6397

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.*

Comprehensive IAQ Survey in Canadian Office Building

From December 1989 through January 1990, investigators performed a comprehensive IAQ assessment of a nine-story Canadian office building and the building's annex, in response to occupant complaints of discomfort. The building was leased for use by government employees and the building's operations were privately contracted by the owner. There are approximately 450 occupants in the office building, and 16,000 square feet (1,500 square meters) per floor. The annex contains approximately 75 people.

Occupant complaints included high temperatures, low humidity, headaches, and eye/nose irritation. Investigators distributed questionnaires to 350 workers; out of 202 responses:

145 were too hot	(72%)
120 had headaches	(59%)
116 were fatigued	(57%)
92 had sinus congestion	(46%)

The investigators concluded that IAQ problems in the office building were primarily due to the central HVAC system not operating as designed and high levels of total volatile organic compounds (TVOCs) from liquid-process photocopiers. IAQ problems in the annex were primarily due to low levels of relative humidity and an inefficient filtering system.

Indoor Air Pollutant Measurements

In both structures, the investigators measured levels of temperature, relative humidity, carbon dioxide (CO_2), carbon monoxide (CO), respirable particulates, TVOCs, and airborne microbials. An ACR Stick-On Logger recorded temperatures and relative humidity for two weeks. The investigators spot-measured TVOC levels using an HNU photo-ionization detector and collected long-term samples on a multi-absorbant tube, which they analyzed using thermal desorption and a gas chromatograph/mass spectrometer (GC/MS) equipped with a flame ionization detector. In the office building, measurements of CO and CO_2 were within normal range.

TVOC measurements taken in the office building indicated "significantly higher than normal" levels on floors with liquid-process photocopiers. One floor had a measured level of 20 milligrams per cubic meter (mg/m^3) using the photo-ionization detector (10.2 mg/m^3 using GC/MS). In the photocopy room, TVOC levels of 200-250 mg/m^3 were detected. This air was entering the ceiling return plenum and was recirculated throughout the floor. Other floors without liquid-process photocopiers had background TVOC levels of 2.5-3.0 mg/m^3.

In the annex, the investigators noted that the measured CO levels of 2-3 parts per million (ppm) were "expected normal values." Though the outdoor air intake is located in a ramp leading to a garage, the air handling unit fan is programmed to shut off from 6:00-9:00 a.m. and 4:00-7:30 p.m., which would "eliminate the possibility of CO being pulled into the system during the heavy traffic periods." CO_2 levels in the annex workplace were between 600-650 ppm, indicating that the ventilation system was providing an ample supply of fresh air.

Microbial analysis from the annex indicated "high normal" values in two of the four offices sampled: 381 and 479 colony forming units (cfu) per cubic meter of air. The dominant species found was *Cladosporium*, which is "a common outdoor leaf and plant mold (phylloplane fungi) and is not considered toxigenic. Its presence is due to the inability of the filter system, consisting only of a primary panel filter having a dust-spot efficiency rating of less than 20%, to completely arrest fungi from the outside air."

Humidity and Temperature

Monitoring the office building's temperature, the investigators found conditions exceeding

ASHRAE's Thermal Comfort Chart according to Standard 55-1981. Average RH measurements were below ASHRAE standards, averaging about 20%. Temperatures in some areas were 25°-26° Celsius.

In the annex, RH levels were very low, approximately 6%. According to the investigators, this was due to the annex having no humidification system.

Office Building HVAC System

A central HVAC unit located on the 9th floor of the office building supplies conditioned outdoor air for the entire building. Through a vertical shaft, this central unit delivers outdoor air to "compartmental air handling units" located on each floor. These compartmental units contain a supply fan, filter, cooling coil, and electric steam humidifier. Air is mixed with return air and supplied to variable air volume (VAV) boxes and slot diffusers.

The mechanical engineer found several operational problems with the HVAC system. First, all air conditioning apparatus in the central unit had been valved-off and its use had been discontinued. He pointed out that the outdoor air could only be conditioned in the compartmental units; the compartmental units, however, were capable of only a limited amount of cooling and humidification. This was problematic during the winter, but especially during the summer, as the interior building area needs to be cooled in order to maintain comfortable conditions in the building.

The engineer also found that the automatic dampers installed on the VAV boxes may have excessively reduced the amount of outdoor air during the peak air conditioning periods, i.e., summer and winter.

The mechanical engineer pointed out that in the absence of spray humidification in the central ventilation units, the electric steam humidifiers on each compartmental unit were inadequate for humidification of the building. In addition, movement of air at workstations was typically below 0.05 meters per second (m/s) (10 feet per minute [fpm]), and many buildings have satisfactory conditions with workstations around 0.08 m/s (15 fpm). This issue, having an effect on comfort, is difficult to resolve from a mechanical engineering viewpoint. The investigator noted that a more satisfactory solution may be obtained by reducing the temperature.

In summary, the mechanical engineer found that "the building HVAC system gives a sub-par performance. It is presently too hot in the building, there is no air movement to be felt, and the air is too dry. Most likely, there are periods of too little ventilation in the middle of winter and also during summer months. Also, most likely, temperature and humidity control in summer is inadequate."

Primary Recommendations

In summarizing their inspection, the investigators found that high temperature, low humidity, and high TVOC levels were the primary sources of the building's IAQ problems. To reduce the daytime ambient temperature and increase the relative humidity, the inspectors noted that the HVAC system, especially the central unit on the 9th floor that had been shut down during the winter period, should operate as designed and built. In addition, the air distribution system in the suspended ceilings, ductwork, and VAV dump-type boxes should be inspected and repaired. Reducing TVOC levels on the floors with liquid-process photocopiers required increasing ventilation or replacing the liquid-process photocopiers with dry-process models (the installation of a dedicated exhaust system was not feasible).

Recommendations for the annex primarily focused on the need for increased humidity. According to the investigators, installation of a steam humidifier was necessary to increase RH levels to 25%-35% in winter. In addition, the investigators recommended vacuuming the mixing air plenums and ducts, and upgrading the filtering system. The investigators also recommended that additional microbial monitoring be performed during the spring and summer after the snow cover had melted to see if there were any amplification sites for mold growth. As it turned out, the ceiling air handling units and return air ceiling space did have a microbial problem, which was addressed in a later phase of the building examination. The investigators' recommendations were implemented, including replacement of the photocopiers.

For More Information

The investigation was managed by Tedd Nathanson, Senior Engineer, Architecture and Engineering, Public Works Canada, Ottawa, ON K1A 0M2, Canada; (613) 736-2144.