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## Terrorist Bomb Scores Direct Hit on Trade Center HVAC System

When a terrorist bomb exploded in the World Trade Center, New York City, USA, on February 26, the complex's custom-made HVAC chillers were close to ground zero.

A trade center spokesperson told ***IAQU*** that officials believe all or most of the seven 7,000-ton units were buried under 3,500 tons of reinforced concrete debris. While nearly 1,900 tons of debris had been removed at press time, workers still hadn't reached the units to determine the amount of damage.

The air handling units for the giant towers were unhurt in the blast and continue to operate, but without the cooling ability provided by the chillers. Replacing the specially made units could take up to a year. "We have a little breathing room," the spokesperson told ***IAQU***, "because we've never needed the chillers until later in the year." Right now, officials have restored condenser water to cool computer rooms and steam heat for building heat.

The damaged chillers provide the cooling for not only the two towers, but also the smaller buildings that make up the huge complex. Workers in the smaller buildings returned to work shortly after the blast, and those in the towers began trickling back in late March.

Once the weather warms up and turns more humid — the towers are very close to the waterfront — ventilating the buildings with unconditioned outside air could have a dramatic impact on IAQ in the buildings.

Officials at the Port Authority of New York and New Jersey, which operates the trade center, say they are prepared for the worst. If the chillers can't be brought back on line before the cooling season begins, they will bring in temporary auxiliary chillers and locate them outside the building.

# CASE STUDY

*[In each issue **IAQU** presents a case study on indoor air in a particular building. The editorial staff relies on information provided by the environmental consultants involved. **IAQU** presents a variety of approaches to design, 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 **IAQU**'s endorsement of the techniques employed in the case. **IAQU** invites readers to submit comments, suggestions, and questions concerning any case. At the discretion of the editors, correspondence may be presented in a future issue.]*

## Aerospace Building Design Incorporates Concern for IAQ

One of the newest buildings in the state of Ohio was designed and built with an eye toward indoor air quality. Realizing that the building's unusual design presented unique challenges, the architect and engineer called in a mechanical firm that specializes not only in heating, ventilation, and air conditioning (HVAC), but in indoor air quality as well.

The building — the Ohio Aerospace Institute (OAI) — now incorporates a state-of-the-art HVAC and control system that includes IAQ monitors to respond to changing environmental conditions.

OAI, a high-tech academic and research facility, is located adjacent to the US National Aeronautic and Space Administration's (NASA) Lewis Research Center in suburban Cleveland, Ohio, USA. Providing classrooms, seminar facilities, and offices for students, the building also houses a 200-seat auditorium.

Members of OAI, all of whom share the facility, include NASA, several major corporations, and nine universities: Case Western Reserve, Cleveland State, Ohio State, Ohio University, University of Akron, University of Cincinnati, University of Dayton, University of Toledo, and Wright State University.

The facility also houses the Great Lakes Industrial Technology Center, one of NASA's regional technology transfer centers. It incorporates the latest video, computer, and communications capabilities.

### Building Design

The round building is glass and steel, with a predominantly glass exterior. Its design features a sloped and curving perimeter. Inside, office spaces and common areas are intermingled to facilitate integration of the students, faculty, and researchers.

The design of the building envelope and interior use create some unique challenges from an IAQ perspective. The glass exterior presents an opportunity for tremendous solar load on the building, and mixed spaces, along with variable occupancy of its 70,000 square feet (ft$^2$), create a need for tightly controlled ventilation.

Very early in the building's design, the engineer called in The Enterprise Corporation of Cleveland an HVAC contractor that considers IAQ as part of HVAC design, and also specializes in direct digital control (DDC) for building mechanical systems.

DDC uses a variety of sensors and computer control to provide fine-tuned responses to building demands and situations (see ***IAQU***, January 1993). This can improve IAQ by allowing facilities managers, either directly or through computer programs, to provide ventilation when and where it is needed.

Richard A. Starr, president of Enterprise, told ***IAQU*** that his firm was called in "before the engineer had a line on a piece of paper. He knew that the building's design would require an innovative approach to IAQ."

## HVAC System Design

The HVAC system designed for the OAI includes four air handling units (AHUs) with different capacities.

AHU-1, a four-zone unit, has a capacity of 30,000 cubic feet per minute (cfm). AHU-2, a single-zone system, can move 3,600 cfm, while AHU-4, a penthouse unit, is rated at 2,400 cfm and also serves a single zone. AHU-3, with a capacity of 56,000 cfm, has 106 variable-air-volume (VAV) zones.

All units, which are located in mechanical rooms, have supply and return fans, except AHU-4, which has only a supply fan. The outdoor air (O/A) intakes for AHU-1, AHU-3, and AHU-4 are all located on the building's roof. The intakes for AHU-2 are at ground level with an airway wall.

With the building's suburban campus-type setting, the quality of the outdoor air wasn't a particular concern for designers. However, a pre-filter protects the HVAC equipment and high-efficien[illegible] filters remove particulate matter from [illegible] indoor air.

Humidity co[illegible] comes from sensors in the supply and r[illegible] air ducts. The sensor in the return duct [illegible]tors the return air (R/A) and controls the [illegible] humidifier to maintain relative humidity [illegible] at 35%. When the R/A humidity fal[illegible] 35%, the humidifier adds moisture to [illegible].

Another sens[illegible] the supply air duct limits the supply air R[illegible]ess than 95%. This is a protective device to [illegible]ent too much moisture from entering the [illegible]m.

The discharg[illegible] temperature set point in each AHU is main[illegible] by modulating two separate dampers per [illegible]. These control the air mixture from the [illegible] deck, cold deck, and bypass deck. Therm[illegible]s in each zone control the temperature [illegible]e air that enters the zone, while fans re[illegible]n continuously.

## IAQ Sensors

What disting[illegible]es this system from other HVAC system[illegible]hat "IAQ sensors" determine the amount [illegible]A that enters each AHU. These sensor[illegible]roduced by Staefa Control Systems, Inc., of [illegible] Diego, California, USA, are part of the ov[illegible] DDC system (also from Staefa) that controls [illegible] entire building.

Many so-call[illegible]Q sensors monitor only carbon dioxide ($CO_2$) [illegible]s within a building. While $CO_2$ measure[illegible]s are important as an indicator of ve[illegible]ion effectiveness for occupied buildings, th[illegible] to give adequate information to control IA[illegible]perly.

For example, [illegible] building systems are shut down during [illegible]ght or weekend set-back, pollutants other [illegible] $CO_2$ can build up. If a system is sensin[illegible] $CO_2$, the ventilation will not eliminate the[illegible] pollutants from the space.

The sensors [illegible] in the OAI, however, react to a wide variet[illegible] chemicals by sensing the reduction pote[illegible] of the air. In general, volatile organic comp[illegible]ds (VOCs) exhibit a high reduction pote[illegible]. The sensors respond to the aggregat[illegible]ct of these chemicals in the return air. W[illegible] they detect an increased level, they send a [illegible]lt signal that changes the setting of the O/[illegible]ampers from their 5% minimum setting [illegible] 10% setting.

**Table 3 — Some Common Pollutants in Decreasing Order of Sensitivity to IAQ Sensor**

| | |
|---|---|
| Hydrogen sulfide | $H_2S$ |
| Vinyl chloride | $C_2HCl$ |
| Methyl ethyl ketone | $C_2H_8O$ |
| Hydrogen | $H_2$ |
| Methanol | $CH_4O$ |
| Gasoline | * |
| Formaldehyde | $CH_2O$ |
| Trichloroethylene | $C_2HCl_3$ |
| Acetone | $C_3H_6O$ |
| Ethanol | $C_2H_6O$ |
| Freon-22 | $CHClF_2$ |
| Ammonia | $NH_3$ |
| Freon-12 | $CCl_2F_2$ |
| Propane | $C_3H_8$ |
| Methane | $CH_4$ |
| Methyl Chloride | $CH_3Cl$ |
| Carbon Monoxide | CO |
| Nitrogen Dioxide | $NO_2$ |
| Chlorine | $Cl_2$ |

* Chemical composition varies

Source: Staefa Control Systems, Inc.

Some of the common chemicals detected by the IAQ sensors are shown in Table 3.

The Staefa sensor includes a sensing element and a signal conditioning circuit. A small ceramic tube coated with stannic oxide contains a heater to heat the element.

The stannic oxide coating absorbs the air sample. If reducible gases are present, an electron transfer takes place between these gases and oxygen atoms from the heated stannic oxide. This electron transfer increases the conductivity of the sensing element in relation to the amount of polluting gases within the return air.

With signal conditioning, this converts to a signal in the 0- to 10-volt range. The unit is calibrated with methane at 1,000 parts per million (ppm), which produces a 3.5-volt signal.

The nerve center of the building's HVAC operation is a computer control located in a basement room. This both monitors and controls the various sensors and relays within the building, allowing facility managers to stay on top of how the building is performing and to modify system responses based on the actual building situation.

Operators can enter commands for various controls and see the consequences of those commands. Also, the operators can write programs for control sequences that respond to building situations.

## Operation and Maintenance

A full-scale building commissioning was not part of the HVAC installation, according to Starr. A start-up test-and-balance procedure, however, was incorporated.

The building presently operates on a 10-hour schedule keyed to building occupancy. This is on a Monday-through-Friday basis, with nighttime and weekend shutdowns.

The HVAC system also incorporates an economizer cycle, which comes into play when the outside temperature is below that demanded by the zone calling for the most cooling.

The mechanical system designers, Bacik-Karpinski Associates, Inc., of Cleveland were conscious of maintenance requirements and designed HVAC components to allow easy access for routine chores, according to Starr.

Because the building is in the early stages of occupancy, the HVAC designers and facility managers are still in the process of working out procedures and schedules.

Starr said that, while no formal tests have been done on air quality in the building, occupants have reported satisfaction with the air quality since the building opened in December 1992.

Because the building is still in its opening phase, energy consumption figures are unavailable, as are any comparative figures due to the unique design of the structure. However, Starr estimates that the innovative HVAC system is producing energy savings of about 20% over what would be consumed in a similar building using conventional mechanical and control systems.

## Conclusions and Comments

Incorporating IAQ concerns into the design of a building and its mechanical systems is extremely valuable in maintaining a satisfactory indoor environment. It is even more important in buildings such as the OAI, where designers realize that some aspects of the building might have an impact on the air quality.

Giving occupants more direct control over individual spaces is also a major step toward ensuring satisfaction.

However, having said that, there are some cautionary notes illustrated by the above case.

The first is that many IAQ problems develop later in a building's life, when changes in occupancy cause building managers to alter the design, usually by subdividing spaces or changing the layout of the building. This can often vitiate the initial design intent, unless the HVAC design is changed to accommodate the structural changes.

The addition of the IAQ sensors is certainly an improvement over not having any sensors at all. However, their placement in the R/A duct raises some questions.

One concern is that such sensors could conceivably make a bad situation worse. In the OAI case, the sensors would compensate for internally generated contaminants by increasing the amount of outside air brought into the system.

However, if some outside situation were generating a contaminant — for example, a pesticide sprayed outside the building — which entered the AHUs, the IAQ sensors in the R/A duct would detect the contaminant and in response would open the O/A dampers, bringing even more of the substance into the building.

***IAQU*** asked Starr about this possibility, and he said that the building engineers decided that because of the building's location in a suburban campus-type setting, the likelihood of outside contaminants was low. They felt the current setup was adequate.

While the OAI installation is a major step forward in HVAC controls and IAQ, it doesn't yet tap the full potential of DDC systems. One advantage reported from other DDC installations is the ability to run the system 24 hours a day, improving IAQ while reducing energy costs (see ***IAQU***, January 1993).

DDC also offers the opportunity to use occupancy sensors and integrated lighting controls to ensure ventilation to occupied spaces based on actual occupancy, rather than on a predetermined time schedule.

### For More Information

For more information, contact Richard Starr, The Enterprise Corp., 6858 Cochran Road, Cleveland, OH 44139, USA; (216) 248-5560, Fax: (216) 248-6002.

For more information on Staefa controls, contact Tom Leonardis, Staefa Control Systems, Inc., 8515 Miralani Drive, San Diego, CA 92126, USA; (619) 530-1000.

# READERS' FORUM

## Reader Questions Value of CDC Studies on Cotinine in Blood

To ***IAQU***:

The article *Smoking in the US Heats up in Wake of ETS Report* [see ***IAQU***, February 1993] included reference to an ongoing CDC [US Centers for Disease Control] study in which cotinine levels of 23,000 people are to be tested as an indicator of nicotine in their blood. ***IAQU*** commented that the researchers were surprised to find detectable levels of cotinine in the blood of all the first 800 subjects tested, then immediately jumped to the conclusion that the cotinine was the result of exposure to ETS (environmental tobacco smoke) from spouses, coworkers, or smoke-filled rooms.

Not necessarily! Everyone tests positive for cotinine because of the nicotine in their diets. It is well-known that tobacco is not the only substance that contains nicotine. Nicotine is found commonly in many foods as well, especially in a large number of vegetables, as well as in green and instant tea. For example, tomatoes, potato peels, eggplants, and green peppers contain significant nicotine concentrations. In fact, some diets may be so rich in nicotine as to cause levels similar to those found in moderate smokers. This information is reviewed by Idle (1990) and by Sherer et al. (1988).

Also, interestingly, in an as-yet unpublished paper, Yano and Kagawa find that Japanese nonsmokers' diets contain a significantly higher proportion of nicotine-containing dark green vegetables and green tea than do smokers. This is probably true for the US as well, because non-