CONDITIONING A RESEARCH FACILITY

A desiccant system has improved air quality; halved cooling requirements, and reduced heating and humidfication requirements by more than two-thirds at the Johns Hopkins School of Medicine.

BY ROBERT DiBLASIO

Six years ago, the Johns Hopkins University School of Medicine made a decision to accept a novel mechanical design proposed by Ross, Murphy and Finkelstein for its world-class Ross Research Building. It was based upon a unique desiccant-based total energy recovery technology, designed to reduce first-cost and operating expenses, as well as improve and control indoor air quality.

Today, with approximately four years of successful operating history, the decision to use a desiccant-based approach was clearly a correct one.

In short, desiccant technology allowed the Ross Building to cut its cooling requirements by half, and its heating-humidification requirements by more than two-thirds. This design provided first-cost savings of more than $1 million, actually paying for itself before it was put into operation.

Over the past four years, the total recovery system has saved the Johns Hopkins School of Medicine an estimated $2,580,000 in heating and cooling costs, including utility demand charges. Additional benefits include improved humidity control and wintertime coil freeze protection.

The Johns Hopkins Hospital and University owns and operates more than 100 buildings in the greater Baltimore area. None of these facilities presented a greater mechanical design challenge than the Ross Research facility, which was commissioned in 1991. This eight-story facility houses all types of laboratory space, where a diverse range of medical research projects is conducted.

Johns Hopkins takes pride in the fact that it is considered one of the world's best medical institutions. Its goal was to design the Ross facility to live up to this reputation.

During the initial design phase, numerous challenges were posed to Ross, Murphy and Finkelstein, the mechanical consultants. The design had to accommodate five important operational criteria.

Most important were environmental safety and maintaining space conditions, followed closely by project first cost, energy conservation, and system dependability.

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As with any project, a construction budget was allocated. Keeping the project within this budget was the primary responsibility of the construction management group, Whiting Turner.

ENVIRONMENTAL SAFETY

Ensuring environmental safety is the responsibility of Dr. Byron Tepper, associate professor of Environmental Health Sciences and director of the Johns Hopkins Office of Safety and Environmental Health.

Tepper established a design requirement of 10 air changes per hour in each laboratory, and stressed a strong preference for a constant-volume system operating with all outdoor air. He also worked with researchers and determined that humidity as well as temperature would need to be controlled year round.

To meet these requirements, energy conservation and first cost became particularly important. One obvious reason was the cost associated with controlling both temperature and humidity for what was to become a 300,000-cfm system located in the Baltimore area, which experiences cold winters and hot, humid summers. Another reason was that the central energy plant designated to provide chilled water and steam for this facility was reaching maximum capacity.

The load required by the Ross Building would make it difficult to serve future facilities. Installing a separate physical plant in the Ross Building would absorb valuable realestate and exceed the mechanical budget. As a result, reducing the connected heating, humidification, and cooling load became another key objective for the design team.

As director of maintenance-operations for the facility, I was especially concerned about the reliability of the final mechanical system design.

The valuable research that was to be conducted in this facility would not allow for system downtime or fluctuating conditions. Other buildings in the School of Medicine had also experienced many 3 a.m. freeze-stat alarms for coils in air-handling systems handling 100% outdoor air; I did not want to experience this problem in this important laboratory facility.

After a thorough analysis, the consulting engineer and construction manager presented an overall design that appeared to provide an excellent solution to each of the objectives. They recommended two large, field-built mechanical equipment rooms incorporating advanced, desiccant-based total-energy-recovery wheels, in addition to the fans, coils, filters, humidifiers, and other components required to condition the Ross Building.

In concept, this total-energy-recovery approach would provide the significant reduction in energy consumption required to make the 100% outdoor air approach feasible. It would also reduce the required chiller and boiler capacity enough to meet the design conditions set for the Ross building, without taxing the capacity of the central energy plant.

Evaporative heat recovery would help control humidity during the cooling and heating seasons. And the heat recovered would preheat the air enough to protect the heating coils from freezing even on the coldest days.

The benefits offered by the total-recovery approach were considerable, and clearly offered the best design approach for the Ross facility. Since Hopkins had no prior experience with this technology, however, all parties involved challenged the attractive recovery claims, and wanted to see independent performance documentation.

Tepper added that the researchers worked with various chemicals, and wanted to know how moisture could be transferred without transferring contaminants contained within the exhaust airstream.

In response, the design team reported that a careful investigation had confirmed that a total-energy-recovery wheel manufactured by Semco, Inc., marketed under the "Exclu-Sieve" trademark, was determined to be the only product suitable for the facility.

The Semco system would allow the building's ventilation system to bring in significantly more fresh air, without raising energy costs. It does this by pre-conditioning the air. Depending on outside conditions, the total-energy-recovery system deliv-

Johns Hopkins chose a desiccant-based system for its Ross Research facility.

ers supply air to the hvac system at a temperature of 60º to 80ºF, with humidity levels of 40% to 60% rh. This means conventional heating-cooling systems can be downsized — and on many days of the year, don't need to operate at all.

The system buffers the building from extreme weather conditions, providing outdoor air to the system's heating-cooling coils at springtime conditions year round. In short, the building never knows when winter or summer arrive.

The heart of the total energy wheel is a desiccant-coated honeycomb matrix. The wheel rotates at about 20 rpm between the building exhaust and supply airstreams. The desiccant coating transfers 75% to 90% of the heat, while it adsorbs and transfers moisture from one airstream to the other.

Moisture is transferred in vapor form; there are no wet surfaces to support microbial growth or chemical byproducts associated with boiler steam humidification.

The product has been applied to numerous similar installations, with a successful track record. Independent test data were available to confirm the performance claims, as well as the ability of the product to limit cross-contamination.

Figure 1: Johns Hopkins Ross Research Building energy savings and economic analysis.

ANNUAL ENERGY SAVINGS SUMMARY

	Conventional system	"Exclu-Sieve" preconditioning
Energy cost for outdoor air heating and cooling	$1,070,50	$503,300
Demand charges on energy cost	$151,800	$73,800
Total energy cost	$1,222,300	$577,100
Energy savings with total energy preconditioning		$645,200

Notes:
1. Supply air 300,000 cfm; exhaust air 280,000 cfm.
2. Electric cost is $0.045/kWh; gas at $0.45/therm.
3. Based on a 24 hour/day, 7 day/week operation.
4. Reheat to 650F during winter with humidification.
5. Assumes cooling to 52'F during cooling season.
6. Demand charges are $14.42 from June to September.

FIRST-COST COMPARISON SUMMARY

	Conventional system	"Exclu-Sieve" preconditioning
Cost of energy recovery or AHU preconditioner	$450,000	$1,056,900
installation-ductwork	$235,000	$73,800
Chiller and cooling tower	$3,158,400 (2,632 tons)	$1,538,000 (1280 tons)
Boiler and piping	$286,300 (818 hp)	$71,400 (204 hp)
Total installation cost	$4,129,700	$2,959,300
Exclu-Sieve preconditioning first-cost savings		$1,170,400

PILOT PROJECT

Given the Ross project's magnitude, the School of Medicine decided to first apply the technology on a smaller scale at one of the other Johns Hopkins' facilities. The objective here was to allow for in-house testing of recovery

performance, and confirmation that desiccant technology would not transfer airborne contaminants from the exhaust air to the clean outdoor airstream.

This pilot installation was completed in a new animal virology laboratory, which was housed in a renovated bookstore. The project was tested for cross-contamination by our own Health and Safety Department; the system was found not to transfer contaminants from one airstream to the other.

This system operated for approximately two years prior to construction of the Ross Building. The reliability was excellent. This positive experience gave us the confidence needed to give our approval for the Ross facility.

With final design completed, the outdoor air requirement was determined to be approximately 300,000 cfm, with an exhaust requirement of approximately 280,000 cfm. The space conditions needed to be controlled to approximately 75°F, 50% rh, 24 hours per day, seven days per week.

Chilled water and steam are supplied from the Johns Hopkins central utility plant. A heat exchanger produces steam free of treatment chemicals for humidification.

All mechanical equipment is housed inside a

rooftop penthouse. Outdoor air enters through a floor-to-ceiling intake louver, and passes through a series of filters to remove particulate. Fans then draw the air into one of two mechanical rooms, each outfitted with four I 4-ft-dia desiccant wheels.

In hot weather, the bottom of each desiccant-coated wheel adsorbs humidity and heat from the outdoor air. Cooler, drier air leaves the other side of the wheel, and passes through chilled-water coils before being circulated throughout the building. Exhaust air is drawn from the many laboratory areas, lab hoods, and biocontainment cabinets throughout the facility. Before leaving the building, this air picks up heat and humidity from the top part of the rotating wheel.

In colder weather, the process is reversed. Cold, dry air enters the building and passes through the wheels, picking up heat and moisture recovered from the exhaust air. Then the pre-heated, pre-humidified air passes through hot water coils, and — if necessary — is further humidified. The heated and humidified air is circulated to occupied areas of the building.

As shown in Figure 1, the cooling and heating loads would have been 2,632 tons and 818 boiler hp, respectively, had the total-recovery approach not been applied. With the total-recovery approach, only 1,280 tons and 204 boiler hp are required on design days.

By reducing this load from our central utility plant, a dedicated chiller and boiler plant for the Ross facility was avoided, thus reducing project first cost and conserving valuable facility space.

Figure 1 also shows annual estimated energy savings. The $645,200 per year in estimated energy savings reflects a 53% reduction in the projected cost of maintaining space conditions within the Ross facility without total recovery.

The effectiveness of energy recovery is perhaps best demonstrated by standing in front of and behind the energy

The Ross Research facility houses all types of laboratory space, where a diverse range of medical research projects is conducted.

Figure 2: Heating mode.

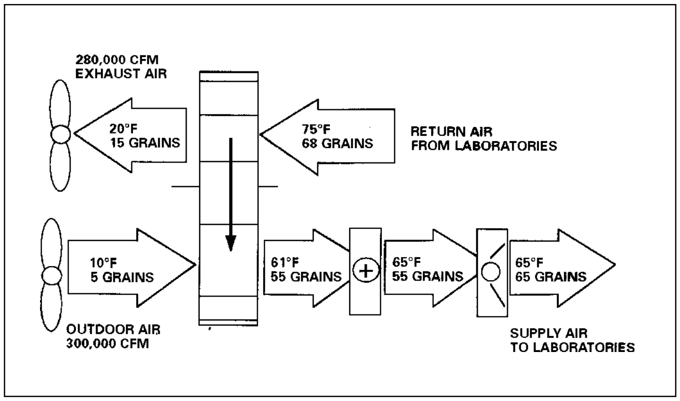
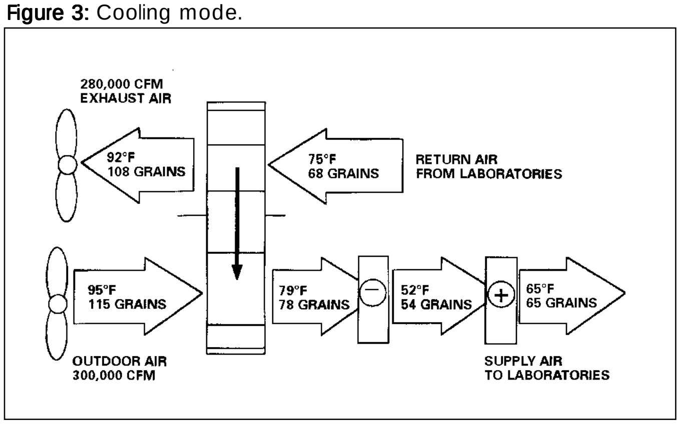


Figure 3: Cooling mode.



wheels on a cold winter day. The supply air to the space (Figure 2) feels like a tropical breeze by comparison. In fact, during most of the heating season, the energy recovery is efficient enough to provide the 65^0F desired by the building, allowing it to be conditioned entirely by the internal sensible heat load.

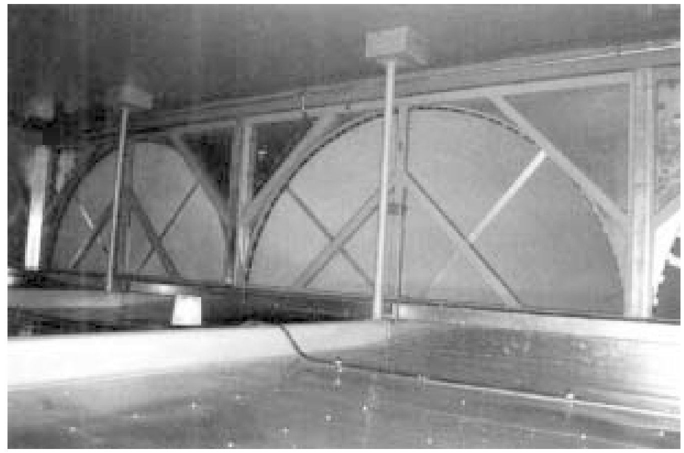
The maintenance required for the energy-recovery wheels has been minimal, amounting to semi-annual bearing lubrication and routine inspections. The system has maintained the conditions desired within the facility, even on extreme days, using the chilled water and steam allocated during design.

REDUCED CONDENSATE

Other benefits documented over the past four years include a dramatic reduction in condensation. Since the wheels remove most of the moisture from the outdoor air, relatively little condensation forms on the cooling coils compared to conventional systems.

This benefit reduces fan horsepower and lowers the risk of moisture carryover to filters and ductwork on very humid days. Since the wheels buffer the cooling coils and humidifiers from extreme swings in outdoor humidity levels, humidity control within the space is simplified. And, as mentioned,

the wheels preheat the outdoor air so effectively on design



A view of the desiccant wheel.

winter days, that the freeze-stat alarms remain silent.

These operational benefits, energy savings, and project first-cost savings have obviously pleased those of us in Operations at Johns Hopkins.

IAO FOR RESEARCHERS

Since providing for the safety of the researchers was the primary directive to the mechanical design team, Tepper also needed to be satisfied with the resultant indoor air quality.

When recently asked about his perception of the system's performance, Tepper reported that he was very pleased. His original concern was that an energy-recovery system would cause cross-contamination — contaminants from the exhaust air coming back into the building. This doesn't appear to have happened at all.

Tepper said that "There hasn't been a single indoor air quality complaint."

Proof of the equipment's effectiveness came through an unscheduled "test" late one night, when a researcher accidentally spilled a container of mercaptoethanol, the chemical added in minuscule concentrations to provide the odor in natural gas. Mercaptoethanol can be smelled in concentrations of three parts per trillion.

Tepper reported that "The odor cleared out of the building within about 20 minutes, and not a trace of it returned."

In conclusion, the decision to employ desiccant-based total-energy-recovery technology proved to be an effective design solution, which has pleased all parties involved with the project.

With all these benefits — safety, comfort, reliability, reduced project first cost, and increased energy savings —Johns Hopkins will continue to consider this particular desiccant-based recovery technology for future expansions of its medical research facilities. **ES**

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