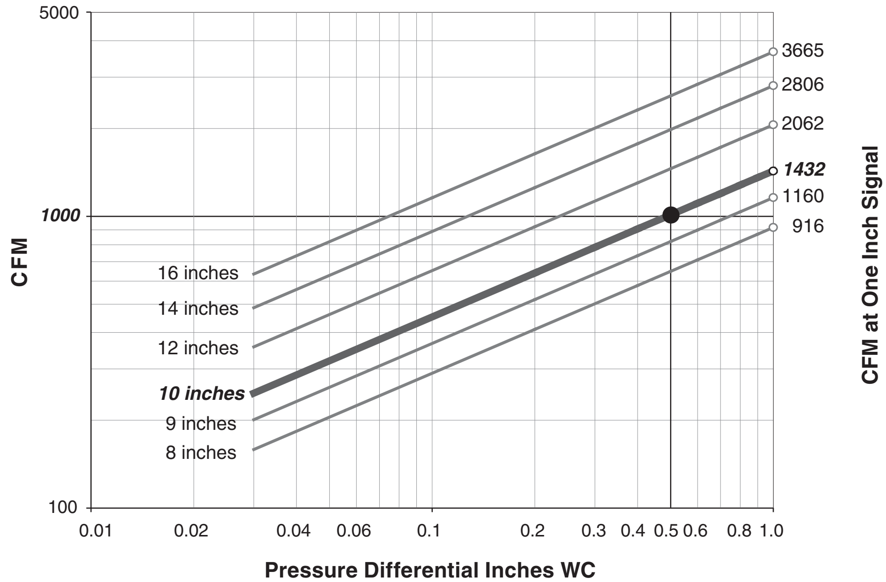
Venturi Valves

Manufacturers require a minimum of 0.3 to 0.6 inch of static pressure drop across a venturi valve. This amount of static pressure is necessary to activate the cone and maintain control. In contrast to the terminal box, once the cone is activated, no scheduled maintenance is required and the venturi valve is accurate across the valve's entire flow range. The accurate and presssure-independent nature of the venturi valves enables simple, progressive valve balancing, which reduces costly start-up time. "After you install a Phoenix Controls venturi valve, there is some minor set up and then nothing else to do...it cuts my set-up time significantly," Walter said.

Performance is not the only concern when selecting terminal devices. In situations where space is constrained, the venturi valve can maintain flow without minimum straight duct run requirements, which decreases costs and increases the flexibility of the design.

Although manufacturers' static pressure requirements favor terminal boxes, multiple criteria, such as accuracy, maintenance and design flexibility, must be considered when deciding whether to select a terminal device or venturi valve.

Figure 3. VAV Box Selection Chart



As shown above, a 10-inch box requires 0.5 inch WC to meet a flow of 1000 CFM.

Options for Saving Energy in Airflow Control Systems

In order to maximize energy savings, designers must optimize energy consumption within the system without compromising safety. Since safety requirements change based on the specific application, the best energy savings option will vary accordingly.

Saving Energy by Lowering Static Pressure

There are many ways to lower static pressure in a building (see Table 1). The option that provides the greatest impact is to increase the duct size in the building, which can reduce static pressure from 1.2 to 3.5 inches WC. Selection of VAV control devices offers a more modest savings of, at most, 0.3 to 0.5 inches WC. This level of system pressure reduction may not even be realized, based on the controllability issues previously noted.

Another consideration for terminal device selection is the duct requirements necessary for accurate control. “While designs look good on paper, installation is one of the biggest problems today,” Schexnayder said. “Sheet metal contractors have to maneuver to avoid pipes and conduit, which increases resistance.” Terminal boxes require long, straight duct lead-in and exit runs to function properly. The straight length may require additional elbows and more duct between airflow devices and the manifold, resulting in additional pressure consumption of up to 0.2 inch WC. This requirement will generally eliminate any pressure drop advantages of using the terminal boxes. In contrast, the venturi valve functions consistently regardless of its location in the duct, which allows builders to minimize duct length.

Table 1. Static Pressure Reduction Strategies
(in order of power consumption savings potential)

Strategy	Savings (in inches WC)
Alter duct design	1.2 to 3.5
Use air handlers low face velocities	1.5 to 2.0
Choose larger heat recovery devices	0.5 to 0.75
Selection of VAV control devices	0.3 to 0.5

Although on paper a terminal box can operate with as little as 0.1 inch WC pressure drop, in applications where directional airflow is required, the difference between a terminal box and a venturi valve is negligible.

However, assuming modest reduction is realized by VAV terminal selection may or may not impact energy at all, depending on where the fan is on its curve, how big the fan is and other strategies for reducing static pressure. For a typical 30,000 CFM system, 0.2 inch WC could cost, at most, $600 per year (assumptions are based on 10 cents per kWh with total one-year usage at 8760 hours). This system could serve several labs or an entire hospital floor.

Saving Energy by Reducing Airflow

Airflow is the other major component of a ventilation system that should be considered when trying to reduce energy consumption. In order to flow 1000 cubic feet per minute (CFM), a 10-inch terminal box and 10-inch venturi valve could be selected. When the goal is to reduce airflow in an unoccupied space, the venturi valve outperforms its competitor by accurately exhausting as little as 50 CFM, compared to a minimum of 250 CFM required from a terminal box. When each CFM costs $6 annually, this difference will add up for every exhaust valve in the system.

For example, assume a laboratory has 30 fume hoods on a 30,000 CFM system. The maximum airflow is, therefore, 1000 CFM. The venturi valve can achieve a minimum of 200 CFM or lower, while the terminal box is typically limited to a 250 CFM minimum. The airflow difference between the two options is 50 CFM, so based on our assumption that each CFM costs $6 annually, this could result in a $300 difference for each fume hood. If the fume hoods operate at minimum flow 50% of the time, a venturi valve outperforms the terminal box by saving $150 per year for each fume hood, or a total of $4500 annually for the space.* This significantly outweighs the impact of potential system static reduction of $600 noted above by using terminal boxes.

** Note that the airflow varies, based on how often the space is occupied and the minimum airflow required when the space is occupied. This affects energy consumption costs and savings.*

Summary

The true cost of increased system pressure involves understanding how terminal boxes operate and their true static pressure requirements. It also involves understanding the limitations of terminal boxes in terms of reducing airflow.

Saving energy saves money and is good for the environment. It seems simple, and with the Phoenix Controls venturi valve, it is. The venturi valve operates with the least additional system pressure drop. It allows for the greatest turndown in airflow. It demonstrably saves more energy than a terminal box while maintaining its proven standards of safety, reliability and performance.

Footnotes

[1]U.S. Environmental Protection Agency, *Laboratories for the 21st Century: An Introduction to Low-Energy Design*, August 2000, http://www.labs21century.gov/toolkit/ledintro.htm.

[2]Taylor, Steven T., "Sizing VAV Boxes," *ASHRAE Journal*, March 2004, p. 34.

References

Schexnayder, Wayne, Coastal Air Balance Co., Inc. Interview, August 4, 2006.

Taylor, Steven T. "Sizing VAV Boxes." *ASHRAE Journal*, March 2004, pp. 30-36.

U.S. Department of Energy, http://www.eia.doe.gov/.

U.S. Environmental Protection Agency. *Laboratories for the 21st Century: An Introduction to Low-Energy Design*. August 2000, http://www.labs21century.gov/toolkit/ledintro.htm.

Walter, Todd, TABB Certified Contractor at Comprehensive Test and Balance, Inc. Interview, July 31, 2006.

Weale, John, Peter H. Rumsey, Dale Sartor and Lee Eng Lock. "Laboratory Low-Pressure Drop Design." *ASHRAE Journal*, August 2002, pp. 38-43.

Honeywell

Phoenix Controls
Corporation

For additional information and a listing of our global offices, please visit our Web site at www.phoenixcontrols.com or call (800) 340-0007.

MKT-0123 MPC-0824