New Demands, New Opportunities.

by Mike Thoresen & Jim Regan

Strategies exist to help today's HVAC systems meet increased needs — if you know where to look.

Comfort and control, flexibility, equipment loads, energy efficiency and reliability: Today's business environment is placing increased demands on building mechanical systems in a wide variety of ways. At the same time, improved HVAC technologies and design strategies offer many opportunities to meet these demands cost-effectively.

Facility executives have always been concerned with maximizing occupants' comfort and minimizing complaints. Today this is more important than ever. In fact, space comfort — including temperature and air quality — is the number one or two complaint in most surveys of office workers. Business owners are recognizing the effect of the office environment on their ability to attract and retain highly qualified employees.

Part of the issue of comfort is control: the increased demand by occupants to control the temperature and air flow in their immediate area. Where mechanical engineers used to group four or five perimeter offices together on one thermostat, now there are often only three offices, on average, per thermostat.

Occupants also are demanding improved air quality, whether that is achieved with increased air flow, improved filtration or a combination of the two. With today's attention on "green building" construction in all its aspects — including energy efficiency, construction materials, outside air exchange and purity — air quality issues must be addressed in just about every project.

Flexibility Is Key

The increased churn rates in today's commercial buildings require increased system flexibility to accommodate reconfiguration of interior space. The issues of comfort, control and flexibility are exacerbated by the need to operate businesses a greater number of hours a day than in the past — in many cases, 24 hours a day, 7 days a week.

Although office equipment is becoming more efficient, requiring less power and putting out less heat, there is more equipment per person — individual PCs, copiers, printers, etc. — which means increased overall office equipment loads. In fact, there has been a 50-percent increase in design loads over the last few years from an average of 4 to 6 watts per square foot.

Data center load density also is rising. Where 20 to 40 watts per square foot load density was typical, now it is not uncommon to see design loads of 80 to 100 watts and higher. At the same time, computer facilities are becoming more critical to companies' business missions and productivity, and there is increasing reliance on networked systems. This demands greater reliability from the cooling system, therefore higher levels of system redundancy.

Increased Lead Time

Among the current challenges in any new construction or renovation project is increased demand for the equipment itself. In today's construction market, a project involving supplemental air conditioning for a building space is typically on an 8- to 12-week construction cycle, with an average lead time of 20 weeks to obtain an air conditioning unit. One company specializing in cooling equipment for data centers requires over 40 weeks lead time. This may require selection of an alternate off-the-shelf product, although it can also affect the design strategy overall.

Renovations of older buildings present special challenges. Many older mechanical systems simply cannot support increased loads, and supplemental systems must be installed. But each space must have the spatial and structural capabilities to accept additional generation and distribution equipment. Existing ceiling heights are often a problem. Rooftop space may be limited or structurally inadequate. In some cases, there is no feasible alternative other than taking floor space to house new mechanical rooms.

At the same time that demands are increasing on mechanical systems, improved off-the-shelf technologies such as under-floor systems, fan-powered terminal units, variable air volume (VAV) diffusers, direct digital control (DDC) systems and increased chiller efficiency are providing opportunities to meet facility executives' needs.

Below Deck

One of the most interesting developments is the underfloor air distribution system. Traditional systems rely on above-ceiling installation of ductwork and large distribution units. In this system, a raised floor is divided into separate plenums to control the distribution, and these act as the "ductwork." VAV boxes are attached directly to floor tiles.

If the space needs to be reconfigured, those floor tiles are simply picked up and moved elsewhere. Furthermore, the system replaces the traditional large overhead diffusers with a greater number of small diffusers, allowing for more individual control of air flow. This type of system carries a higher capital cost than the traditional above-ceiling distribution system. But it typically saves space, design work and related costs in the initial installation, and it may quickly pay for itself in a building with high tenant turnover.

That said, the system is great for new construction but is not appropriate for a retrofit. Even in a building with good floor-to-floor height, elevator and stair landings and other basic building construction elements present obstacles, and the cost of accommodation becomes prohibitive.

Fan-powered Units, VAV Diffusers

A standard VAV box reduces the amount of air as the load decreases. In a variation on the traditional above-ceiling distribution system, fan-powered terminal units can replace standard VAV boxes to increase occupants' comfort. A fan powered VAV box reduces the amount of primary or cold air as the cooling load decreases but mixes in return air to keep a constant circulation rate in the space, which tends to make people feel more comfortable.

VAV diffusers also can be used to offer control over air flow in individual offices, although at a cost of 20 to 30 percent higher than a standard VAV system. Both fan-powered terminal units and VAV diffusers can be introduced in a renovation without great difficulty, although a fan-powered terminal unit is larger than a standard VAV box, presenting challenges where there is limited space. In contrast, VAV diffusers require less space.

Other Systems

DDC systems provide more information about the operation of individual equipment in occupant spaces (e.g., temperature and volume of air), centralized equipment control and improved documentation of

HVAC operation. A DDC system either can be overlaid on, or replace, an existing control system — and it can control nearly all types of HVAC equipment. So, it is a good option in either renovation or new construction.

The new generation of chillers is more efficient. Fifteen years ago, an efficient chiller was 0.7 kilowatts per ton; today they may be 0.5 kilowatts per ton and less. Amenable to use either in new or existing facilities, new chillers can improve the building's energy efficiency, in some cases, to a significant degree.

In existing facilities, the distribution system's energy efficiency can be improved by a retrofit using variable frequency drives on fans and pumps. Although these have been around for some time, they have gotten better, smaller and less expensive.

System Redundancy

When it is essential to keep computer networks and data centers up and running, building owners take a serious look at the investment in system redundancy. N+1 has become pretty much the minimum standard, providing back-up for every piece of equipment, if not throughout a facility, then in key areas.

Take a brokerage house, for example, where a trading floor and data center may be supported by two separate, interconnected, fully redundant systems — two separate piping risers, either of which can support the system, two sets of pumps, and two sets of cooling equipment. If any part of the system fails, the other takes over. The degree of redundancy implemented depends on the degree of risk the owner is able and willing to take.

At the same time that new and improved HVAC technologies are being deployed, we are also seeing improvements in other types of building systems and office equipment, which are having a positive impact on the size of HVAC equipment and energy required to heat and cool office buildings. For example, new glass and lighting technologies — even flat screen PC monitors — reduce heat gain in the building and could reduce size requirements of the mechanical system.

Are there technologies over the horizon that will improve the operational efficiencies? Every time HVAC system technology seemed to have reached its pinnacle, this assumption has been proven wrong. The gains may come a little slower than in other fields, but they are probably still out there. There is new sound wave-based refrigeration under development, for example, which some day may be applicable to commercial HVAC equipment.

Given that the efficiency of HVAC technology generally improves in slow, steady increments, rather than great leaps of efficiency, it pays to consider upgrades about every 15 to 20 years. At that point, the gains are usually sufficient to justify a capital investment. But HVAC technology is only part of the story. An effective design strategy is also essential to getting the most out of opportunities for increased comfort and control, flexibility, capacity, energy efficiency and reliability.

Effective Design Strategies

The past few years have seen a greater recognition of the importance of advance planning in HVAC systems design. Part of the shift has come about because of new computerized tools that help maximize system design and operational efficiency.

Even more significant has been the realization of the benefits that can accrue from having mechanical engineers involved as early as possible in the design of a new facility or renovation project, rather than being brought in after many essential decisions about the overall building have been made. The concept of “whole building design” requires architects and mechanical, electrical and structural engineers to work as a team to develop a building that not only meets an owner’s program needs but performs efficiently and cost-effectively.

For example, consider the impact of heat gain, building siting and orientation, lighting strategies, and wall and roof insulation systems on the mechanical system. Unfortunately, whole building design is the exception rather than the rule. Yet it can have a big impact on the HVAC system.

HVAC today is characterized by new demands for comfort and control, flexibility, capacity, energy efficiency and reliability, and new opportunities to apply improved off-the-shelf technologies to meet building owners’ and managers’ needs. To ensure the best outcome, bring all members of the design and engineering team together from the outset. The measure of a building’s operational success is more than the mere sum of its parts.

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