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quality, meets our standards. Our policy on providing a healthy, safe, and productive work environment will not change. However, as more is learned about sick building syndrome and building related illnesses, it is only natural that our program will evolve.

### Richard Abernathy

Virginia Power

Virginia Power does not have a specific, company-wide policy on indoor air quality. However, we do keep an eye on developments in the field of indoor air quality, and will certainly maintain corporate policy in accordance with any regulatory efforts that may be forthcoming.

The issue of smoking is an extremely difficult political problem in our area. The state of Virginia has derived a significant amount of financial support from the tobacco industry. One of our customers is in the tobacco industry, and naturally we do not want to unnecessarily irritate that customer. In light of this, Virginia Power has left the decision of whether or not to allow smoking up to the individual office managers.

For example, in one of our offices we found that the personnel were exposed to a significant amount of tobacco smoke. After we took measurements and made recommendations, the manager made several changes, including moving personnel and breaks. Another tactic

has been to designate specific smoking rooms. In one building, which we leased, additional ventilation was installed for eliminating the accumulated smoke. But in general such actions are limited. The issue in general is diminishing in scope and size, but it is still very controversial in Virginia.

In one interesting case, our newest building in Richmond adopted a no-smoking policy, although because a former president of the company smoked, the policy was changed whenever the president visited. However, the building is now strictly no smoking.

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## 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.

### IAQ Problems in an Office Suite

A law enforcement division had occupied an office building for years without significant IAQ incidents. However, one spring employees complained to the management of severe flu-like symptoms, which generally cleared up when they were away from the building. This led to the suspicion that environmental contaminants

in the office were the cause. Initial investigations were inconclusive, and management then evacuated the office and carried out a major duct cleaning effort. Further investigation concluded that the symptoms were not related to the building environment.

## Building Description

Constructed about 70 years ago, the building contains office and retail space leased to a wide variety of tenants. In one office, approximately 75 law enforcement personnel occupied a 14,000-square-foot L-shaped area. The space contained standard office equipment, along with small rooms for temporary incarceration, and storage areas for evidence and supplies.

In the investigation, the consultant divided the office space into five units, each corresponding with a "working group." These units are designated units #1 through #5.

## General History

After the first wave of symptoms in April, management allowed most employees to work at home and contracted for an industrial hygiene investigation. This initial investigation was based on a general understanding of the complaints and included limited IAQ testing restricted to one office suite. No investigation was permitted in other building areas because the facility management wanted to avoid creating anxiety in other occupants.

The investigators found no obvious environmental problems with the building. However, management took the precaution of having another contractor clean the ducts and diffusers. Employees resumed occupancy of the building in late May; three weeks later, employees reported a second wave of symptoms. In July, the employees moved to a new facility permanently, due to continuing illnesses and the unresolved environmental concerns.

At this point, the initial investigators convinced facility management to conduct a more comprehensive look at both medical and environmental aspects of the outbreak. Management contracted an IAQ consultant and an occupational physician to reevaluate the facility and the results from the previous IAQ investigations. (For the sake of clarity, IAQU will refer to the investigators who submitted this case study as the consultant.)

## Building Inspection

During April and May, various industrial hygienists conducted environmental studies of the office space. The following describes the consultant's analysis of these initial investigations.

The initial inspection took place in mid-April. The investigators tested for carbon monoxide

(none detected [ND]), ozone (ND), formaldehyde (ND), airborne bacteria and fungi (0-150 colony-forming units per cubic meter of air [cfu/m<sup>3</sup>]), and surface bacteria and fungi (0-30,000 cfu per square foot). Concern over the microbial results led to a cleaning of all ducts in the suite. In retrospect, the consultant noted that seven of nine surface microbial wipes made during this initial study were within the range of generally acceptable sanitation. Of the other two, one was located on a dusty diffuser and the other was inside the mechanical system (drip pan). With low airborne microbial counts and no widespread allergy complaints, the consultant did not consider these results to correlate with the complaints.

The initial investigators noted a slight odor from a newly installed carpet. The consultant observed that the impact of the new carpet was limited to a very small area of the office. In addition, irritation was not a component of the employee complaints, and symptoms were not related to carpet age. The investigators also noted that the employees had been highly concerned about the installation of a new computer system in the office one month prior to the outbreak of symptoms. However, the consultant found that the computer system installation, including the removal of ceiling tiles, did not coincide with the onset of illnesses.

A second evaluation of the office took place in late April. Again, testing found no carbon monoxide or formaldehyde, and low levels of airborne fungi (2-6 cfu/m<sup>3</sup>) and airborne fibers (less than 0.01 fibers per cm<sup>3</sup>). One employee complained of a solvent odor, and the consultant suggested that this may have been an employee cleaning his or her weapon. The consultant also considered the possibility of criminal evidence leaking from receptacles, but found no indication of problems from this source.

In May, investigators sampled for volatile organic compounds (VOCs). Total VOCs were less than one part per million (ppm); specific compounds were not identified. Air volume measurements were taken in the HVAC system; the consultant later noted that the system supplied sufficient ventilation to the office, but that such detailed measurements were not necessary to establish this. Even in a worst-case scenario, ventilation problems would not cause the symptoms experienced in the office. In addition, minimum ventilation rates did not coincide with

the onset of the complaints or the major complaint period.

Also in May, after cleaning of the HVAC system, investigators repeated microbial sampling. All bioaerosol samples were in the normal background range (less than 350 cfu/m<sup>3</sup>), and microbial wipe samples were all low (less than 700 cfu/square foot).

In August, after all occupants had relocated to another facility, the consultant was asked to reevaluate the evidence and determine if there had been exposure to any potential hazards in the workplace. The consultant expanded on the previous investigations by considering the building as a whole and identifying indications of medical or environmental problems that might have been responsible for the complaints. The consultant's findings included the following:

- The HVAC system was dirty in some sections, even after the cleaning. However, conditions were not unusual for a 70-year-old building, and no change in the system was noted to have occurred at the time of the complaints. Also, sanitation problems would have led to allergic symptoms, and these were not a major factor in the complaints.
  - Limited smoke tube observations indicated a positive pressure in the complaint zone office suite, which would tend to exclude contaminants from other building locations (e.g., pipe chases and corridors).
  - Recirculated air for the major complaint area came from that specific area only. Outside air entered from an open courtyard in the center of the building, and air did not appear to be affected by major contamination sources. Welding took place on an elevated rail line about 30 feet below the office, but did not start until after the onset of complaints. There was no loading dock. Occupants reported occasional vehicle odors from street traffic, but not in the subject office space.
  - Housekeeping was conducted each afternoon using standard products. Some occupants had reported that the office was dirty. There were apparently no complaints of odors from cleaning materials. The consultant noted that tiles of the suspended ceiling were covered with debris from old plaster and ceiling tiles, but these were not considered hazardous materials.
  - Except for one small carpet, new furnishings were not present. No odors were detectable.
- Exterminators had used standard products and methods. Occupants did not report any pesticide complaints.
  - Inspection and interviews in neighboring and other offices revealed no concern about unusual health problems and no significant pollution sources.
  - No fires or floods had been reported in the building.

### Health Concerns

The consultant pointed out that clusters of symptoms can result from many causes besides environmental exposure. Contagious diseases, stress, a series of random events, or a combination of these factors may also be responsible for apparent clusters of symptoms. A classic epidemiological approach was therefore taken to identify any common elements and possible causes of the complaints.

The medical team interviewed 41 employees, most of whom had had symptoms. Employees not interviewed generally had not experienced symptoms. The interviews attempted to elicit information on the nature and timing of symptoms along with possible associations and underlying conditions.

The interviews revealed three basic symptom groupings. The first group consisted primarily of headaches and fatigue, some with occasional nausea or dizziness ("headache group"). The second group complained of the same symptoms along with gastrointestinal problems such as vomiting, diarrhea, and abdominal cramps ("GI group"). The third group consisted of miscellaneous symptoms, each occurring at most in only a few individuals ("other group"). These miscellaneous symptoms included skin rash, miscarriage, abnormal pap smear, infections, sinus problems, and allergies. They included two claims of sinus problems, both of which were ongoing, did not clear when away from the office, and persisted after the move into the new building. The three cases of allergy problems (hay fever and asthmatic bronchitis) also appeared to have begun before the onset of the general office complaints.

In some cases, employees reported severe and frequent headaches or gastrointestinal problems, including several cases of significant weight loss due to diarrhea. Other employees reported mild and infrequent symptoms.

## Case Patterns

The interviews indicated that employees from units #1 and #2 had the highest incidence of symptoms. These adjacent units were served by different HVAC systems, although there was much interaction between the two groups of employees. Units #3 and #4 reported much lower symptom rates, even though they were located in the same room and HVAC zone as unit #1. Unit #5 had a very low incidence of symptoms even though it shared an HVAC zone with unit #2 (high symptom rate) and several other building areas where no problems were reported.

A minority of complainants indicated that the same symptoms existed prior to the cluster of cases that occurred in April. Some employees stated that they had experienced headaches and fatigue for some time before April, attributing this to stress until other employees discussed IAQ problems in the office.

Complainants generally said that the severity of the symptoms increased with time spent in the office; most symptoms improved when away from the office. In some cases, however, symptoms such as severe diarrhea and allergies did not clear up when the complainants were away from the office.

The employees generally reported that symptoms cleared up for two to three weeks after their return in May (following the duct cleaning), though they recurred afterwards. With few exceptions, they reported that symptoms ended after the July move to the new facility.

The medical interviews considered a wide range of possible factors. The pattern of symptoms did not indicate a foodborne or waterborne illness, as unaffected building tenants shared the same water supply and complainants utilized a variety of individual food and water sources. The consultant also considered viral or bacterial infection unlikely, as no symptoms were reported among the employees' immediate families. The consultant suggested that some, but not most, of the symptoms could possibly have been flu-related.

Symptoms did not include irritation of the mucous membranes (eye, nose, or throat) or allergic reactions, except for five preexisting cases. The consultant noted that irritation and/or allergic reactions are usually prominent when IAQ is poor. In addition, the employees reported no odor problems in the office, and

there were no suggestions of overexposure to carbon monoxide, pesticides, or solvents. The severity of symptoms and incidence of vomiting or diarrhea did not suggest sick building syndrome (SBS). In addition, most practitioners consider SBS to be caused by poor ventilation, whereas ventilation appeared to be generally adequate in the office. The "other" group of symptoms appeared to represent a diverse mix of nonenvironmental medical concerns among individual employees.

As an alternative to physiological and environmental explanations for the symptoms, the consultant suggested that the highly stressful work environment (law enforcement) may have been a significant factor in the onset of symptoms. The consultant also noted that employees with severe ongoing gastrointestinal problems may have "triggered" the more widespread symptoms in other employees.

The consultant noted that such a situation, sometimes referred to as mass psychogenic illness (MPI), should only be considered when other medical and environmental causes have been discounted. MPI has been documented to include headaches, nausea, and vomiting. Fatigue and diarrhea can also be stress-induced in some situations. Stress factors in the office included several months of continuous overtime in conjunction with a major investigation, and a recent in-house disciplinary action. One characteristic of MPI may be a higher rate of symptoms for females. Though employees of both sexes reported symptoms, there was insufficient data to determine sex-specific attack rates. (For more information on MPI, see *IAQU*, February 1990).

## Consultant's Assessment

The initial investigations depended primarily on industrial hygiene testing with no medical input. Results of these studies were inconclusive. The consultant took an epidemiological approach to the situation, and cases were screened by medical professionals. In addition, the consultant reexamined the testing results of the previous investigation, and found them to be within the realm of normal indoor environments.

The consultant characterized temporal and spatial characteristics of potentially significant sources. The consultant then raised and evaluated several hypotheses regarding possible relationships between the occupants and their environment. No significant environmental

change was correlated to the symptoms, and no single cause for the symptoms was ever identified.

The consultant found nothing in the pattern of symptoms, air quality testing, or potential environmental sources to indicate a building-related IAQ problem. Increased stress in the workplace may have been an important factor in the onset of the symptoms. However, lacking psychological expertise and follow-up access to the subjects, the consultant could not verify the existence of MPI. In conclusion, the consultant found that no further studies of the office space were warranted, and no long-term effects were anticipated from this incident.

The consultant became involved relatively late in the incident and had no direct role in risk communication. Misunderstanding and over-reaction on the part of management, the con-

sultant believed, may have played a major role in prolonging the situation. By evacuating the office and cleaning the ducts, credibility was given to the environmental hypotheses and symptoms recurred.

This investigation was conducted by the Division of Federal Employee Occupational Health (FEOH), US Public Health Service. Ed Light, CIH, was the lead consultant and Lena Marinberg, M.D., was responsible for the medical component. Michelle Craddock coordinated industrial hygiene aspects, with project oversight by FEOH Region III (Frank Lewis) and FEOH Region V (Dr. Ernest Hardaway, II, and E. Frank Ellis, M.D.). For more information, contact Ed Light, c/o Pathway Diagnostics, P.O. Box 315, Reston, VA 22090, USA; (703) 242-3424.

## NEWS AND ANALYSIS

### ASHRAE Presents Highest Award to Indoor Air Scientist

Professor Ole Fanger of Denmark recently received ASHRAE's highest award, the F. Paul Anderson Medal, at the recent semi-annual meeting of the American Engineering Society in Los Angeles, California, USA. *IAQU* has examined Professor Fanger's work several times (see *IAQU*, October 1988, October 1990, September 1991). Fanger has performed extensive IAQ modeling of indoor air quality, ventilation, thermal conditions, and draught. He developed the subjective air quality evaluation system in which a unit called an *olf* is equal to the bioeffluent generated by one person at rest. According to the Laboratory of Heating and Air Conditioning, Technical University of Denmark,

the results of Fanger's work "are used worldwide in international and national standards and guidelines on the indoor environment. Fanger has previously received scientific awards in 10 countries. He is an honorary member of the HVAC&R engineering societies in France, Belgium, Italy, and Russia." This is the first time that the Anderson medal has been awarded to an individual outside North America.

For more information, contact the Laboratory of Heating and Air Conditioning, Technical University of Denmark, Building 402, DK-2800 Lyngby, Denmark. Tel: +45 45 93 11 99, ext. 4041; Fax: +45 45 93 21 66.

### Environmental Issues in the Workplace: IAQ at the Top of List

A poll of members of the International Facility Management Association (IFMA) found that IAQ rates highest on the list of concerns regarding the indoor environment. Other environmental concerns include solid and hazardous waste, water quality, and video display terminal (VDT) use. According to a report on the survey results, the poll "was prompted by growing concern over the work environment's impact on employee health and productivity, increased emphasis on businesses' environmental respon-

sibilities, and rising awareness of potential legal liabilities."

The Gelb Consulting Group prepared the report, *Environmental Issues in the Workplace*, for the IFMA. About 24% of those polled on IAQ responded, and the survey produced several interesting results:

- 44% said that their facility monitors health problems associated with IAQ;