

## CASE STUDY

[In each issue **IAQU** presents a case study on an investigation of indoor air problems in a particular building. The editorial staff relies on information provided by the environmental consultants involved in the investigation. **IAQU** 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 **IAQU**'s endorsement of the investigative procedures, analysis, or mitigation 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.]

### VOC Infiltration at Airport Building Leads to Widespread Complaints

Sixty percent of the workers in a temporary office building at a major US airport complained of symptoms typically associated with poor indoor air. IAQ consultants identified volatile organic compound (VOC) infiltration combined with a lack of adequate ventilation as the most likely source of the problem. Mitigation efforts, including proper fresh air dilution and upgraded filtration, seem to have alleviated the situation.

#### Building and HVAC Description

The five-year-old temporary office building includes a "bullpen" working area for 50 of the client's 60 employees. Six four-ton rooftop package units compose the HVAC system for the one-story, 8,640-square-foot building, in which there are no opening windows. Soft-wall partitions had recently been added to segment the "bullpen" area. The building is located in a major metropolitan area in the Northeast, in a generally humid environment.

#### Presenting Problem/History of Complaints

The facilities supervisor called in the consultants as the result of two years of complaints from employees. Symptoms included fatigue, allergic reactions, environmental tobacco smoke (ETS) sensitivity, shortness of breath, headaches, lack of productivity, and lack of concentration.

With approximately 60% of employees complaining of one or more symptoms, the facilities supervisor had contracted for an investigation one month prior to the current inquiry. The previous investigators reported the building was "all clear."

#### Investigative Focus

The multi-disciplinary team included HVAC engineers, as well as air testing, IAQ investigation/design, and procurement personnel. This last group, employees or subcontractors of the environmental consultants, assisted in specifying mitigation equipment.

Investigators focused on the HVAC system and the presence of VOCs and other contaminants in the air, including carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>).

#### HVAC Investigation

Real-time measurements with an air velocity vane showed that air distribution and change rates within the building met ASHRAE standards. However, an inspection of the HVAC system revealed that it was taking in no fresh air; the system was recirculating 100% indoor air.

Spot readings with a real-time measuring device indicated that the temperature in the building averaged 74°F and the relative humidity (RH) averaged 34%, levels that consultants deemed acceptable.

#### IAQ Investigation

The investigating team used eight-hour infrared monitoring in the return ducts and determined that the CO levels were generally excellent. Six of the seven tests resulted in 0 parts per million (ppm), while the seventh registered 50 ppm, primarily due to auto exhaust infiltration at that location.

Using infrared detectors, the consultants measured CO<sub>2</sub> at seven sites in the center of the occupied spaces and also at the return ducts. CO<sub>2</sub> levels ranged from 747 ppm to 1,921 ppm, well above acceptable limits. (ASHRAE prescribes a CO<sub>2</sub> limit of 1,000 ppm.)

Eight-hour VOC tests by the EPA Method TO<sub>2</sub>, conducted in the return ducts, photocopy room, and conference room, showed elevated levels of a number of VOCs.

Acetone, the most prevalent, registered 203 µg/m<sup>3</sup>. Other significant levels (all in µg/m<sup>3</sup>) included: 1,1,1-trichloroethane, 124; trichloroethene, 54; toluene, 54; and total xylenes, 33.

Several other VOCs were also detected (see Table 1).

Numerous compounds were tentatively identified. The most prevalent, trichlorofluoromethane, registered 118  $\mu\text{g}/\text{m}^3$ . Others included limonene, 36; 2-propanol, 32; 1,2-butadiene, 3-menthyl, 31; and benzaldehyde, 26. For other tentatively identified VOCs, see Table 2.

VOC infiltration from the airport was occurring despite the closed windows and lack of outside air intake. Investigators determined that the 100% recirculation resulted in "neutral pressure" in the building, which allowed the VOCs to infiltrate every time the front and side doors were opened. Also, five photocopy machines, a large quantity of printed materials, and tobacco smoking by employees throughout the office added to the VOC levels.

### Recommendations for Mitigation

The investigating team determined that the elevated levels of  $\text{CO}_2$  were due mainly to the 100% recirculation of indoor air. The VOCs detected were consistent with the gases in the outside air at the airport.

The team concluded that, in accordance with ASHRAE standards, the building needs 20 cubic

**Table 1 — VOCs Detected at Airport Office Site**

VOCs	Test Results ( $\mu\text{g}/\text{m}^3$ )
Chloromethane	4
Methylene Chloride	2
1,1-Dichloroethene	3
1,1,1-Trichloroethane	124
Total Xylenes	33
Trichloroethene	54
Benzene	19
Tetrachloroethene	11
Toluene	54
Ethylbenzene	10
2-Hexanone	2
Acetone	203
2-Butanone	32
4-Methyl,2-Pentanone	18

Pump Flow: 100 ml/min  
Total Volume: 12 l  
Method Detection Limit: 0.1

**Table 2 — VOCs Tentatively Identified at Airport Office Site**

Parameters	Test Results ( $\mu\text{g}/\text{m}^3$ )
Trichlorofluoromethane	118
Methane, dichlorodifluoro	5
Propene, 2-methyl	17
Methane, oxybis	5
1,2-Butadiene, 3-methyl	31
Pentane, 2-methyl	5
Hexane	8
Furan, 2-methyl	5
Pentanal	7
2-Propanol	32
Hexanal	10
Cyclobexane, 1,3,4-trimethyl	3
Ethanol, 2-butoxy	20
Trans-2-carene	26
Pentane, 2,2,3-trimethyl	4
Decane	13
Benzene, 1-ethyl-4-methyl	16
2-Beta-Pinene	9
Phenol	5
Benzaldehyde	26
1-Hexanol, 2-ethyl	7
Limonene	36
Benzene, 1,3-dichloro	4
Undecane	5

Pump Flow: 100 ml/min  
Total Volume: 12 l  
Method Detection Limit: 0.1

feet per minute (cfm) of fresh air per person — 1,200 cfm total — to reduce the  $\text{CO}_2$  and VOC levels. It also suggested using activated carbon filters to remove VOCs from the airstream. The soft-wall partitions, although recently installed, did not contribute to the air-flow problems, according to the investigators.

The IAQ team recommended:

- Retrofitting three of the six rooftop HVAC units with fixed air dampers and dampers in the return ducts to allow proper fresh air dilution;
- Replacing standard fiberglass filters with special carbon media and pleated panel filters;

- Providing a CO<sub>2</sub> sensor for "on demand" control of the HVAC system air handler side, independent of heating and cooling; and
- Balancing the air flow.

### ETS Control Addressed Separately

Investigators reported that while ETS was a factor in the VOC buildup, it wasn't among the original complaints of the occupants. However, company officials had decided on a separate smoking area before the consultants began their study, and timed its implementation to coincide with changes brought about as a result of the investigation.

The consultants recommended that the new smoking area be equipped with a carbon-media-based ceiling-mounted air cleaner with a VOC sensor/controller for "on-demand" control. The team felt that this approach was preferable to an electrostatic air cleaner, as the carbon-based filtering system would handle both the particulate and the gaseous phases of the tobacco smoke, while the electrostatic system would handle only the particulate phase.

The system installed consists of a pre-filter, backed up by a high-efficiency filter for capturing particulates, and a carbon bed to absorb the gaseous elements.

### Implementation and Followup

Company officials adopted all the consultants' recommendations. Followup monitoring, both by the consultants and a state agency, show significant reduction in both CO<sub>2</sub> levels and the VOCs in the indoor air. Employees report reduced levels of fatigue and headaches, as well as other physical complaints. Company officials report a reduction in employee absences, as well as an increase in productivity.

The IAQ consultants feel that the clients, in configuring the HVAC system, hadn't accounted for the fact that the building would be occupied by so many personnel on a full-time basis. The failure to provide fresh air led to the CO<sub>2</sub> buildup. At the same time, inadequate filtering allowed too many VOCs from outside to stay in the indoor air, and this level increased with the addition of those compounds produced by the building occupants through photocopiers, ETS, and the large amounts of printed materials.

### For More Information

David Mandell, Air Pro Systems, Flowerfield Industrial Park, Building #1, St. James, NY 11780, USA; (800) 886-2392, Fax: (516) 584-4292.

## NEWS AND ANALYSIS

### Environmental Health Group Asks ACP to Rescind Position on MCS

The National Center for Environmental Health Strategies (NCEHS) recently asked the American College of Physicians (ACP) to rescind its position statement on multiple chemical sensitivities (MCS) first published in an article entitled "Clinical Ecology" in the *Annals of Internal Medicine* (Vol. 111, No. 2, pp. 168-78). In the article, Abba Terr, M.D., proposes that there is no evidence that MCS exists. According to NCEHS President Mary Lamielle and NCEHS lawyer Earon Davis, this position statement "has been used repeatedly by people with private agendas to discourage research on MCS and to encourage discrimination against people suffering from that type of illness." (For more information on MCS, see *IAQU*, April 1991 and December 1991.)

In a letter to H. Denman Scott, M.D., senior vice president of health and public policy of the ACP, Lamielle and Davis point out that the California

Medical Association has already retracted its position and that the American Medical Association has "shown great restraint on this issue and rejected the advocacy efforts of Dr. Terr and others." Lamielle and Davis also point out that a recent report from the National Academy of Sciences (NAS) [see Information Exchange] determines that Terr's conclusions in the 1989 article are a "poorly supported opinion expressed by one who has evaluated patients on behalf of a workers' compensation appeals board." Davis told *IAQU* that NCEHS received a prompt reply from Dr. Scott, who said that the ACP has "requested copies of the NAS/NRC [National Research Council] reports and will use those and other studies to determine whether reevaluation of our 1989 paper on Clinical Ecology is warranted." In his reply, Scott pointed out, however, that the original paper concluded with