As an interesting adjunct in its April article, ***EDU*** reported that UL technicians purchased and tested 30 models of UL-listed CO detectors. Some 25% of those alarms failed at least one UL response test. Asked about that result, a UL official said the sampling, which totaled only several dozen alarms, was too small to be statistically significant. (In Canada, CO detectors that meet the Canadian standard feature labels with a distinctive blue flame. The corresponding standard on detectors sold in the US is IAS-696, and the labels have a blue-star logo.)

Next Steps for ASHRAE

Under ASHRAE's bylaws, Sherman's committee must respond to the comments and questions the society receives during public review. This can be a lengthy process when a committee receives thousands of comments. Sherman said he plans to convene his committee for perhaps a day and a half in November after the public review to "decide in principle" how to respond to the expected avalanche and to assign workloads to various committee members. The committee would make formal decisions on the public feedback when it convenes next January. Sherman added, however, that the number and nature of the comments might alter this plan.

Asked what his committee would do if many thousands of comments pour in, Sherman noted that ASHRAE allows committees to give one response to a group of similar comments. "There likely will be some issues we'll resolve that leave someone or some group unhappy," Sherman acknowledged. "We'll do our best to provide the best solutions for the greatest number of stakeholders."

TOOLS AND TECHNIQUES

Multipoint Monitoring of IAQ Parameters Provides Highly Effective Tool for Top HVAC Performance

Except for thermal performance, it has historically been difficult for managers of HVAC systems to know how well their systems were operating. Continual multipoint-monitoring systems, however, now allow them to measure many areas of HVAC performance. David Bearg is director of IAQ Programs at AIRxpert Systems, Inc., a firm that markets multipoint-monitoring systems. In his paper, "Monitoring for Ventilation and Airtightness," he states that, arguably, you couldn't fine-tune a system to consume the least energy and provide adequate ventilation if you don't have feedback on ventilation performance. Bearg further suggests that multipoint-monitoring systems have distinct advantages over alternative monitoring techniques.

Bearg notes that monitoring key indoor air quality (IAQ) parameters such as carbon dioxide (CO_2), dew point (absolute humidity), and carbon monoxide (CO), will provide HVAC operators with valuable information about building airtightness, ventilation, and energy performance. Monitoring CO_2 concentrations, for example, allows them to determine the relationship between the distribution of ventilation and actual occupancy loads, how effective the overnight purge is of air contaminants, and if ventilation is adequate.

Monitoring Methods

Systems for monitoring IAQ parameters include:

- Manual collections of air samples at a single location, also known as "grab" samples
- Wall-mounted sensors that continually monitor CO_2 levels
- Continual multipoint-monitoring systems

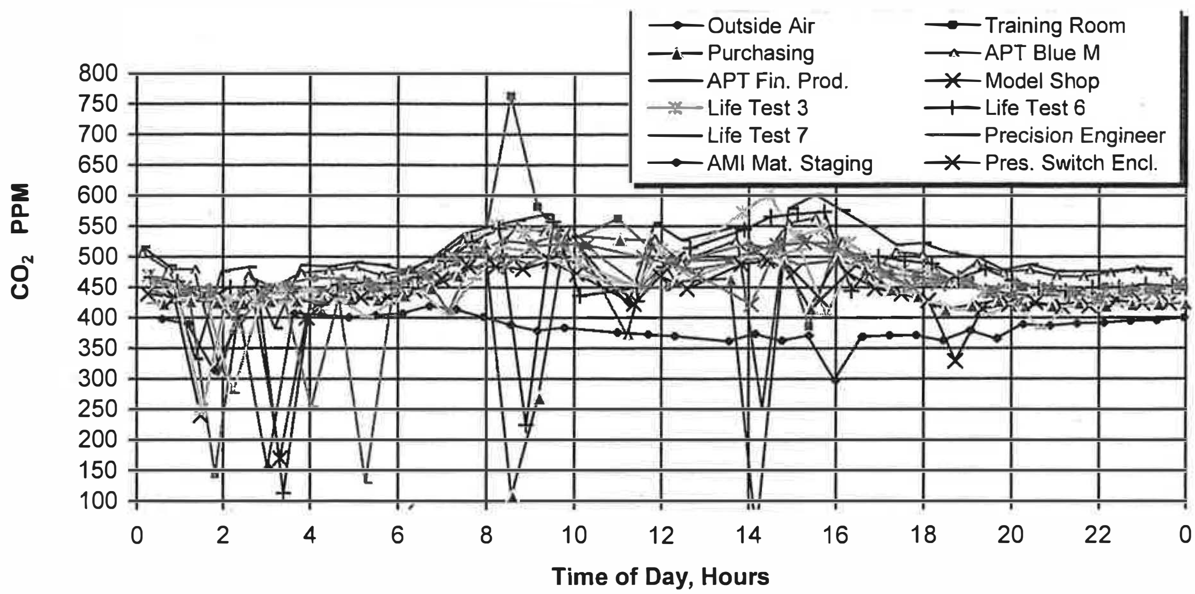
Regarding the grab-sample method, Bearg says that it is impossible to know from this isolated sample if the CO_2 concentration measured represents a peak value. If it doesn't, it may overstate how much ventilation the system is providing. On the other hand, continual multipoint monitoring not only reveals the peak values, but also when and where they happened. He cites as an example a building where the CO_2 concentration peaked in the morning. This happened because the HVAC system overcooled the space each morning so that, even with the influx of people, it maintained the minimum ventilation setting for two hours. Since occupants exhale CO_2, concentrations rose significantly, he says. After the space warmed up, the local setting opened, ventilation increased, and CO_2 declined.

Regarding wall-mounted CO_2 sensors, Bearg notes that these sensors could drift or fail with no feedback to track their reliability. Recalibrating them periodically can become expensive. In contrast, he states that a single CO_2 sensor in a shared-sensor system automatically provides feedback on its own and the HVAC system's performances. A shared-sensor system has a vacuum pump and an array of sampling lines that deliver air from various parts of a building to a single sensor. Such systems provide feedback about each IAQ parameter that operators track. Figure 1 shows that even if this system drifts or fails, its data measurements reveal their obvious unreliability through random inconsistencies and numerous inaccurate readings of CO_2 below 300 parts per million (ppm). Therefore, the single, shared-sensor system reveals that any differences operators observe between locations can only be due to differences in the density of occupancy or to the system's performance, but not to differing responses from different sensors. And since the network of sampling lines, vacuum pump and data collection, and storage system are already in place, he adds, the shared-sensor system makes it easy to sample multiple IAQ parameters.

"Continual multipoint monitoring of several parameters offers many advantages over the other approaches intended to optimize the management of indoor environments," Bearg states. For starters, building operators only need one sensor to track IAQ parameters. These parameters might include CO, hydrocarbons, and pressure differentials, in addition to CO_2 and dew point. Since there's only one sensor, the multipoint system is much cheaper to maintain than one with distributed sensors, Bearg points out. One model of a multipoint-monitoring system analyzes air from up to 48 rooms or locations. Using the information such a system gathers, operators can pinpoint when and where infiltration occurs and how well the system ventilates the building. The operators can then employ the system's continual monitoring feedback to guide them to make system adjustments that improve ventilation and reduce infiltration. And the computer used to control sequencing of the solenoid valves among the 48 sampling lines also automatically archives and separately plots IAQ data that the system graphs daily.

In addition, multipoint monitoring of CO_2 concentrations allows system operators to assess how much ventilation the system supplies to occupants, "because the measured CO_2 concentrations reflect the dynamic interaction between the amount of ventilation provided and the number of people in the space," Bearg reports. This would let the operators not only measure but also verify how much ventilation the system provides and whether that amount is adequate. "For instance, if the indoor to outdoor difference exceeds 530 ppm (e.g., outdoors at 370 ppm and indoors greater than 900 ppm), then the ventilation rate is less than 20 cfm [cubic feet per minute] of outdoor air per person at that location,"

Figure 1



Data measurements reveal failed carbon dioxide (CO_2) sensor in randomly inconsistent readings and inaccurate CO_2 readings below 300 ppm.

he observes. Furthermore, multipoint monitoring also reveals information about the performance of the distribution system for each air-handling unit under review. "This is a major step forward in the assessment of HVAC performance with respect to ventilation compared with previous efforts that have focused only on how much outdoor air was entering the HVAC system (Warden 1995)," Bearg argues.

Figure 2 illustrates an example of nonuniform ventilation among zones served by an air-handling unit. Bearg explains that the deficiency of ventilation to Location 6 compared with the other locations was due to a section of wall above a suspended ceiling that blocked the plenum return. When the wall was removed, the ventilation to Location 6 and the other locations became uniform (see Figure 3). He says this demonstrates the system's value at both identifying ventilation problems and documenting whether efforts to fix them are effective.

Building Airtightness

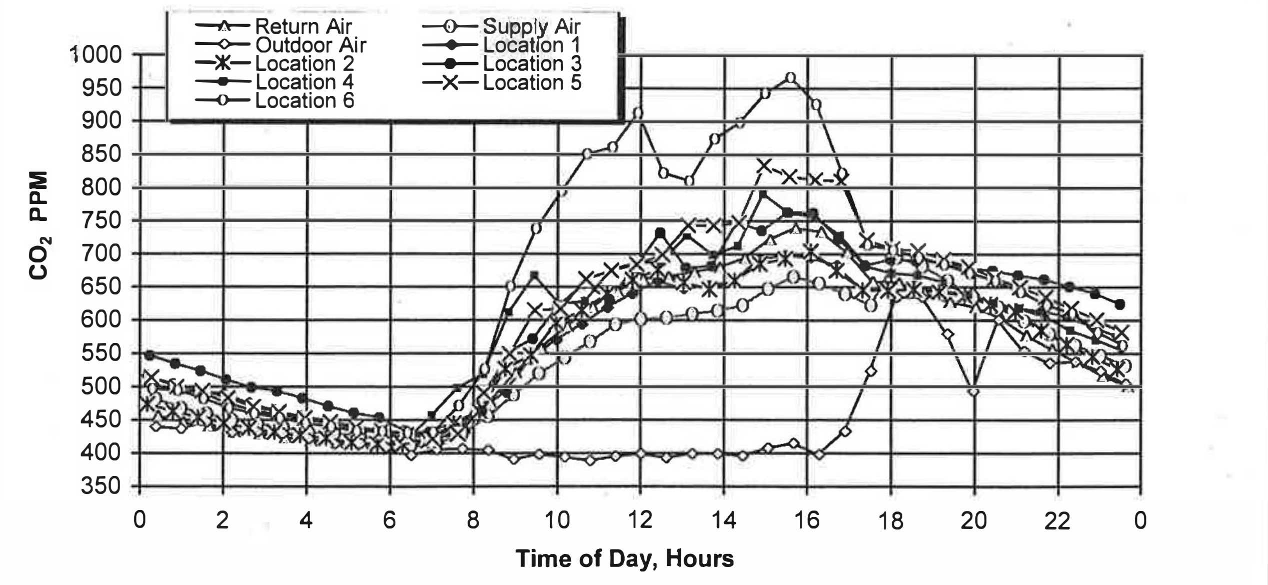
Multipoint monitoring also assesses how airtight a building is because building envelope tightness in combination with pressure relationships contributes to the infiltration of unconditioned air, Bearg notes. By combining dew point measurements and CO_2 concentrations, you can determine infiltration. Bearg cites an auditorium where multipoint monitoring revealed dew point values on a given day that were dramatically different from dew point values elsewhere in that building. In fact, they fell between the building's other dew point values and the outdoor dew point and were significantly closer to the outdoor value for up to 10 hours. That indicated either an indoor source of moisture or infiltration. In this case, when the HVAC is off in the early morning and late evening, the values are almost identical to the outdoor dew point, which points the finger at infiltration leakage.

"An even more interesting situation can be observed for the supply air of RTU-1 [at another building], where there is a difference in the dew point temperature compared with the rest of the building," Bearg reports. The monitoring data tipped off the operators that something was amiss with the equipment. They found, in fact, that a piece of sheet metal had broken free to allow internal leakage around the cooling coil.

"Similarly, infiltration from lower-level parking facilities and loading docks can be assessed by the inclusion of CO among the IAQ parameters being monitored," Bearg continues. This is evident in Figure 4, which shows spikes of CO measured in a basement parking garage and loading dock. Fortunately, the figure also shows that the HVAC system is successfully blocking infiltration of the CO into the occupied building.

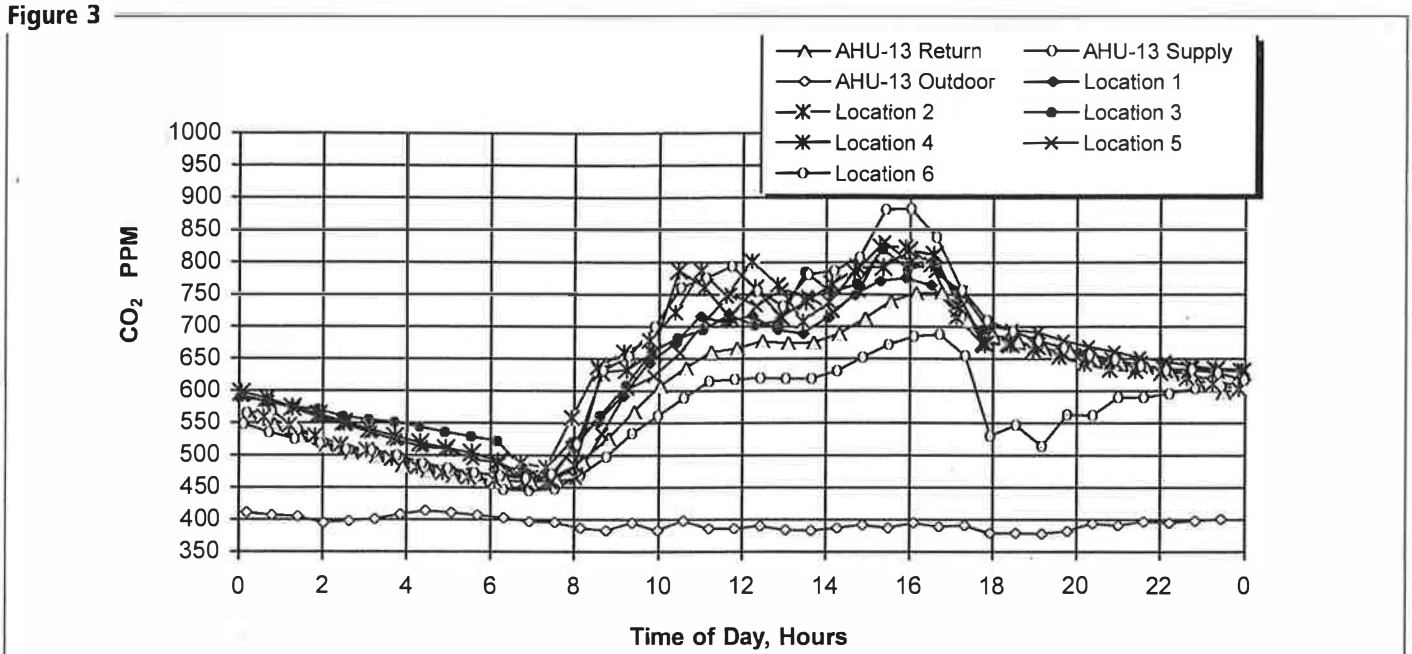
Multipoint monitoring of CO_2 concentrations can also reveal if an outdoor air intake is drawing in motor vehicle exhaust, because CO_2 concentrations

Figure 2



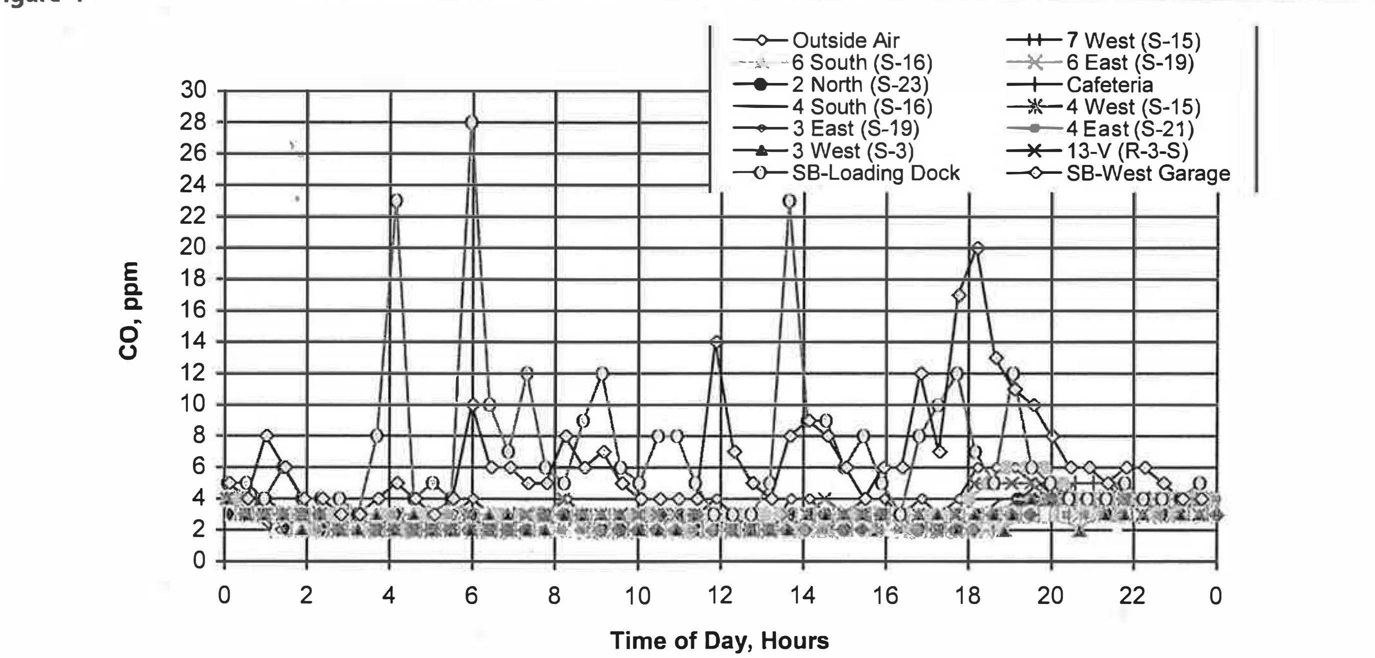
Example of an air-handling unit providing nonuniform ventilation. The multipoint-monitoring system pinpointed the deficiency in ventilation to Location 6, which led system operators to unblock a plenum return.

Figure 3



After system operators removed the plenum blockage, all locations began receiving uniform ventilation.

Figure 4



Multipoint monitoring pinpoints spikes of carbon monoxide (CO) in a basement garage and loading dock. The system also reveals the HVAC system is succeeding at blocking CO infiltration into the building.

there will increase compared with typical CO_2 values of between 360 and 420 ppm. Reintroducing building exhaust to the building through an outdoor air intake might also be the cause.

Finally, monitoring CO_2 concentrations and dew points overnight when few people occupy the building provides another measure of how airtight a building is, its ventilation efficiency, and its energy use, Bearg points out. The rate at which indoor values approach the outdoor value indicates how much ventilation the system provides. If the building leaks, or if its ventilation system operates too long after occupants leave, or both, indoor values will rapidly reach the outdoor value, indicating energy inefficiency. Conversely a tight building or one where ventilation cycles off too soon may prevent the building from purging human air contaminants (CO_2 and various chemical compounds from skin bacteria) overnight. Monitoring CO_2 concentrations would reveal if the overnight purge is optimal, which is when indoor values decrease to the outdoor value just before people reoccupy the building each morning.

Bearg concludes, "Multipoint monitoring of key IAQ parameters in buildings can be a very effective way of achieving feedback on ventilation performance and can thereby reduce uncertainty and risk that otherwise could be present in the operation of the HVAC systems. Monitoring can therefore improve the management and control of ventilation system performance, leading to improved indoor environments."

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CASE STUDY

[In each issue, IEQS *presents a case study on an indoor air investigation in a particular building. The information in the cases comes from various sources, including published material, reports in the public record, and, in some cases, reports supplied by the consultants involved in the case.* IEQS *presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply* IEQS*'s endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case.* IEQS *invites readers to submit comments, suggestions, and questions concerning the case. At the discretion of the editors, correspondence may be presented in a future issue.]*

After Remediation, Unique Fan-Coils Are Key to Keeping Mold, Mildew Away at Hawaiian Hotel

Shortly after the US Army Community and Family Support Center opened its new 12-story Maile Tower addition at the Hale Koa Hotel on Honolulu's Waikiki Beach in Hawaii, hotel staff began to notice a decline in indoor air quality (IAQ). The US Army Community and Family Support Center is the proponent agency for the operation of US Armed Forces Recreational Center facilities around the world. All active military and retired military members of the US Armed Forces and their families may use these facilities. The construction of the Maile Tower was funded at a cost of $50 million with nonappropriated funds (nontaxpayer dollars). Part of the hotel tower's cost included an extensive program to ensure quality construction. Despite that conscientious effort at quality assurance, the building developed high humidity that triggered mold growth and mildew, making the room air feel damp and degrading the room wall covering.

Background and Investigation

The US Army Community and Family Support Center's contractor completed the Maile Tower in 1995. When the excess moisture and mildew became apparent, hotel staff members tried to control it by putting room fan-coil units at their coolest setting. As room temperatures dropped to about 60°F, however, relative humidity increased to nearly 90%, which foiled their action. When other attempts to combat the problems failed, the Community and Family Support Center enlisted CH2M Hill's aid early in 1997. With more than 7,200 employees at 84 US offices and nearly 20 overseas offices, CH2M Hill — headquartered in Orlando, Florida — packs plenty of firepower and bills itself as the largest environmental engineering firm based in the US.

CH2M Hill joined forces with Bruce Parzych, the Community and Family Support Center's project manager for the Hale Koa Hotel expansion, and the Army Corps of Engineers, Pacific Ocean District to identify the causes of the excess moisture, correct them, and defeat the mold. CH2M Hill engineers studied the building for about a year and pinpointed three key factors that promoted the indoor moisture, mold, and mildew problems. First, the HVAC fan-coil units didn't adequately dehumidify tower guestrooms. Second, the bathroom-exhaust system caused unconditioned outdoor air to infiltrate the building, boosting humidity. Finally, the vapor retardant — a vinyl wall covering — was deployed