ENGINEERING UPDATE

OCTOBER 2012 - **VOLUME 8**

THIS PACKAGE INCLUDES A COLLECTION OF ARTICLES FROM VOLUME 8 OF THE OCTOBER 2012 ENGINEERING UPDATE.

TABLE OF CONTENTS:

Floor Mounted Active Beams Earn A High Grade.. 1
Product Feature: Fan Filter Units (FFU)... 7
Tech Tips: Customer Mock-Ups 8

ENGINEERING UPDATE

October 2012 | **Vol. 8**

FLOOR MOUNTED ACTIVE BEAMS EARN A HIGH GRADE

By Julian Rimmer, M.Sc., P. Eng.
Senior Product Manager - Sustainable Technologies

Educational facilities are an interesting market. They are often governed by significant financial constraints, being largely publicly funded, yet are also keen early adopters of new building technologies. The choices of mechanical systems available to designers today have never been more plentiful, with new systems being introduced all the time. This is due in large part to statutory "green" targets, such as jurisdictional adoption of minimum LEED® or CHPS® certification levels, but is also a response to an increase in emergent HVAC technologies.

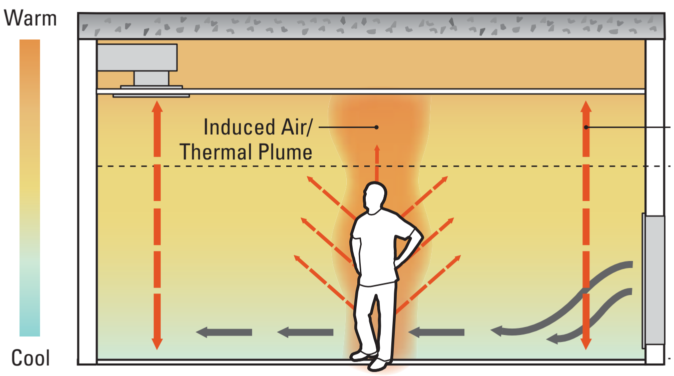
Two technologies – displacement ventilation and active beams – have caused a shift in what used to be considered standard classroom design, likely a packaged DX VAV mixing system. Displacement ventilation has seen widespread adoption in the K-12 and post-secondary education markets due to its improved acoustics, IAQ, energy performance and thermal comfort – all primary concerns of parents and teachers alike. Active beams offer significant energy savings when compared to traditional VAV systems and are one of the fastest growing HVAC markets today.

DISPLACEMENT VENTILATION

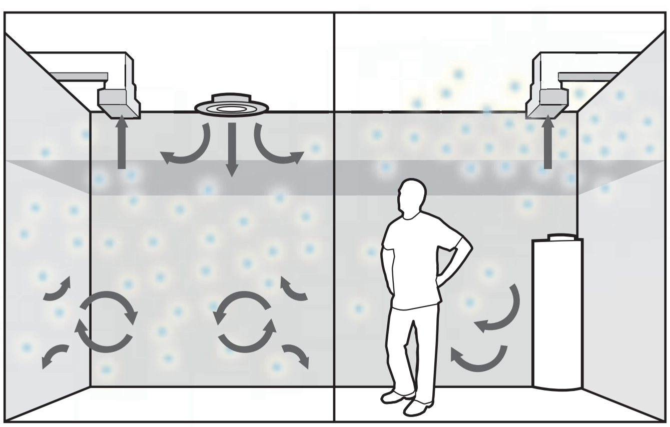
The benefits offered by a displacement ventilation system stem from the fact that they deliver air directly into the occupied zone. This has several implications on the supply air system:

- The supply air temperature must be warmer to avoid the risk of draft, thereby increasing hours during which the system can be in full economizer mode and saving compressor and pump energy.
- The velocity of the air delivered to the space must be low, again, to avoid draft. This results in lower HVAC system noise, but also reduces the amount of mixing in the zone, causing the supply air to pool at floor level. Heat sources in the room then warm the surrounding

- air, making it more buoyant and causing it to rise in the space, being replaced by the cooler air at the floor level. This results in a thermally stratified environment where the temperature is cool at the floor and warmer towards the ceiling. This allows for a reduction in the supply air cooling capacity, as the air is only required to condition the occupied zone. Any loads that are located above head level can be largely ignored in the air volume calculation (Chen et al., 1999), provided that they were not ignored when initially sizing the air handling equipment.



- The supply air passes through the occupied zone as it makes its way to the return system (provided that the returns are located at high level), resulting in a ventilation effectiveness and indoor air quality that is significantly improved compared to other systems (ASHRAE, 2009). This translates into a reduction in the volume of ventilation air that must be delivered to the zone per ASHRAE Standard 62.1 -2010.



Mixing Ventilation　　Displacement Ventilation

ACTIVE BEAMS

The benefits offered by active beam systems are largely due to shifting the majority of the sensible cooling from the ventilation system to a distributed water system. This allows the size of the air system to be reduced, thereby saving significant fan energy.

Further benefits offered by active beam systems include:

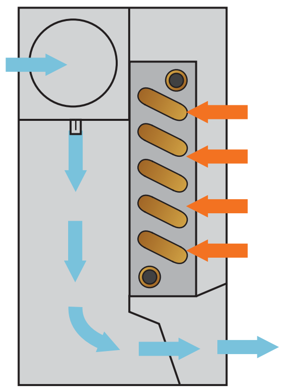
- Reduced maintenance: Active beam systems are generally designed to operate with dry coils, eliminating the need for pre-filtering and condensate collection typical of fan coil systems. Maintenance of an active beam system is often reduced to a periodic inspection of the zone coils.
- Reduced mechanical footprint: Because water carries a lot more energy than the equivalent volume of air, the designer requires much less of it to satisfy the zone loads. By replacing air ducts with water pipes, the designer can significantly reduce the space occupied by the mechanical system.

FLOOR MOUNTED ACTIVE BEAMS

An exciting new option to designers is the floor mounted active beam. This device offers most of the benefits of both displacement systems and beam systems.

HOW IT WORKS

The Price ACBC operates in the same manner as ceiling mounted active beams: it uses ventilation (primary) air to pressurize an internal plenum which distributes it to a bank of nozzles. The primary air is then forced through the nozzles to a section behind a water coil.



The relatively high velocity of the air behind the coil draws room (secondary) air through the coil where it is cooled or heated and mixed with the primary air at a rate called the induction ratio. This ratio gives an indication of beam performance, and is typically written as the ratio of the total discharge air flow to the amount of primary air delivered to the beam:

$$IR = \frac{Q_{total}}{Q_{primary}}$$

The mixture of primary and secondary air, or total air, is then discharged out of the bottom of the beam at relatively low velocities in order to create a displacement air pattern.

This configuration allows a simpler constant volume dedicated outdoor air system to handle the ventilation and latent cooling requirements, while allowing the more efficient water system to handle the sensible cooling. Because the air must pass through the occupied zone before being returned, the ventilation effectiveness will be between 1.2 and 1.4 depending on space loading.

Note that ASHRAE Standard 62.1 currently requires that the ventilation effectiveness, E_z, be determined in reference to Table 6-2, or 1.2 for a displacement ventilation system in cooling mode. This allows the designer to reduce the amount of ventilation air delivered to the zone:

$$V_{oz} = \frac{V_{bz}}{E_z}$$

The most interesting characteristic of this beam configuration is that the secondary air is pulled from the occupied zone, as opposed to from the ceiling level. This characteristic, coupled with the stratification resulting from the displacement flow, means that there are some loads in the room that are transparent to the beam system. These include any located higher than the secondary airflow of the beam:

- Lighting loads
- Conduction and radiant loads
- Occupant load radiated to the ceiling

Lab studies have shown the reduction in room load to be 20 to 30% for a typical load arrangement. The system effect of stratification is not immediately obvious. **Referring to the figure on Page 5, we can trace the loads in the room to the system.**

1. As air is brought into the building, it must be conditioned, processed through the total energy wheel and water coil, and then supplied to the zone. In cooling mode, this ventilation load is simply:

$$q_{Ventilation} = 60\rho C_p (Q_{OZ})(T_2 - T_{Primary})$$

2. This primary air is then blended with secondary air, or air that is induced from the room. This secondary air is pulled from the occupied zone at T_{OZ}, then cooled or heated in the water coil. The load on the system for this process is calculated by multiplying the volume of supplied secondary air by the temperature differential across the coil (ignoring efficiencies). For IP units:

$$q_{beamcoil} = 60\rho C_p (Q_{Secondary})(T_{OZ} - T_2)$$

3. This air mixture is then supplied to the zone, where it gains heat from heat sources and stratifies. The temperature of the air at any given height can be determined from:

$$T(h) = T_{Supply} + \frac{q(h)}{60\rho C_p (Q_{total})}$$

From this, the temperature in the occupied zone is driven by the loads in the occupied zone only, or:

$$T_{OZ} = T_{Supply} + \frac{q_{OZ}}{60\rho C_p (Q_{total})}$$

4. The temperature in the return can be determined from the remaining load, noting that the air volume is now reduced to primary air only, as the secondary air has returned back to the beam:

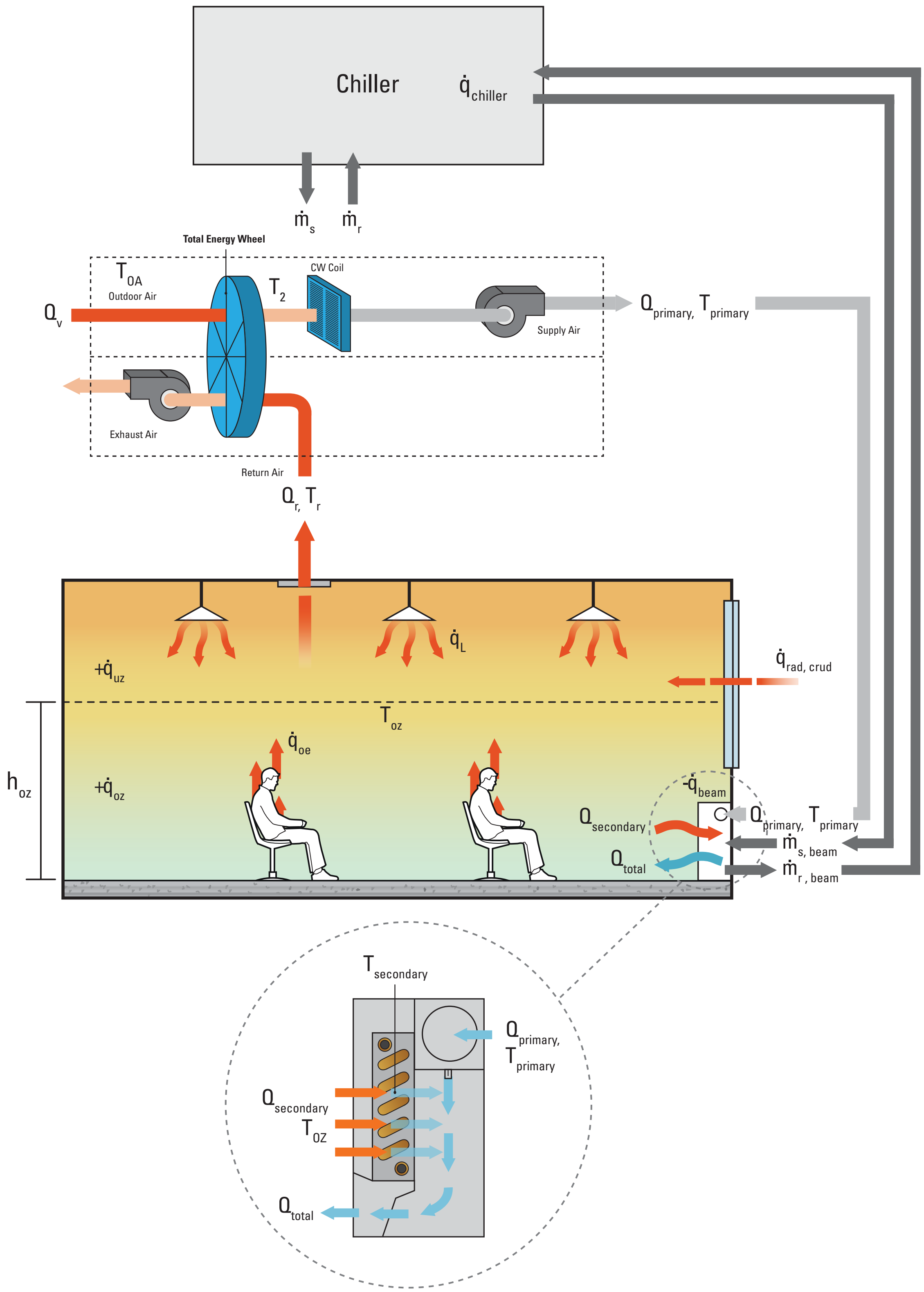
$$T_{return} = T_{OZ} + \frac{q_{UpperZone}}{60\rho C_p (Q_{primary})}$$

5. This return air, and the load carried with it, is then exhausted from the building, being recovered by the ERV during periods of the year where it is beneficial.

These room characteristics offer the following advantages:

- Reduced load: A reduction in total load is possible through a reduction in ventilation rate (ventilation load) and room load, due to the heat gain in the upper zone being exhausted directly from the building.
- Improved IAQ: An increase in the ventilation effectiveness can contribute to higher indoor air quality.
- Drain pan: Active beam systems do not generally use drain pans, as the coil is only used for sensible cooling (i.e. no condensation forms). In some markets, however, the use of drain pans is popular as a precaution. The location of the coil near the floor allows for easy use of a drain pan, whereas a ceiling mounted beam is often challenged to find an appropriate slope for drainage.
- Less ceiling coordination: With fewer elements in the ceiling, there is less coordination required between trades.
- Easier access to the coils: While coil service is rare, the location of the coil near the floor facilitates maintenance.

With such a plentiful choice of HVAC systems offered to today's engineers, it is often challenging to identify those that are ideally suited to a specific market. For good reason, displacement ventilation has been the system of choice in eduction for the past few years. The system offers a quiet learning environment with very high indoor air quality and thermal comfort. The addition of active beam technology to this type of HVAC system has allowed for further energy savings, particularly in markets where significant economizer use is not possible.


Chiller
q̇chiller
ṁs
ṁr
Total Energy Wheel
TOA
Outdoor Air
T2
CW Coil
Qv
Supply Air
Qprimary, Tprimary
Exhaust Air
Return Air
Qr, Tr
+q̇uz
q̇L
q̇rad, crud
Toz
q̇oe
hoz
+q̇oz
-q̇beam
Qsecondary
Qprimary, Tprimary
ṁs, beam
Qtotal
ṁr, beam
Tsecondary
Qprimary,
Tprimary
Qsecondary
TOZ
Qtotal

REFERENCES

ASHRAE. (2004b). *Standard 62.1-2004—Ventilation for acceptable indoor air quality*. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.

ASHRAE. (2009). *Research Project-1373—Air distribution effectiveness with stratified air distribution systems*. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.

ASHRAE. (2010). *Standard 62.1-2010—Ventilation for acceptable indoor air quality*. Atlanta, GA: American Society for Heating, Refrigerating and Air Conditioning Engineers, Inc.

Badenhorst, S. (2002). *Underfloor Air Distribution.* Aachen, Germany: Krantz Komponenten.

Breum N. O., & Orhede E. (1993). Proceedings from the *14th AIVC Conference: Energy Impact of Ventilation and Air Infiltration*. Copenhagen, Denmark.

Brohus, H. (1997). *Personal exposure to contaminant sources in a ventilated room*. PhD Thesis. Aalborg University, Aalborg, Denmark.

Chen, Q., Glicksman, L.R., Yuan, X., Hu, S., & Yang, X. (1999). Final report for *ASHRAE RP-949: Performance evaluation and development of design guidelines for displacement ventilation.* Cambridge, MA: Department of Architecture, Massachusetts Institute of Technology

Helenius, T., Seppanen, O., Maranen, A., et al. (1987). Measurements of air exchange efficiency and ventilation effectiveness. Proceedings from *Roomvent '87: Air Distribution in Ventilated Spaces.* Stockholm, Sweden.

Jung, A., & Zeller, M. (1994). *Analysis and testing of methods to determine indoor air quality and air change effectiveness.* Aachen, Germany: Rheinisch-Westfalische Technical University of Aachen.

Lee, K.S., Jiang, Z., & Chen, Q. (2009). Air distribution effectiveness with stratified air distribution systems, *ASHRAE Transactions, 115* (2).

Price Industries Limited. (2011). *Engineer's HVAC Handbook, Edition 1: A Comprehensive Guide to HVAC Fundamentals.* Winnipeg, MB: Price Industries Limited.

Schiavon, S., Bauman, F., Tully, B., & Rimmer, J. (2012). *Temperature stratification and air change effectiveness in a high cooling load office with two heat source heights in a combined chilled ceiling and displacement ventilation system,* in press.

Zhang, P. (2007). Ventilation considerations for indoor environmental quality for a control center. Proceedings from *Clima 2007: WellBeing Indoors*. Helsinki, Finland.

ENGINEERING UPDATE

October 2012 | **Vol. 8**

PRODUCT FEATURE: FAN FILTER UNITS (FFUs)

Price Fan Filter Units (FFUs) are fan powered diffusers with integrated high efficiency filters for critical applications that require additional static pressure boost. All FFUs are assembled and leak tested inside the Price Cleanroom.

Typically used in laboratory, cleanroom and pharmacy applications, FFUs consist of a fan/motor assembly and high efficiency HEPA/ULPA filter, and are designed to provide filtered, unidirectional vertical air flow. Acoustical insulation and motor vibration isolators attenuate sound for quiet operation.

- The High Capacity FFU offers the largest active filter area and the highest air flow capacity of all Price Fan Filter Units. Removable UL900 certified filters allow for periodic filter changes via the ceiling plenum, and an expanded mesh screen protects the filter media from inadvertent damage during installation.
- The Room-Side Replaceable FFU offers all the standard features of the High Capacity FFU, with the additional convenience of room-side access for HEPA/ULPA filter replacement. The filter is attached by embedding its continuously welded knife-edge into a gel seal, creating a leak-proof barrier. Once installed, the filter is protected by a perforated face that is secured to the main assembly using quarter-turn fasteners.

Fan Filter Unit Options

- Open or ducted inlet
- Permanent Split Capacitor (PSC) or Electronically Commutated Motor (ECM) motor options
- Motor BAS signal
- Multiple speed controller options, including wall-mounted kits and BMS integration
- Walkable plenums
- Room-Side Replaceable FFU only: Static pressure port
- Room-Side Replaceable FFU only: 3/8” NPT aerosol challenge port
- Room-Side Replaceable FFU only: LED Filter & Motor indicators
- Room-Side Replaceable FFU only: Ion Bar

To learn more about Price FFUs, please contact **Nolan Hosking, Senior Product Manager for Critical Environments**: phone 770.623.8050 or email NolanH@price-hvac.com.

MOTOR OPTIONS

Feature	Permanent Split Capacitor (PSC)	Electronically Commutated Motor (ECM)
Motor Description	Low cost, adjustable speed	Less noise, heat and energy consumption than PSC
Motor Operation	Motor speed will reduce as filter loads	Factory programmed – constant CFM (relationship between RPM / CFM / motor torque)
Speed Controller	PSC Speed Controller	ECM or ECM Deluxe Speed Controller
Speed Controller Operation	Adjusts between minimum and maximum speed	Manual or BMS, can control multiple ECM motors, has diagnostic LED (ECM) or digital display and analog BMS output (ECM Deluxe)

ENGINEERING UPDATE

October 2012 | **Vol. 8**

TECH TIPS: CUSTOMER MOCK-UPS

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

In the HVAC design world, there is some uncertainty about the application of new and existing air distribution technologies since codes change so quickly and sometimes drastically. Customer mock-ups of the proposed HVAC design for a specific space are a great way to help resolve design uncertainty! And of course, bringing customers to our facilities helps them understand the wide range of solutions we offer. My ideal mock-up includes the design engineer, representative, architect and owner. This diversity makes for a lasting impression. Some designers and contractors recall mock-ups from over ten years ago!

Our mock-ups are typically categorized as Acoustical, Energy or Physical performance. Recent mock-ups of each include:

ACOUSTICAL

There are two types of acoustical mock-ups available: In-Situ and Reverberant.

1. In-Situ

An In-Situ test (performed in Atlanta and shown in Figure 1) is a measurement of the radiated and discharge sound characteristics of a specific fan-powered device.

We install the terminal in a ceiling cavity above a room that has an acoustical ceiling with no penetrations. This allows for direct measurement of radiated sound in a space that approximates the size and construction of a typical private office. The terminal has both primary and discharge air duct connections. Discharge air is passed through a divider section in the plenum, allowing little to no radiated sound from the terminal to penetrate into the plenum over the discharge sound room. Then a specific amount of discharge air is directed through a diffuser in the ceiling of the discharge sound room, which allows direct measurement of discharge sound. This is great for educating on the two types of sound, radiated and discharge.

2. Reverberant

A Reverberant test (performed in Winnipeg and shown in Figure 2) is a measurement of the sound characteristics taken per a specific test standard such as ASHRAE Standard 70 or ASHRAE Standard 130. The results are a quantification of the sound power generated by the device. Benefits of a reverberant room test are verification of catalog data or development of sound data for a special or custom product.

Figure 1: Atlanta's In-Situ Acoustical Test Chamber

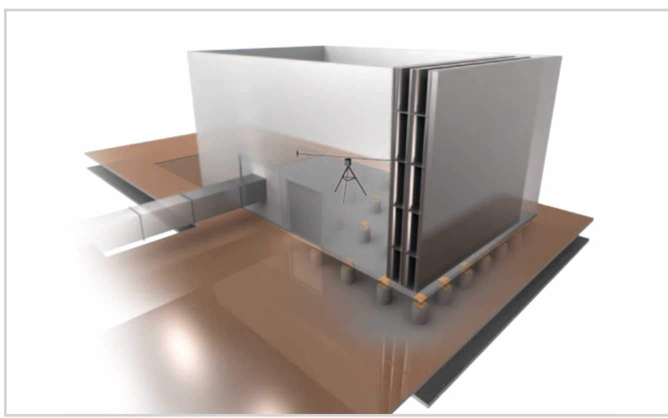


Figure 2: Winnipeg's Reverberant Room

ENERGY

One type of test for energy characteristics is a chilled beam test in the Hydronic Test Chamber located in PRCN (Figure 3). This is one of my favorite tests as it highlights the unique testing capabilities of PRCN. There is no equivalent of this test chamber in North America—you would have to travel to Europe to find a chamber of similar accuracy. This room shows VERY WELL!

Other types of energy tests include fan coil performance and fan energy consumption.

PHYSICAL

Physical tests include throw distance for a diffuser, pressure drop across a terminal unit primary valve, or temperature mixing characteristics of a dual duct terminal. These mock-ups can take place at either the Atlanta or Winnipeg location, depending on the measurements needed.

Often, a mock-up involves acoustical, energy and physical aspects. One recent mock-up in Winnipeg explored the interaction between a displacement diffuser and chilled sails, studying the impact on the occupant predicted thermal comfort.

We have four ready-to-go mock-up facilities in Atlanta:

Mock-up room one (Figure 4) is a full-scale classroom that highlights displacement, chilled beams and overhead air distribution and simulates loading for occupants, as well as shell gain or loss.

Mock-up room two (Figure 5) is a full-scale, single occupancy patient room that shows various methods of distributing air to meet the requirements of ASHRAE Standard 170, allowing us to discuss the advantages of each.

Mock-up room three is a full-scale surgical space with operating table and surgical lights, capable of demonstrating the two common cleanroom air distribution methods: perimeter curtain and laminar flow.

Mock-up room four is a full-scale office that can show overhead, displacement, underfloor, and chilled beams in operation.

If you are interested in utilizing our mock-up services contact your local Price Representative.

Figure 3: Hydronic Test Chamber in Winnipeg

Figure 4: Classroom mock-up in Atlanta

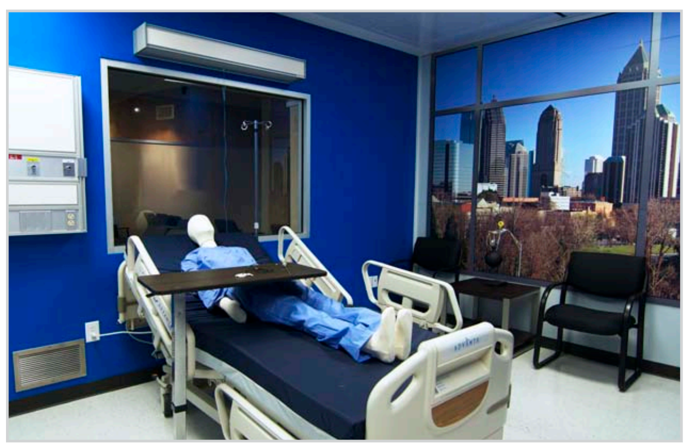


Figure 5: Patient room mock-up in Atlanta

Our mock-up capabilities are perfect for unusual applications of technology. They leave a strong and lasting impression on clients by showing them how our products work firsthand – and we enjoy showing them off!