ENGINEERING UPDATE

FEBRUARY 2015 - **VOLUME 17**

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LABORATORY AIRFLOW CONTROL VALVE FUNDAMENTALS

By Jarvis Penner,
– Product Manager, Critical Controls

The control of air distribution in modern laboratories is typically accomplished by using air terminal units. An air terminal unit will regulate the volume of conditioned air from the central air handling device to maintain thermal conditions and minimum fresh air volumes in the occupied space. In laboratories, room pressure is also controlled using the air terminal. The selection of air terminals is a critical component of the overall laboratory HVAC system and has a direct impact on the turndown, operating pressure, and acoustics of the space. This article provides an overview of the differences between a typical blade damper terminal unit and a venturi valve.

MECHANICAL OPERATION

A venturi valve is a mechanically pressure-independent control device that utilizes a venturi-shaped housing containing a cone with an internal spring to mechanically compensate for pressure changes in the system. A rise in system pressure increases the force against the cone, compressing the spring so that the cone travels deeper into the valve throat. As a result, the open area within the valve is reduced to maintain the preset flow at the higher pressure. A decrease in pressure allows the spring to extend, driving the cone out of the valve throat. In turn, the open area within the valve increases to maintain the preset flow at the lower pressure.

Since the venturi valve is mechanically pressure-independent, the relationship between airflow and cone position can be mapped to the controller to provide flow feedback without the use of airflow measuring devices in the airstream.

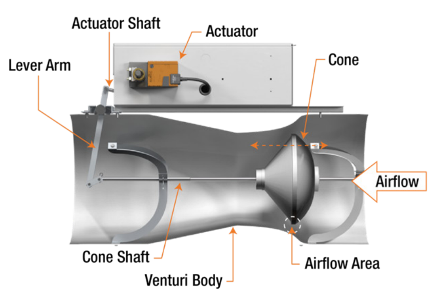
A blade damper is inherently a pressure-dependent control device. To maintain airflow as the system pressure changes, a blade damper must be connected to an airflow controller to modulate the damper position. As the pressure in the system increases, the controller will close the damper to maintain the flow setpoint. As the pressure in the system decreases, the controller will open the damper to maintain the flow setpoint. A typical blade damper requires direct airflow measurement using in-stream flow sensors to provide a signal to the controller.

OPERATING PRESSURE

Venturi valves have defined operating pressure ranges where pressure independence is achievable. The ranges are typically classified as low or medium pressure. Minimum operating pressure or drop is the value at which the spring can no longer extend to position the cone to maintain the preset flow. The minimum operating pressure is 0.3” W.C. for low-pressure valves and 0.6” W.C. for medium-pressure valves. Maximum operating pressure or drop is the value at which the spring can no longer compress to maintain the preset flow. The maximum operating pressure is 3.0” W.C. for both low- and medium-pressure valves.

Blade damper minimum pressure is defined by the pressure drop across the device with the damper fully open at the rated flow. Blade damper terminals commonly operate down to 0.01” W.C. The maximum pressure drop is typically defined as the value at which the airflow becomes difficult to control and can be in excess of 3.0” W.C.

Venturi Valve



Single Blade Damper

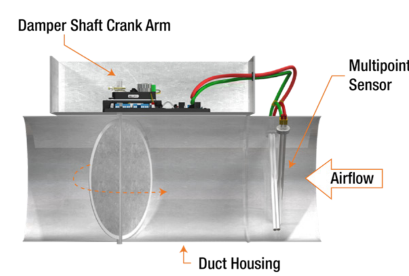


Diagram showing the mechanical components of a venturi valve and single blade damper

TURNDOWN

Airflow turndown is frequently used to express the airflow control range without the need to have specific minimum and maximum airflow rates. Blade damper control valves typically have a larger airflow capacity than a venturi air valve of the same diameter, but the turndown ratio is reduced due to the increase in minimum airflow. As shown in **Figure 1**, the turndown ratio of the venturi valve can be as high as 20:1 compared with the 6:1 ratio of a conventional blade damper valve.

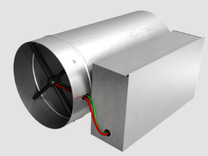
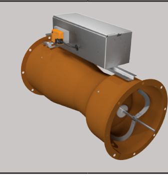
Valve Size	Conventional Valves (> 0.01" W.C.)			Low Pressure Venturi (0.3" - 3.0" W.C.)			Medium Pressure Venturi (0.6" - 3.0" W.C.)		
	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**	Min. Flow (CFM)	Max. Flow (CFM)	**Turndown Ratio**
Size 8	160	800	**5:1**	35	500	**14:1**	35	700	**20:1**
Size 10	225	1350	**6:1**	50	550	**11:1**	50	1000	**20:1**
Size 12	350	2100	**6:1**	90	1200	**13:1**	90	1500	**16:1**
Size 14	500	3000	**6:1**	200	1400	**7:1**	200	2500	**12:1**
Product									

Figure 1 - Turndown comparison between blade dampers and venturi valves

AIRFLOW ACCURACY

Venturi valve airflow accuracy depends entirely on the flow-versus-position relationship of the valve that is completed during factory calibration. Venturi valves typically have airflow accuracies within +/- 5% of flow signal. The stable opening characteristic of venturi valves allows for high-resolution control at low flows as shown in **Figure 2**. Venturi valves do not have straight inlet or outlet requirements to maintain airflow accuracy but only require the device to be within the operable pressure range.

Blade damper airflow accuracy depends on the accuracy of the flow measuring sensor used for control. These flow measuring sensors typically require several duct diameters of straight duct leading into and out of the device to provide smooth laminar flow. The transducer error can also negatively impact the accuracy of airflow measurement at low flows. An example using a typical HVAC transducer with 1" W.C. range and error of 1% full scale is shown in **Figure 4**. In addition, the quick opening characteristic of blade dampers makes high-resolution control at low flows difficult, as shown in **Figure 3**.

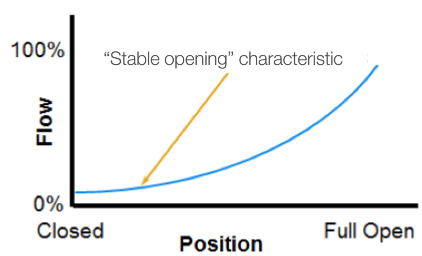


Figure 2 - Flow characteristics of the venturi valve

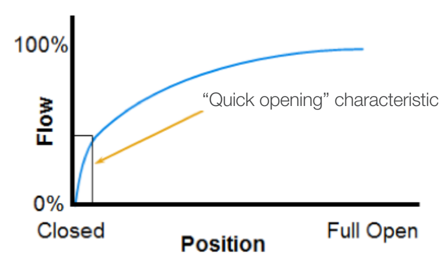


Figure 3 - Flow characteristics of the blade damper control valve

CFM	Actual VP*	Transducer Error	Measured VP	Measured CFM	Error
1000	0.452	0.01	0.462	1011	1%
500	0.113	0.01	0.123	521	4%
200	0.018	0.01	0.028	249	25%
100	0.004	0.01	0.014	179	79%

*Size 10 blade damper control valve; K-Factor = 1487

Figure 4 - Airflow transducer accuracy chart

SOUND

Venturi valves will typically generate higher discharge and radiated sound power levels when compared to blade dampers. This is a result of the internal cone continually restricting a portion of the open area within the venturi valve. Sound attenuation may need to be considered if acoustics is a concern in the design.

SUMMARY

The venturi valves and blade dampers have very different mechanical characteristics that can provide advantages depending on the application. It is critical to understand the mechanical limitations of the device prior to writing job specifications. The next Engineering Update will focus on how the mechanical operation of a venturi valve affects speed of response and how changes to laboratory standard ANSI Z9.5 affect what valve type should be specified.

Valve Size	Flow (CFM)**	Terminal Discharge NC Value*	Terminal Radiated NC Value *	Venturi Discharge NC Value*	Venturi Radiated NC Value*
Size 8	400	21	21	31	23
Size 10	750	25	21	37	29
Size 12	900	27	21	32	24
Size 14	1500	26	26	41	44

*NC values are calculated based on typical attenuation values outlined in Appendix E, AHRI Standard 885-2008

** Flow measurements taken at 1.5" w.c. pressure drop

Figure 5 - Valve data obtained in accordance with AHRI Standard 880-2011 and ASHRAE Standard 130-2008

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PRODUCT FEATURE: PRICE MODEL 85 RETURN GRILLES

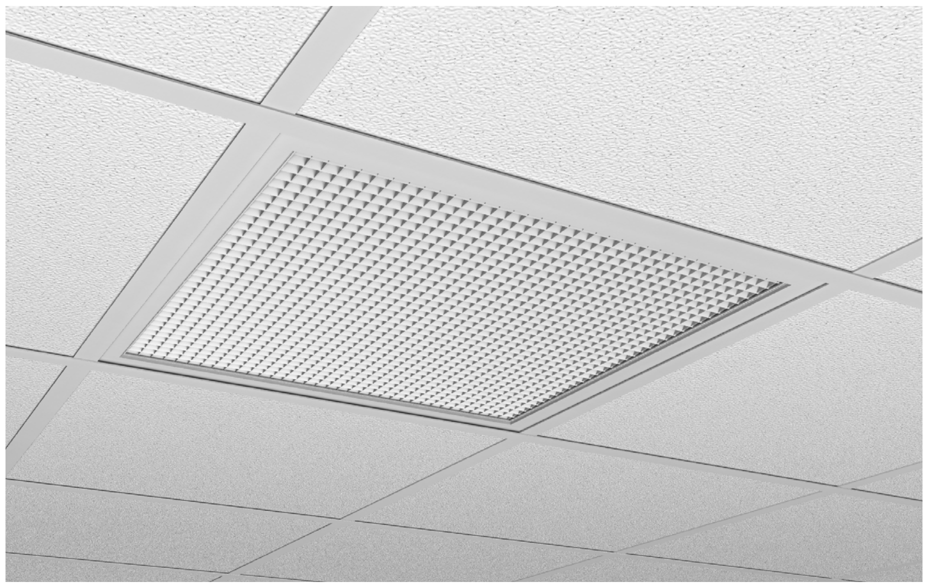
By Matthew Joyce, P.Eng.,
– Product Engineering Manager - GRD

In most buildings, return air grilles typically serve two main purposes, one of which is ventilation, and the other is architectural. Egg crate grilles are a popular and effective choice for return air applications, offering both low resistance to airflow and appealing aesthetics. However, in some applications it is not only the appearance of the grille itself that matters; the ceiling plenum may contain cables, piping, insulation, and ceiling structure that can be visible through the grille.

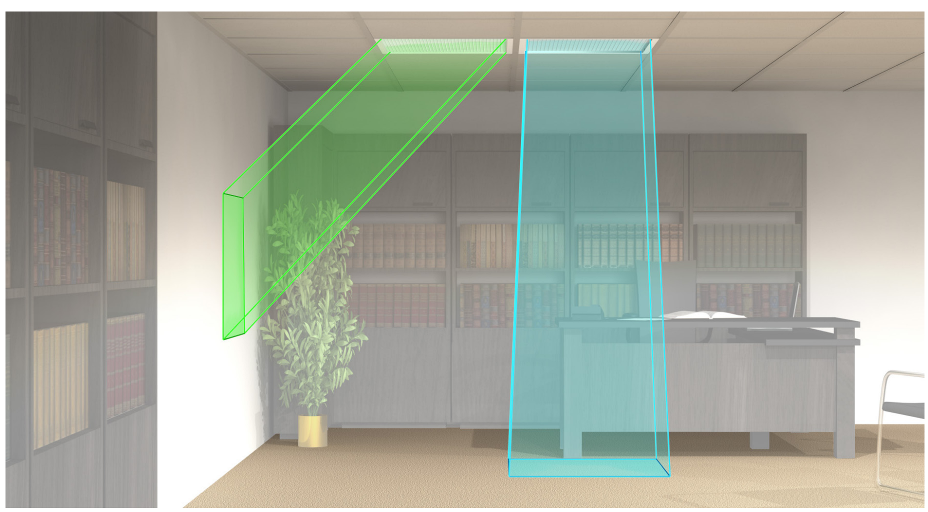
Enter the model 85 return grille, the newest member of Price's extensive GRD offering. The model 85 features a cellular construction similar to egg crate grilles, but with one set of louvers angled at 45 degrees. This ensures that the model 85 effectively blocks sightlines through the grille when viewed head on and from three sides, and reduces the amount of light diffused into the plenum space. Price also offers the model 85 in the widest selection of sizes, frame styles, and panel options in the industry. This provides an optimum combination of low pressure drop, low generated noise, and excellent visual appeal.

Features of the model 85 return grille:

- 45° angled core offers high resistance to sight-through
- Choice of lay-in panels or extruded aluminum frames for easy integration into various wall and ceiling designs
- Durable white powder coat finish



The aesthetically pleasing model 85 grille effectively blocks sightlines when viewed head on and from three sides



Line of sight through model 85 return grille shown in green, compared with straight egg crate grille shown in blue

Further information can be obtained by downloading performance data and submittal drawings from www.**priceindustries**.com, or by contacting our application engineering department.

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TECH TIP: A BRIGHT FUTURE FOR CHILLED BEAMS

By Jerry Sipes, Ph.D., P.E.
– Vice President of Engineering

Building energy efficiency, sustainability, and interior aesthetics are concepts that at times may appear to be at odds with each other. The designer must balance those concepts while meeting the design goals of the building. Designers are always seeking more efficient methods of providing a comfortable and pleasing occupied space while meeting both budget restrictions and energy code requirements.

The energy codes are in continual modification with the goal of improved building energy efficiency. One metric that can be used to look at the ongoing changes in building energy codes is the Annual Energy Outlook 2014 published by the U.S. Energy Information Administration (EIA). The EIA estimates that between 2012 and 2040, commercial building energy consumption will grow by 0.6% per year, commercial floor space will increase an average of 1% per year, and the energy intensity (energy use per square foot) will decrease by 0.4% per year. This decrease is expected to come from federally mandated gains in equipment efficiency and reduced consumption by space heating, cooling, lighting, and plug loads. This data indicates that as time passes, it will become increasingly difficult to balance the energy code requirements, budget restrictions, and interior aesthetics.

What is the designer to do?
Can the design goals be met while reducing energy?

Traditionally, the majority of buildings have used air movement to transfer both the fresh air and thermal energy needed to properly heat, cool, and ventilate our occupied spaces. Air is not a very energy dense media; to provide the necessary volume of thermal energy, a significantly higher volume of air is often required than the volume that is necessary to provide fresh air.

Due to the high volumes of air and the inherent inefficiency in moving air, it is becoming more challenging to use the traditional all-air HVAC design approach to meet the higher efficiency levels required by our increasingly restrictive energy codes. One way to find energy efficiency gains in the HVAC system is to consider alternative methods of providing and transporting thermal energy for heating and cooling. Designers are considering the use of water as the transport media for the bulk of the thermal energy transfer rather than just air. This is due to the ability of water to store significantly more thermal energy per unit volume than the same volume of air. Due to the higher energy density of water and higher pumping efficiency, it takes less transport energy (pump or fan) to move the same amount of thermal energy into and out of the occupied spaces with water than it would using air. Simply put, air is not very energy dense and costs more when used as the only media to provide all of the building's heating and cooling. Of course, a certain amount

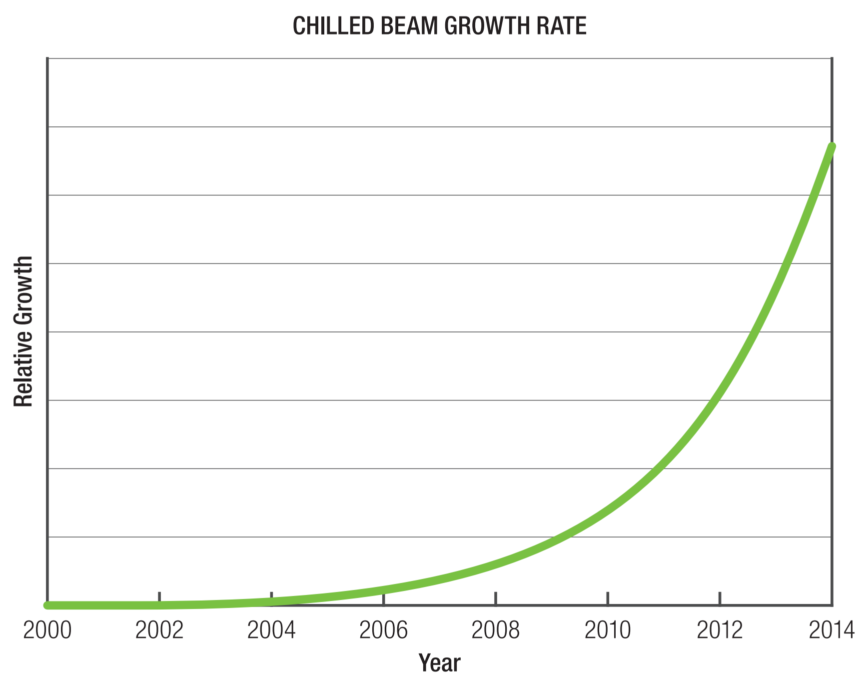

Figure 1 - Relative growth of chilled beam projects in the United States.

of air movement is required for the proper code required ventilation of the occupied space. It has been estimated that the use of an air-water HVAC system that provides the required air volumes for ventilation and humidity control can lead to a reduction in building brake-horsepower of 10 to 20% depending on the overall mechanical system design.

Active chilled beams are often considered as they incorporate the distribution of the ventilation air and use room air induced across a water coil to transfer sensible thermal energy (heating or cooling) to the occupied space.

When active chilled beams were first introduced to the North American market, there were limited choices for the designer to consider, and many times they did not meet the aesthetic and architectural integration goals. That being said, many solutions exist today to integrate active chilled beams seamlessly in the building of the most demanding customers.

BENEFITS/DRAWBACKS

Active chilled beams have both benefits and drawbacks that should be evaluated, and may not be appropriate for all building/occupancy types.

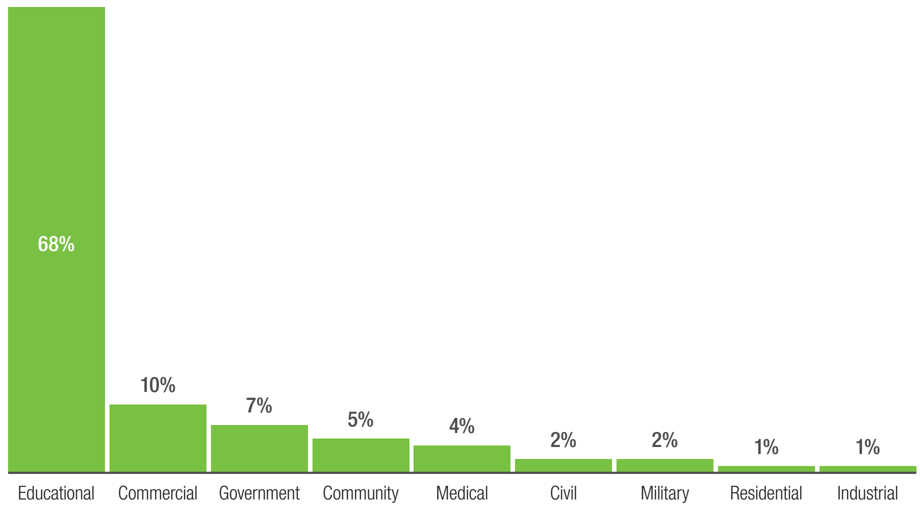

Table 1 - Building types and percentage of total building types using chilled beams (2012 to 2014*) *Data from 2014 was annualized based on 11 months of data from Reed Insight.

Benefits:

- Chilled beams have no internal moving parts and have little to no maintenance requirements compared to the traditional all-air VAV system.
- A chilled beam system using a dedicated outdoor air system (DOAS) may see 25 to 65% less air movement required than the traditional all-air VAV system.
- Lowered volume of air compared to all-air systems can lead to reduced floor-to-floor height as chilled beams do not need as much interstitial space for ductwork and have smaller mechanical room footprint requirements.
- Due to the energy density of water compared to air, it takes about 1/10 of the energy to move the same amount of thermal energy with water than air.
- It is easier to achieve superior mixed air distribution with chilled beams which leads to higher levels of occupant thermal comfort.
- Quiet operation when primary air is kept to a minimum.

Drawbacks:

- Lack of familiarity of MEP engineers, contractors, occupants, and building owners with chilled beam technology.
- Most common perceived issue is risk of condensation.
- Building envelope should have good control of moisture infiltration.
- Chilled beams may occupy a higher percentage of the ceiling plane face area than traditional VAV.
- Space humidity sensors and condensate sensors are required for the best occupied space humidity control and least risk of condensation.
- Not appropriate for high-humidity (high latent load) spaces such as kitchens.
- Not appropriate for spaces that experience high air volume change such as laboratories with fume hoods.

RAPID GROWTH IN BEAM MARKET

Active chilled beams have been used in Europe for over 30 years and were initially used primarily in high-performance buildings in the United States. As energy efficient HVAC designs have become more common, many designers are using them in all types of buildings and finding that along with energy savings, occupant thermal comfort is also enhanced. The potential exists for chilled beams to have a significant role in both new construction and renovation of existing structures. Reed Construction Data indicates an increasing use of chilled beams in the U.S. market (see **Figure 1** on page 6). **Table 1** above shows the types of buildings that chilled beams are being used in; some of the

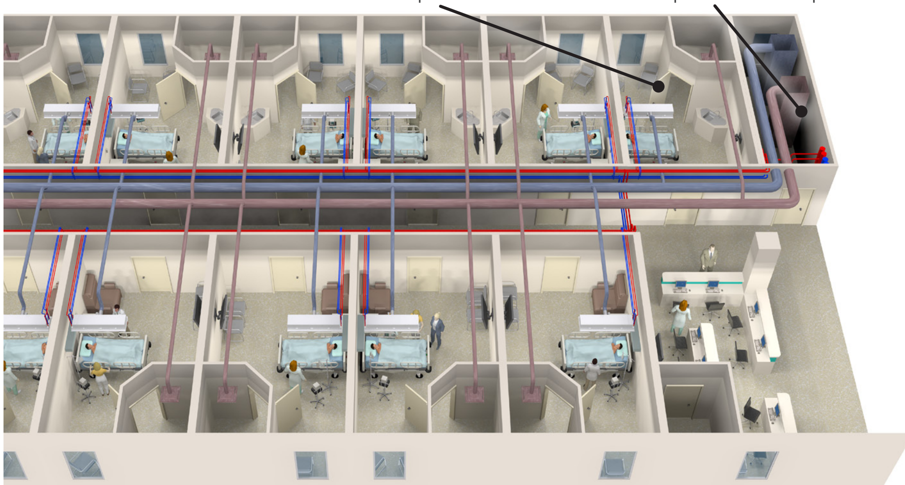

Figure 2 - Reduced riser and mechanical room space requirements could allow for an additional patient room on each floor.

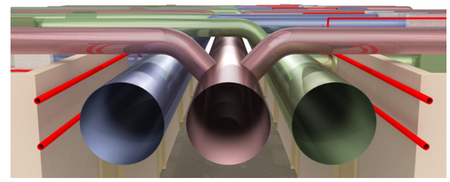

Figure 3 - Hospital patient room hall interstitial space for an all-air system (supply duct, exhaust duct, and return duct).

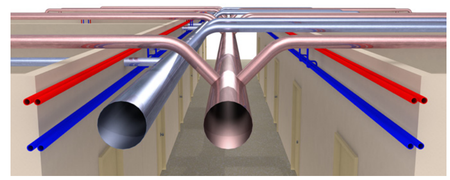

Figure 4 - Hospital patient room hall interstitial space for an active chilled beam application (supply duct, exhaust duct, and chilled water piping).

building types such as healthcare have really just started using chilled beams, as standards such as ASHRAE 170 *Ventilation of Health Care Facilities* now allow chilled beams in patient rooms. Chilled beams work well in healthcare renovations due to their reduced need for interstitial space (less ductwork).

BENEFITS OF REDUCED PRIMARY AIR VOLUME

Active beams can supply a significant portion of the sensible cooling or heating load of a building with a relatively low ventilation rate. In most commercial buildings, the ventilation rate required to condition the building can potentially be reduced by up to 75% of the ventilation normally required by an all-air system. A study by Dan Weiger[1] detailed the potential benefits of active chilled beams in a hospital setting. He found that chilled beam HVAC systems in non-invasive (non-surgical) spaces such as patient rooms and office areas have the potential to shorten the construction cycle and lower the cost, both initial and life-cycle.

On the scale of the overall system, the reduction in airflow will translate to a smaller air handler and smaller duct network. The reduction in system size may allow a lower floor-to-floor height as well as an increase in usable space on each floor due to reduced riser footprint. In certain building types such as healthcare facilities, reducing the congestion in the interstitial spaces will speed construction and allow for more useable floor area due to the significant reduction in the riser spaces needed. Weiger found that the cross sectional ductwork could be reduced by 75% with a corresponding 50% reduction of the material ductwork cost. The riser footprint was reduced by 50% and savings in the mechanical room footprint were estimated at 25%.

The reduction in riser and mechanical room footprints frees that area to be used in revenue generating activities such as patient rooms. It is possible that the reduction in riser footprint could allow for an additional patient room on each floor with in essence no additional cost when compared to using a traditional all-air HVAC system (see **Figure 2**).

In healthcare applications, when the system is designed to provide 100% fresh air at code required volumes to patient rooms. The return duct may actually not be needed as the exhaust air volume from the patient room bathroom often matches the room supply leading to other cost savings (see **Figures 3** and **4**).

CONCLUSION

Active chilled beams have a bright future due to their energy efficiency and potential lowered floor-to-floor height, smaller ductwork, and reductions in riser and mechanical room footprints.

The use of active chilled beams in the North American market is ramping up and in my estimate, becoming a main design option for all types of buildings, not just the high-performance buildings that they were first used in when introduced to the U.S. market in the early 2000s.

For more information on chilled beams, condensate, induction, and other topics related to the use of active chilled beams, please visit www.**priceindustries**.com or contact a Price application engineer.

[1]Weiger, D. (2009). Master's Thesis entitled "The John Hopkins Hospital New Clinical Building", Penn State University, University Park, PA, Department of Architectural Engineering