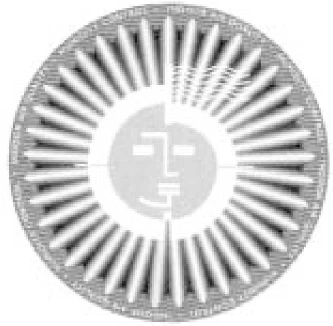

NO PLACE LIKE HOME

A desiccant-based system in place at a Georgia Institute of Technology dormitory is maximizing indoor air quality while minimizing energy consumption.

BY CHRIS DOWNING, P.E.

The athletes who will be housed on the campus of Georgia Institute of Technology (GIT) for this summer's Olympic Games in Atlanta should enjoy all the comforts of home. In fact, the newly constructed dormitory complexes may just provide more comfort.

The design scheme for the new apartment-style living quarters on the GIT campus is based on a desiccant-based system designed to provide acceptable IAQ, comply with ASHRAE 62-89 ventilation guidelines, and control space relative humidity.

This "EPD" system (as it is referred to by the manufacturer, SEMCO Inc., Columbia, MO) provides humidity-controlled, temperature-neutral air using a dual-wheel, total-energy-recovery concept that typically produces 2.4 tons of cooling output, most of which is latent, for every one ton of cooling input.

The EPD systems have had a very successful test run at the university's Undergraduate Living Center (ULC). ULC's indoor environment is considered very acceptable. The cost of operating the facility appears to be on par with other similar facilities providing only minimal outdoor air. No humidity problems have been experienced. And the maintenance required for the EPD systems has been minimal.

The system in place at the new Undergraduate Living Center on the campus of the Georgia Institute of Technology has been providing the center with humidity-controlled, temperature-neutral air using a dual-wheel, total-energy-recovery concept.

In addition to providing an energy-efficient design, the EPD "preconditioning" design concept also provided the lowest-cost way of conditioning the outdoor air required by the ULC facility, said Don Alexander, manager of GIT's Facilities Engineering Dept. As a result, this technology was placed in four more new dormitory complexes on campus. involving more than 800,000 sq. ft of conditioned space and approximately 200,000 cfm of preconditioned outdoor air.

RESEARCH SUPPORTS DESIGN

When ULC was evolving, one of the specific guidelines presented to mechanical consultants Nottingham, Brook, and Pennington (NBP), Macon, GA, was to ensure a comfortable and safe indoor environment that would complement the building's attractive architecture.

Another design requirement was to provide a separate heating and cooling system for each apartment, to allow independent occupant temperature control.

When considering design options, both the GIT Facilities Engineering Dept. and NBP benefited from previous IAQ research conducted by the Georgia Tech Research Institute. A GTRI research group, headed by Dr. Charlene Bayer, has been conducting IAQ investigations for the past 15 years on all types of facilities, ranging from classrooms to office facilities.

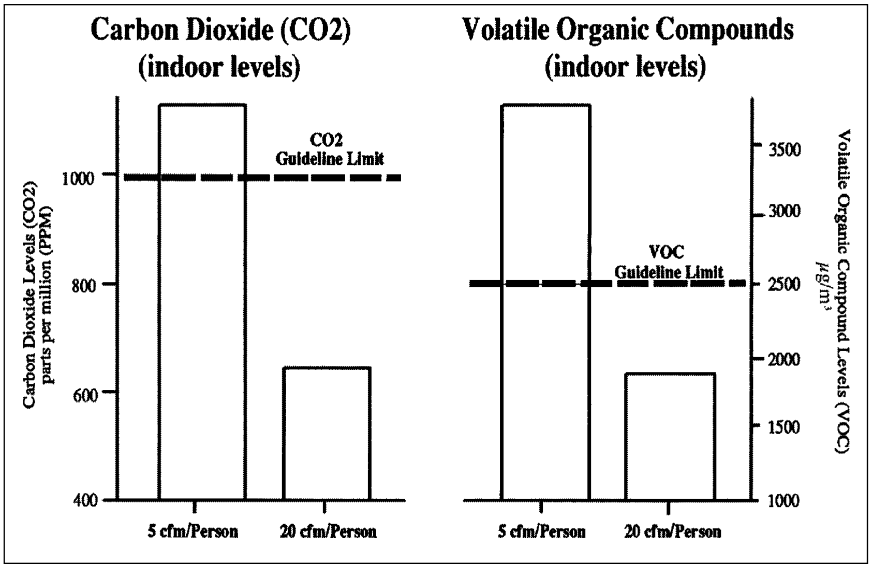

TABLE 1: Actual field measurements of occupied office space CO_2 and combined VOC concentrations as a function of outdoor air ventilation rates. Study supports ASHRAE 62-89 recommendations, since CO_2 and VOC levels are controlled below the guideline limits when 20 cfm per person is provided. (Source: GTRI.)

GTRI conducted two relevant studies on projects where this desiccant-based technology was applied. The first study, which was completed for a new 30-story Southern Bell office building in Atlanta, documented the benefits offered by continuous outdoor air at the quantities recommended by

ASHRAE 62-89.

Results of this study confirmed that 20 cfm per person was required to maintain levels of total volatile organic compounds (VOCs) below the generally accepted guideline of 2,500 pg/rn^3 (see Table 1).

As part of a separate study conducted at an elementary school in Augusta, GA, an IAQ investigation conducted by GTRI documented the clinical and perceived improvement in IAQ when outdoor air quantities were increased from approximately 7 cfm per student provided intermittently, to 15 cfm per student provided continuously, as recommended by ASHRAE.

In addition, the space relative humidity was measured at these two conditions. It was documented that with the use of the EPD system, 15 cfm per student could be provided continuously; at the same time, relative humidity could be controlled to the desired 50% level, regardless of the cooling season outdoor weather patterns (see Table 2).

The conventional equipment originally installed for this project (3-ton DX system) was operated intermittently and with half the amount of outdoor air, yet still maintained space humidities above 70% for a large percentage of the day. This study documented the need for continuous ventilation and humidity control for acceptable IAQ.

In addition to cooling season humidity control, a significant body of research has concluded that as the space rh decreases below 30%, the likelihood of infection with an airborne illness, such as the common cold, increases significantly; as the body's airways begin to dry, the ability to fight off infection lessens.

The total-energy wheel in the EPD system recovers humidity from the exhaust airstream, thereby maintaining more desirable humidity levels in the space during the heating season for most types of facilities.

DORMITORY CONCERNS

Based in part on the results of these two IAQ investigations, GTRI suggested that the mechanical design for the ULC incorporate the increased, continuous outdoor air ventilation quantities recommended by ASHRAE 62-1989 (which at the time was in the process of being adopted by the Southern Building Code).

For a dormitory, this means providing outdoor air to the facility 24 hours a day. This presents a significant challenge to the ability of conventional cooling and heating systems to control space humidity during both cooling and heating seasons.

This is especially true, since increased energy efficiency ratios (EERs) have actually caused a reduction in the latent capacity of many newer hvac packaged systems.

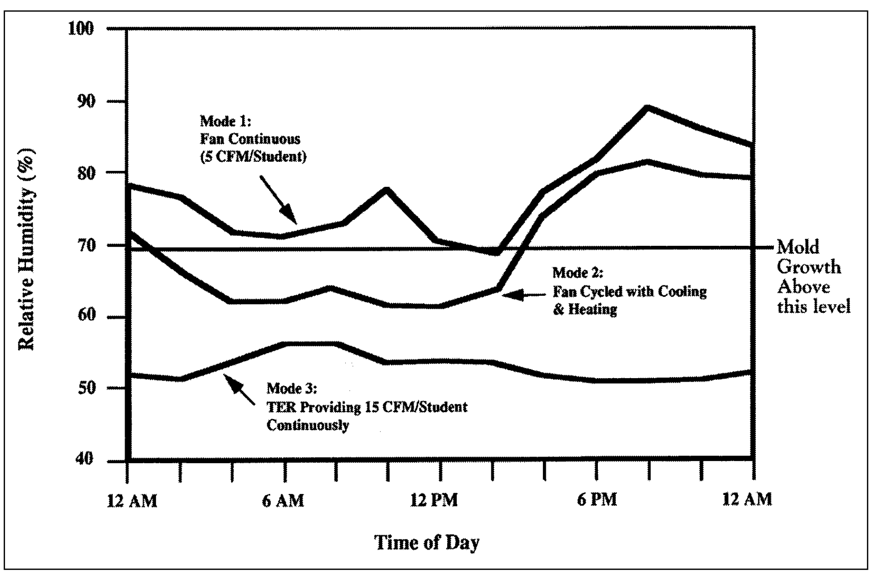

TABLE 2: Actual field measurements were taken of space relative humidity over time in an elementary school classroom. Data compares a conventional 3-ton DX system supplying 5 cfm per student of outdoor air with (1) continuous fan operation, (2) intermittent fan operation, and (3) a dual-wheel desiccant-based Preconditioner. (Source: GTRI.)

Dual-wheel "preconditioning": How it works

In the EPD system design, the "outdoor air Preconditioner" by SEMCO uses a desiccant-based, total-energy-recovery wheel; a polymer-coated, sensible-only wheel; and a conventional chilled-water or DX cooling coil to efficiently remove the cooling, dehumidifying, heating, and humidification loads associated with outdoor air quantities.

COOLING MODE

When in the cooling mode, the desiccant-based total-energy wheel precools and dehumidifies fresh air supplied to the building, by using the energy contained in the air exhausted from the occupied spaces.

A cooling coil is located in the fresh airstream just after the total energy wheel. This coil is used to deliver the absolute humidity level required by the occupied space. A dewpoint of 53°F is typical.

The cool, dehumidified air is then passed through the sensible energy wheel, which uses the sensible heat load generated within the building to provide "free" reheat to approximately 68˚F.

As the sensible wheel reheats the fresh air to the design condition, it simultaneously cools the exhaust airstream, which is then provided to the total-energy wheel. This enhances the ability of the total-energy wheel to cool and dehumidify the outdoor air, which significantly reduces the chiller or DX cooling capacity allocated for conditioning the outdoor air.

Typical conditions provided by this process are shown in Figure 1.

HEATING MODE

In the heating mode, as shown in Figure 2, the sensible wheel is typically not required, so it is operated at minimum speed or turned off. This allows the total-energy wheel to provide 75% to 80% temperature and moisture recovery.

This allows many spaces to be self heating, even on very cold days, once room conditions are met and the sensible load (due to lights and people) is introduced to the space.

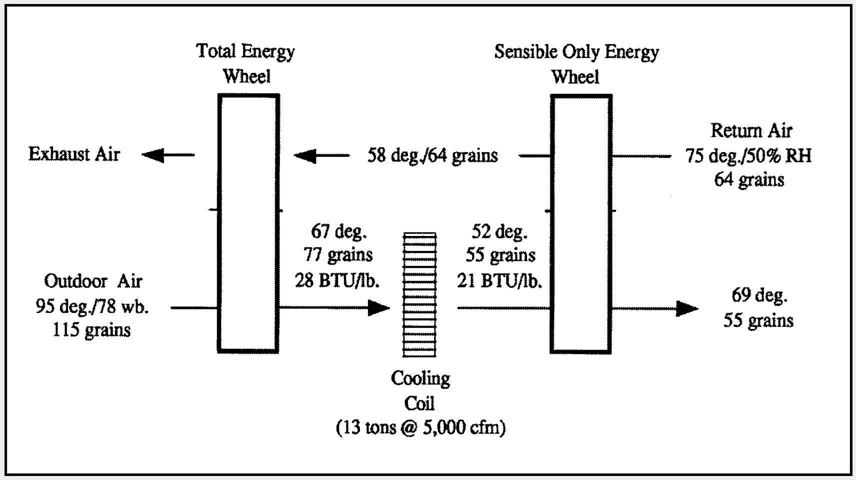

FIGURE 1: Typical performance of EPI) system during the cooling mode. Note that a 13-ton input provides a 32-ton output. (Source: SEMCO Inc)

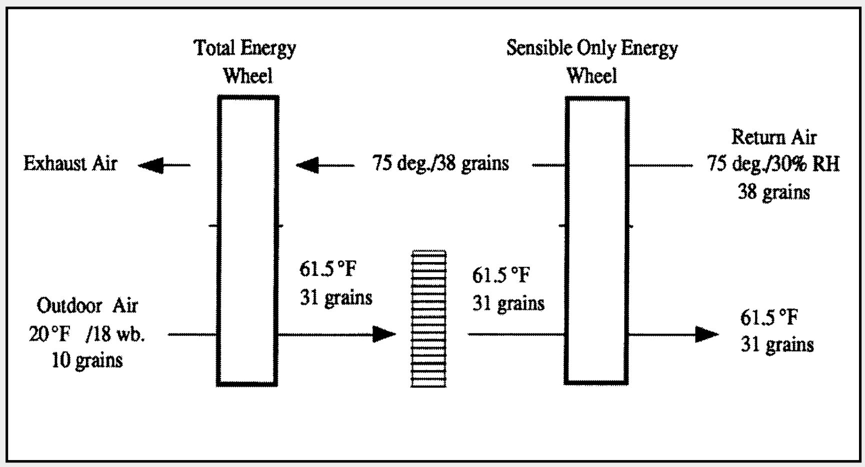

FIGURE 2: Typical performance of EPD system during the heating mode.

This system is considered very effective for controlling space humidities where a significant amount of outdoor air is required.

In the past, conventional cooling systems have been combined with reheat when dry air at a neutral temperature was desired. This approach required ~ high first cost due to the cooling and heating capacity required; often risked freezing the heating and cooling coils during winter operation; and was expensive to operate. In Florida, for example, such systems are not allowed by local energy codes.

The EPD approach, however, when compared to a conventional overcooling and reheat system, typically cuts the required cooling capacity by 60%, eliminates the need for reheat altogether and, most importantly, reduces the cost of operation by as much as 75%. It also allows for downsizing the conventional units typically situated throughout a facility.

One question often raised concerning desiccant recovery wheels, is the possibility for a significant amount of contamination of the outdoor air by the exhaust air, as the desiccant wheel rotates from the exhaust airstream to the supply airstream.

GTRI conducted numerous studies on the SEMCO total-energy wheel, both in the field and in the GTRI lab. This product, which utilizes a patented 3A molecular-sieve desiccant coating to avoid cross-contamination, exhibited no cross-contamination.

— Chris Downing, P.E.

Annual Energy Savings Summary		
	Conventional System	Preconditioning
Energy Cost for outdoor air heating and cooling	$80,670/year	$22,830/year
Demand Charges for outdoor air	$22,420/year	$13,020/year
Total Energy Cost	$103,090/year	$35,850/year
Energy Savings with Total Energy Preconditioning		$67,240/year

NOTES:
1. Supply air 43,000 cfm, exhaust air 28,800
2. Electric cost is $.055/KWH, gas at $.55/Therm
3. Based on a 24 hr/day, 7 day/week operation
4. Assumes preheat to 68 degf. during winter with hot water
5. Assumes cooling to 52 degf. during cooling season with reheat to 68 degf.

First Cost Comparison Summary		
	Conventional System	EPD Preconditioning
Cost of 3 Energy Recovery or AHU Preconditioners	$81,700	$202,900
Installation/ Ductwork	$63,500	$69,000
Chiller, Cooling Tower & Boiler	$171,200	$66,000
Chilled Water Piping Credit	$0	($33,000)
Total Installation Cost	$316,400	$304,900
Preconditioning First Cost Savings		$11,500

TABLE 3 Undergraduate Living Center project economics, comparing the EPD preconditioning approach against a conventional cooling system with hot water reheat. (Source: SEMCO Inc.)

It was noted that dormitories, like hotels, have humidity loads that can fluctuate widely. Occupancy levels and cooking and bathroom activities can result in high relative humidities.

Allowing indoor relative humidities to exceed 70% for extended periods of time usually results in humidity problems ranging from occupant complaints (such as odors and allergic reactions), to damage to carpets and wall coverings from mold and mildew.

Research that has been completed by GTRI, both in the laboratory and in the field as part of an elementary school IAQ investigation, has confirmed that microbial growth, linked to poor humidity control, can actually generate chemicals (VOCs) and emit them into the indoor environment.

If not dealt with, humidity problems would be particularly bad for dormitories during mild, humid days (early morning or rainy days), when the building's sensible load is low, and humid outdoor air is continually supplied to the space.

As a result, it was concluded that a mechanical design for the ULC would need to accommodate increased outdoor air to meet the IAQ requirements, while allowing for control of indoor relative humidity.

DESIGN SOLUTION

Both NBP and GIT, through the research conducted by GTRI, had considerable experience with this desiccant-based system, pioneered by SEMCO.

A key element is SEMCO's "outdoor air Preconditioner," which uses a desiccant-based total-energy-recovery wheel; a polymer-coated sensible-only wheel; and a conventional chilled-water or DX cooling coil, to efficiently remove the cooling, dehumidifying, heating, and humidification loads associated with outdoor air quantities.

In other words, the system allows the sensible and latent loads associated with the outdoor air to be "decoupled" from a building's internal heating-cooling load.

The outdoor air Preconditioner buffers the building from the extremities associated with outdoor air weather conditions, allowing the building's mechanical system to be designed as if it were never exposed to winter or summer conditions.

Approximately 43,000 cfm of outdoor air is provided to the facility on a continuous basis by three dual-wheel, total-energy-recovery systems, located in the attic space above each of the three wings of the dormitory facility. This preconditioned outdoor air is ducted directly to the corridors, common study areas, and individual living spaces, to provide effective dilution ventilation.

Approximately 28,800 cfm is exhausted from the bathroom areas and janitors' closets located throughout the facility. These systems recover approximately 90% of the energy contained in the exhaust air, and use it to precool and dehumidify outdoor air during the cooling season (conversely, to preheat and prehumidify outdoor air during the heating season).

Individual living spaces and all common areas are heated and cooled by four-pipe fancoil units. These are fed by chilled water and hot water, and allow for individual temperature control in each living space via an adjustable wall-mounted thermostat. The fancoil units are activated only when heating or cooling is called for in the space.

Since the fancoil units process only recirculated room air, and since the outdoor air is preconditioned and over-dried by the EPD systems to handle nearly all of the latent load, little condensation is experienced at the individual fancoil units.

The latent load reduction at the fan-coil units allowed smaller-diameter distribution piping to be used to deliver the chilled water required by the fan-coil units, which resulted in a first cost savings (see Table 3).

PROJECT ECONOMIES

The EPD systems installed for the ULC project provide 265 tons of cooling with an input of only 112 tons. The systems provide 2,400,000 Btu of "free" heating and humidification during the heating season.

Estimated energy savings and first-cost savings in boiler and chiller capacity provided a simple payback of one year for GIT. When the savings associated with smaller chilled-water distribution piping is considered, the payback was immediate.

Most importantly, GIT has recognized an estimated $67,240 in energy savings each year, when compared to the energy that would have been required by a conventional cooling-reheat preconditioning approach. Had the exhaust air volumes more closely approximated the supply air volumes for this project, the economic justification would have been even more favorable.

Still, the best endorsement of this desiccant preconditioning design scheme is the fact it was also chosen as the basis of design for four new dormitories on the GIT campus. It was also chosen for the University Apartment Complex, a Georgia State University facility located on the edge of the GIT campus. This complex has 11 dual-wheel preconditioning systems, including 22 SEMCO energy wheels. All of these dormitory facilities will serve as housing for the athletes visiting Atlanta this year for the Summer Olympic Games. ES

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