For a facility to operate properly and economically, four challenges must be met

Ventilation & IAQ *for the Hospitality Industry*

By WILLIAM A. TURNER, MS, PE
President, Turner Building Science LLC
The HLTurner Group Inc.
Concord, N.H.

Designers of HVAC systems for the hospitality industry are faced with the challenge of providing suitable indoor environments for both an establishment's customers and its workers at an affordable price. This involves consideration of first and operational costs, system maintainability, and degree of environmental control, which includes:

- Temperature control.
- Interior moisture management.
- Pollutant control.
- Interzonal pressure control and the influence of adjoining facilities.

This article will explore these environmental-control challenges and discuss ways to meet them.

TEMPERATURE CONTROL

In general, temperature can be readily addressed utilizing conventional packaged heating and cooling equipment only if enough zones of control and stages of cooling are designed into the system. Additionally, the architect and mechanical engineer need to be on the same wavelength regarding building-shell construction (i.e., where glass will be located and how much insulation will be in the rest of the facility).

This design challenge is relatively straightforward. The control of temperature in a number of zones will be used to develop a general cost for the job. The resulting systems will be determined mostly by how much capital the owner or tenant wants to invest in the facility initially.

HVAC-construction costs, excluding exhaust equipment, for this type of temperature-only design approach are likely to be $12 to $16 per sq ft.[1]

INTERIOR MOISTURE MANAGEMENT

This parameter is one of the most difficult to understand and to economically address to anyone's satisfaction, whether it be the person paying for construction, the person paying for operation, the designer, or the contractor. Moisture management in hospitality settings (where conditioning outdoor air is always important) is seriously limited by the moisture-removal capacity (the latent capacity) of conventional packaged rooftop air-handling equipment.

Additionally, pressure differences across exterior walls imposed by site-specific equipment

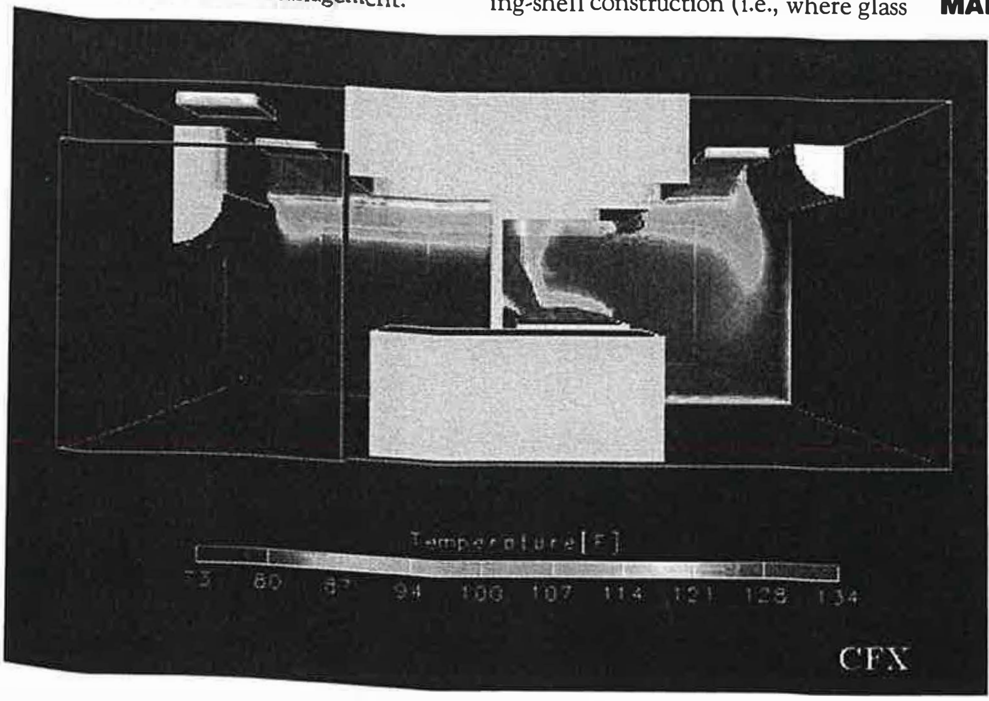

FIGURE 1. CFD model of a kitchen displacement-ventilation system showing air temperatures. Image courtesy of Halton Co.

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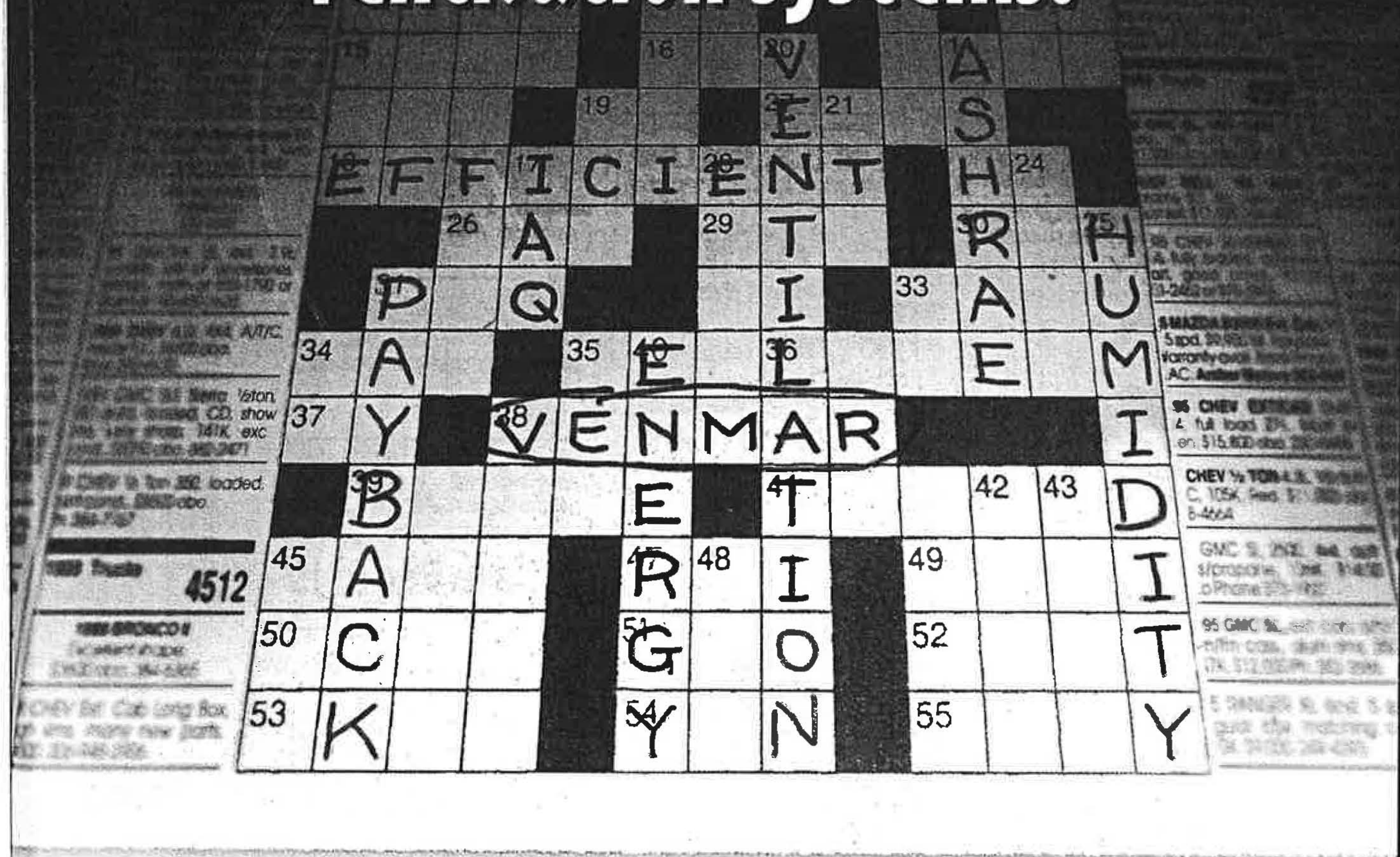

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and air-volume-balancing adjustments may have a dramatic effect on interior moisture levels. In a hot and humid climate, if any part of the building shell is operated at even a modest negative pressure of 5 pascals, moisture loading in the facility will be dramatically increased by the uncontrolled infiltration.

Further, design or construction issues related to air leakage through the facility's shell may significantly impact the ability of the mechanical systems to control interior moisture when there are significant indoor/outdoor temperature differences or when a return plenum is incorporated into the system design.

The following are three design approaches:

Packaged rooftop direct-expansion air conditioning. By design, moisture-removal capacity is extremely limited with packaged air-conditioning equipment. This, in turn, means that design concepts are limited.

A conventional approach for a restaurant is five or so packaged rooftop units to serve the non-kitchen areas. The makeup air obtained from a percentage of outdoor air by each of the units is the only conditioned air available by transfer for makeup to the kitchen. In such cases, additional tempered (heated or slightly cooled with no dehumidification) outdoor air often is provided to the kitchen area for hood makeup. Typically, this additional makeup air would be provided directly to the area of the hood system in accordance with the hood manufacturer's guidelines.

If this additional air is not provided to the kitchen or is restricted, the whole facility will be pulled negative by the kitchen exhaust and moisture management will become extremely difficult. This can result in visible surface condensation on cold surfaces, such as diffusers in the non-kitchen areas, and, sometimes, visible mold growth due to condensed moisture.

A net negative-pressure imbalance is a classic problem observed in many hotel lobbies in hot and humid climates. These types of problems have been reported in work by researchers at the Florida Solar Energy Center.[2]

HVAC-construction costs, excluding exhaust equipment, for this type of design approach are likely to be $13 to $18 per sq ft.[1]

Supplemental dehumidified makeup air and alternate exhaust-hood design. Engineers at Halton Co. in Scottsville, Ky., recently evaluated a novel, cost-effective approach to the conventional practice described above (figures 1 and 2). Computational-fluid-dynamics (CFD) modeling has confirmed that the use of wall-mounted, perimeter displacement supply-air flow coupled with high-efficiency hood design (with capture jet hoods) can drastically improve kitchen temperature and humidity control with reduced overall exhaust-hood flows. The low velocity (less than 50 fpm) provides occupant comfort and acceptable thermal comfort.

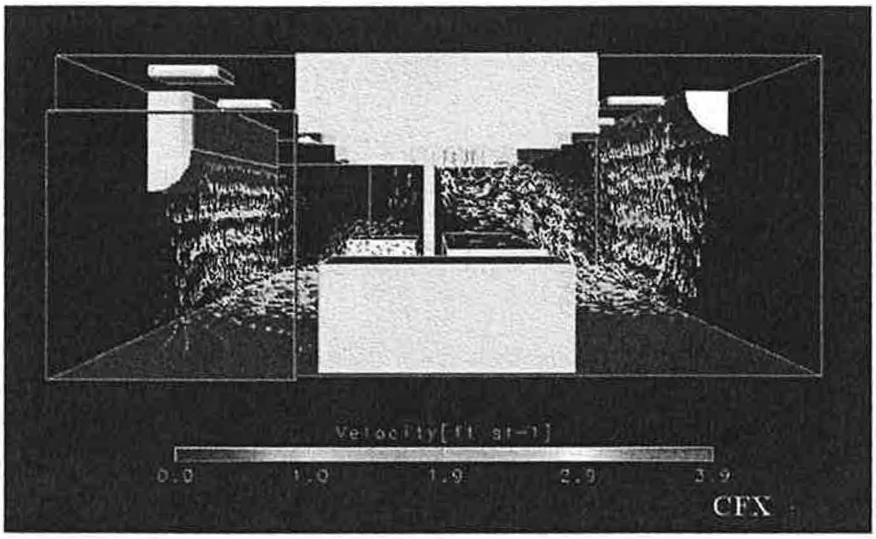

FIGURE 2. Computational-fluid-dynamics model of a kitchen displacement-ventilation system showing air velocities. Image courtesy of Halton Co.

This approach also reduces the amount of cooling tonnage needed in the kitchen design because of minimal cfm and eliminates pressure imbalances.[3]

Construction costs for this type of design approach are likely to be as low as $10 to $15 per sq ft, depending on the need for the dehumidification of makeup air.

Enhanced dehumidification of makeup air and conventional kitchen-hood design. Several companies have made available specialty-type packaged rooftop dehumidification units that use energy recovery for reheat. These units are designed to provide extra dehumidification of makeup air—far beyond the capacity of a packaged rooftop air-conditioning system. They come in a wide variety of sizes and configurations and are highly adaptable. Specialty units such as these are becoming more prevalent in hot and humid climates, where facilities operate more than 12 hrs per day and long-term operational costs, direct-expansion or chiller cost, and first costs are considered.

HVAC-construction costs, excluding exhaust equipment, for this type of approach are likely to be $17 to $23 per sq ft.[1]

For any of the above approaches to be successful, meticulous commissioning is needed to ensure that the equipment is operated as designed and balanced so that the pressure on the building shell is close to neutral or positive with respect to the outdoors.

POLLUTANT CONTROL

Although this is one of the better understood issues in HVAC design for the hospitality industry, it is the poorest addressed nationally. One challenge for designers is that there are few, if any, standardized criteria for acceptable pollutant levels in non-industrial environments. Another challenge is that there are few, if any, inexpensive solutions to control pollutants from internally gen-

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erated or locally generated outdoor sources that will work well over time.

This topic is best approached by first looking at the foul-smelling and potentially hazardous pollutants that are found in the hospitality industry and the most cost-effective and reliable method of eliminating or minimizing them.

Pollutants that need to be managed through design and commissioning include:

▼ *Cooking odors/emissions.* By design, hood layout and roof-exhaust/inlet geometry in accordance with Chapter 14 of the *1997 ASHRAE Handbook of Fundamentals*[4] will handle most sources of cooking odors within the kitchen area. Carbon monoxide and other aerosolized fine particles associated with gas appliances and frying also are readily controlled with proper hood design and operation as long as adequate makeup air is properly provided to match the exhaust-hood design. Innovative kitchen-hood designs are available as noted earlier. In some air-pollution districts, catalytic devices are being utilized to reduce odoriferous charbroiler emissions to the outdoors.

▼ *Restroom/swimming-pool odors.* With proper plumbing-code and ASHRAE design guidance, odors from these areas can be controlled readily with little impact on the rest of the facility. Very often, when odor isolation via pressure control is desired in a hot and

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Dealing With Tobacco Smoke

Clearly, the most efficient way to achieve a tobacco-smoke-free environment is to eliminate smoking activity.[5,6] Because this approach may not be an option for certain segments of the hospitality industry, methods of reducing exposures are presented below.

Air cleaning or dilution. Tobacco smoke and its byproducts are difficult and costly to control in the hospitality industry. Two conventional approaches are:

• *Air cleaning.* To remove tobacco odor, which consists of multiple gases and very fine particles, more than one air-cleaning technique is needed. Historically, a renewable gas-cleaning medium has been used with a fine-particle-removal medium, each with a finite life. Generally, fine particles can be removed with HEPA-type particle filters. However, methods of removing the gaseous and semi-volatile component of tobacco odor to levels acceptable to sensitive non-smokers have not proven to be generally affordable or reliably maintained.

• *Dilution.* Researchers at Yale University conducted research that was utilized in the development of ASHRAE Standard 62, *Ventilation for Acceptable Indoor Air Quality.*[7] A careful review of the data shows that in excess of 100 cfm of outdoor air per smoker is needed to dilute tobacco-odor levels to acceptable levels for non-smokers.

HVAC-construction costs for either design approach are likely to be at least $25 per sq ft.

Because environmental tobacco smoke (ETS) has been classified a carcinogen by the U.S. Environmental Protection Agency, the implications of involuntary exposure to it by employees have become more important to regulatory agencies. Several recent studies, including those by the National Institute of Occupational Safety and Health, documented significant exposures to secondhand smoke and unacceptable health risks among workers in the hospitality industry.

Isolation and exhaust. During a three-day technical workshop on controlling tobacco-smoke emissions as a point-source pollutant in the hospitality industry sponsored by the Occupational Safety and Health Administration and coordinated by the American Conference of Governmental Industrial Hygienists in June 1998, members of the science and hospitality communities concluded that a combination of displacement ventilation and ventilated ashtrays held the most promise in reducing worker exposures in a cost-effective manner (see "News & Analysis," HPAC Engineering, January 2000).

This displacement technique utilizes a carefully placed combination of upper room exhaust and non-mixing supply diffusers. Exhausted ashtrays also have been reported to produce promising results. Recently, the author learned that dedicated smoke-evacuation systems, which are available for the veterinary medicine field, could be adapted to the hospitality industry.

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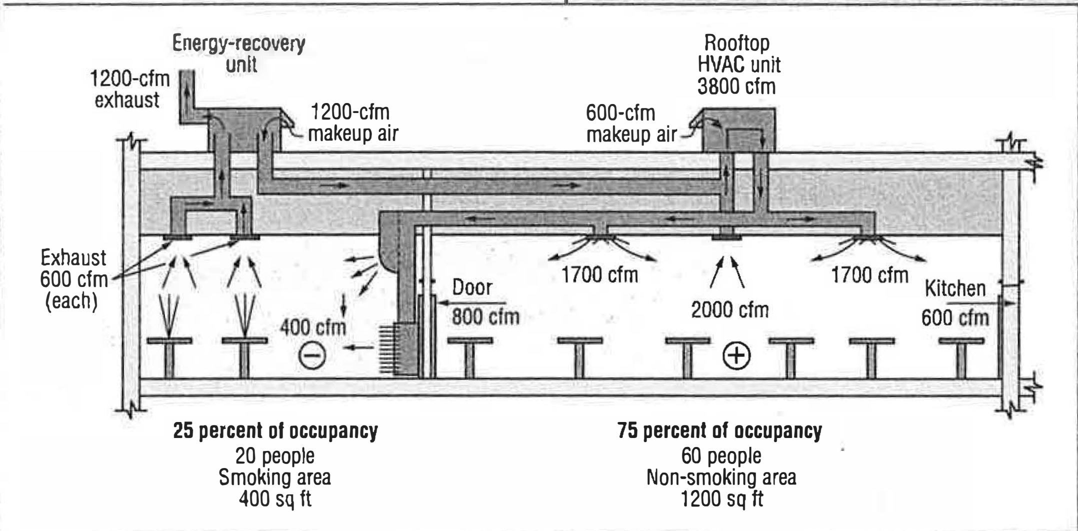

FIGURE 3. Sample installation schematic of a designated smoking area in a restaurant.


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Employing isolation and exhaust makes the location of both the exhaust register and the makeup-supply-air geometry important. It is crucial that they be located in a way that minimizes short-circuiting of the supply air directly to the exhaust. An effective geometry for the collection of ETS air contaminants is the exhaust register located in the ceiling as far as possible from the supply-air diffuser or transfer-air grill.

In a situation in which there is a ducted supply system, exhaust-collection efficiencies will be maximized and a smoke-reduced environment will be most likely achieved if the makeup air is supplied at a low velocity (less than 50 fpm) near floor level at several locations around the room to minimize mixing.

The exhaust register should be located in the ceiling at either the center of the room or as close to the greatest concentration of smokers as possible. This is called vertical displacement ventilation. It is more popular in Europe than it is in the United States.

A sample design utilizing a displacement approach and air-to-air total energy recovery on exhaust recently was developed for the City of Portland, Maine (Figure 3). This approach minimizes operating cost and maximizes desirable pressure relationships.

HVAC-construction costs for this type of design approach are likely to be $20 per sq ft.

For a 12-plus-hrs-of-operation establishment, payback for the total-energy-recovery equipment is expected to occur within no more than three to four years, depending on local energy costs. For a 24-hr operation, payback is expected to occur within two years.

humid climate or a cold climate, this type of exhaust can be run through energy-recovery equipment. Where codes prohibit combined bathroom and general exhaust, variances often can be obtained.

▼ *Outdoor odors/vehicle-traffic emissions.* Occasionally, these make locating a spot to bring in good-quality makeup air containing few contaminants difficult. High-efficiency particle air filters can help; however, if outdoor air is heavily polluted, only gaseous air-cleaning systems, which are expensive to operate and maintain, can do the job.

▼ *Dumpster/loading-dock odors.* Finding a solution to this problem should be a "no-brainer." The dumpster needs to be located away from the facility's air intakes and it must be emptied frequently. Locating air intakes near a loading dock and dumpster is a no-win situation for the designer and architect. Designing and commissioning the HVAC system so that all spaces ad-

joining the loading dock can be operated at a positive pressure with respect to adjacent spaces can be effective in stopping the movement of loading-dock odors into the rest of the facility.

For a discussion of dealing with gaseous and particle byproducts from tobacco products, see the sidebar on Page 40.

INTERZONAL PRESSURES AND ADJOINING SPACES

Although this parameter is one of the least understood, it likely is the simplest to address with the proper design, balancing, and commissioning of mechanical equipment. However, site-specific adjustments can affect the implementation of even good designs.

Once installed and commissioned, a good design will be compromised by changes made to the surrounding area. For example, if an attached building is not balanced, it will interfere with the performance of the design in the adjoining facility.

A simple approach is to look at the exhaust and makeup-air schedules of all of the attached facilities and identify any that are not balanced. If makeup air and exhaust cannot be balanced throughout the entire complex, a significantly pressurized air lock can be placed between the zone that is starved and the zone to be balanced. This principle is frequently utilized in containment planning and design.

CONCLUSIONS

Many advanced ventilation designs can address most, if not all, of the environmental challenges described above. It is especially important to implement these designs in climates that are hot and humid, very cold, or both, which can be found throughout much of the continental United States. In many ways, the environmental challenges found in the hospitality industry are no greater than those found in health-care facilities and semiconductor manufacturing. However, in general, HVAC capital equipment and operational costs are expected to be lower in hospitality-industry applications than in either of the other two types of applications.

All of the advanced solutions noted here require an investment in capital equipment beyond packaged, off-the-shelf rooftop units; however, in most cases, the costs can be recovered in a relatively short period of time. It would be useful for ASHRAE to develop more information regarding these advanced equipment approaches. This information, in conjunction with an expanded section on the control of tobacco-smoke emissions as a point source or mobile point source in the American Conference of Governmental Industrial Hygienists' *Industrial Ventilation: A Manual of Recommended Practice*,[8] would help designers to more uniformly address these issues.

Until sufficient educational material is available, the development of advanced solutions that work well will depend on the talents of engineers and designers who create them through research efforts.

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Hospitality Ventilation and Standard 62

ASHRAE Standard 62-1999, *Ventilation for Acceptable Indoor Air Quality*, contains requirements and other guidance for achieving acceptable indoor air quality, including requirements for minimum ventilation rates for a number of space types. Originally published in 1989, it was updated last year with four addenda, none of which significantly changed the standard's requirements (see "News & Analysis," HPAC Engineering, January 2000).

Currently, the Standard 62 committee is considering several other addenda. Among them are:

• Addendum 62g, which has been out for two public reviews. It contains requirements for separating spaces exposed to environmental tobacco smoke (ETS) from spaces that are not exposed.

• Addendum 62o, which contains guidance on determining design ventilation rates for spaces in which smoking is expected to occur. This guidance is based on the control of odor and irritation from ETS, not health impacts. Addendum 62o has not yet been released for public review; however, the committee is working to release it as soon as possible.

• Addendum 62n, which modifies the procedure for calculating ventilation rates. It could result in an increase or decrease in minimum outdoor air rates, depending on the space type and occupancy level. A second public-review draft was expected to be released no sooner than this summer.

The design ventilation rate in the first public-review draft of Addendum 62n is based on the sum of a cfm-per-person rate and a cfm-per-square-foot rate; so the net cfm per person depends on occupant density. Designers would assume an occupant density and calculate a rate from that; however, they would need to show their assumptions and calculations explicitly.