

However, in their 42-page report, the authors noted research gaps and recommended a plan to acquire additional knowledge of how school conditions affect IEQ. Among their suggestions is a research project to analyze a statistically significant number of schools, comparing:

- Those constructed with conventional HVAC system approaches that do not provide simultaneous continuous ventilation and humidity control
- Schools whose designs include systems that meet the ventilation, humidity control, and filtration criteria the authors suggest

They say that, if their hypothesis is correct, the research should show that schools designed and operated to ASHRAE Standard 62-1989 produce very few occupant complaints. On the other hand, they predict that those schools that don't meet that standard should show high levels of indoor air contaminants and microbial activity. They also predict a higher level of occupant complaints and general dissatisfaction with the schools' IEQ.

You can download a free copy of the report from www.eren.doe.gov/buildings/pdfs/iaq.pdf.

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.]

Renovations, Disrepair Cause Numerous Courthouse IEQ Problems

This case involves a Massachusetts courthouse, which has undergone numerous renovations over the years. As a result of the many changes, the original ventilation design no longer functions, and the only source of outdoor air for most sections of the building is doors and windows. This has led to numerous complaints from occupants about symptoms commonly related to IEQ complaints.

While the building has been the subject of several IEQ investigations over the past five years — all of which found ventilation deficiencies — the most recent study came following a computer fire. The local board of health requested the Massachusetts Department of Public Health for a consultation about the IEQ concerns and related health issues.

A subsequent investigation by the department's Bureau of Environmental Health Assessment (BEHA) found no concerns as a result of the fire, but found that some employees reported health effects that could be associated with poor IEQ.

Building Description

The courthouse, a three-story marble block building, dates to 1903. A 1952 addition included a wing containing offices on the south side of the building. In 1958, the county added a wing to the north side for the 3rd Session courtroom. Another renovation in 1980 added the 2nd Session courtroom. In 1990, workers replaced the entire roof. The building houses 300 employees and several hundred visitors daily.

Earlier investigations noted problems with lack of ventilation, poor building design, poor ventilation of the print shop, bird infestation, and lack of maintenance. The bird infestation was significant. The investigators reported that pigeons had gained access to the ventilation system through a nonfunctioning exhaust fan. They then roosted in the ventilation system.

Subsequently, county officials contracted with a duct cleaning firm to remove the pigeons and associated debris. During this work, the duct cleaners placed a mesh screen over the exhaust

vent through which the pigeons had gained access. The cleaners then cut openings into the duct work and used a HEPA-equipped vacuum device to clean the ducts. According to reports at the time, they removed nine dead pigeons and 240 pounds of debris.

Current Investigation

The current investigation consisted of a visual inspection of the building and its ventilation system. The BEHA consultants also monitored carbon dioxide (CO₂) concentrations and measured temperature and relative humidity. These tests took place under normal operating conditions.

Most of the areas surveyed showed elevated CO₂ concentrations, which the BEHA consultants defined as those in excess of 800 parts per million, which is the limit set by the Massachusetts Department of Public Health. The report also notes that several areas showed concentrations above 800 ppm even without occupants, indicating little or no air exchange. Table 3 shows the conditions for the various spaces in the building.

The temperature in the building ranged from 70°F to 77°F (21°C to 25°C), and relative humidity (RH) ranged from 20% to 32%. The investigators note that the temperatures were within acceptable ranges determined by the BEHA, but that the humidity, especially during the winter, was below the BEHA accepted range of 40%-60%.

The investigators found a complex and problematic arrangement with the building's ventilation system. According to the report, the courthouse relies on four separate types of systems, some of which were altered in the renovations over the years.

Original Building

The original building used stack effect and natural ventilation in combination with openable windows and a series of louvered vents. Each room has a 2x3-foot supply air vent in the center of an interior wall near the ceiling. This vent connects through air shafts to the building's boiler. A corresponding vent in

each room below the supply vent connects to exhaust ventilation shafts that run from the roof to the basement. The exhaust shafts connect to an air mixing room in the basement and terminate in "hearth-like" openings.

The boiler's heating elements warmed the air, which rose up the supply shafts. The resulting negative pressure in the basement drew cold air from the basement area into the heating elements. This air came from three sources: a window system on the exterior wall, grates located below basement-level windows, and return air from the exhaust shafts. These all mixed in the basement mixing room, which used a window system to vary the amount of air coming from each source.

When the negative pressure in the basement drew air from the "hearths" at the base of the exhaust shafts, it created negative pressure within the shafts, which in turn drew air from the exhaust vents in the rooms. This system was controlled by louvers, and a portion of the heated exhaust air rose up the ventilation shaft to exhaust outdoors.

The report notes that fresh air intakes above some basement windows connect to metal ducts and appear to be adjuncts to the air shafts in the back of the building. However, according to the report, the entire ventilation system appears to be either renovated out of existence, adapted to other uses, or abandoned.

The fresh air intakes above basement floor windows, sealed either with plywood or cardboard, no longer function. A small storage shed, built in 1958, blocks the air intake for the north mixing room. According to the investigators, the south mixing room appears to be abandoned. At the time of the investigation, doors and windows provided the only sources of outside air for the original building.

Exhaust Motors

A secondary ventilation system comes from an adaptation of the basement-to-roof air shafts, in which exhaust motors have turned the shafts into vents. However, the report notes that the south wing has no mechanical fresh air supply or exhaust ventilation. In one office

Table 3 — Courthouse Air Monitoring Results

Location	CO ₂ (ppm)	Occupants	Operable Windows	Ventilation	
				Supply	Exhaust
Outside	377				
3rd Session court	>2,000	50	yes	no	no
2nd Session court	1,140	0	no	yes	yes
1st Session court	1,328	12	yes	yes	yes
4th Session court	1,250	3	yes	yes	no
Hallway/check-in area	821	10	yes	no	no
Photostat area	556	2	yes	no	no
Bindery	824	6	yes	no	no
Data processing	810	1	no	no	no
Maintenance/switchboard	938	1	no	no	no
Room 1	872	1	yes	no	yes
Maintenance/main office	818	1	yes	no	no
Room 4	774	0	yes	yes	yes
Central bull pen	1,136	3	no	yes	no
ACPO office	701	0	no	no	no
PO/secretary's office	915	3	no	no	yes
Engineering department	793	3	yes	no	no
Employee lunchroom	1,017	3	yes	no	no
Computer area	756	1	yes	no	no
Scanner area	862	0	yes	no	no
Data entry	1,094	3	yes	no	yes
Room 6	1,067	1	yes	yes	yes
Comparing room	1,108	5	yes	no	no
Assistant register's office	1,166	0	no	yes	yes
Room 15	1,030	0	yes	yes	yes
Room 12	931	1	no	no	no
Office	921	0	no	no	yes
Record Books - V. 3400-4799	1,146	2	no	no	no
Registry of Deeds - south	1,178	>50	yes	yes	yes
Registry of Deeds - east	1,217	>50	yes	yes	yes
Registry of Deeds - north	1,303	>50	yes	yes	yes
Registry of Deeds - center	1,367	>50	yes	yes	yes
Registry of Deeds - west	1,399	>50	yes	yes	yes
Record Books - 11355 - present	1,428	4	no	yes	yes
Land court lobby	1,578	25	yes	yes	yes
Land court office	1,382	12	yes	no	no
Room 210 - main office	1,184	24	yes	yes	yes
Room 210 - cross office	1,169	0	no	no	no

Source: Massachusetts BEHA

on the second floor, duct work connects to a fan with a motor located in the attic above the main office. However, the fan is inoperable.

This duct work also connects to the roof vent shaft and, while it appears to have been adapted for mechanical exhaust, the 1990 installation of the new roof sealed the shaft. The same type of adaptations appeared on the north wing, but the fan motor there is also inoperable, with the fan belt hanging loose.

The investigators note that while many of the air diffusers and exhaust vents were sealed, removing the plywood caused the vents to draw air, leading them to conclude that the stack effect was working to some degree, even though the mechanical system was not.

Unit Ventilator

Investigators found a third ventilation system — unit ventilators in the 3rd Session courtroom. At the time of the investigation, none of the ventilators were operable. Attempts to turn the ventilators on were unsuccessful, and investigators couldn't find any exhaust vents in the room.

The 2nd Session courtroom had a fourth ventilation system, an air handling unit (AHU) with attached duct work connected to ceiling supply diffusers and ceiling exhaust vents. The AHU was not operating during the investigation, which took place in the winter. The investigators were unable to find any ventilation system in the building's south wing.

Mold and Mildew

Several areas of the courthouse showed signs of moisture problems, with stained and damaged ceiling tiles. According to the investigators, several tiles of the interlocking system were missing, opening the plenum above the ceiling and raising the possibility that mold spores and other debris could find their way into the occupied space.

The wood frame windows — apparently part of the original construction — showed water damage and some of the caulking was missing, increasing the possibility of additional water penetration. The investigations found several

areas with potted plants that gave off a characteristic mold-like odor.

In the photostat room, cardboard sealed the vents above the windows, providing a substrate for possible mold growth. A piece of carpet covered the exhaust fan in the office adjacent to the south mixing room. This piece of carpet was exposed to the weather.

In the 2nd Session courtroom, the wall paneling was warped from apparent leaks in the roof. Upon examining the roof, the investigators found pooled water around the bulkhead. They noted the possibility of water leaking in around the skylight.

Pollutant Sources

At least one court office used various microfilm developing chemicals without local exhaust ventilation. The investigators said these chemicals could be responsible for eye, nose, and throat irritation. Several rooms use photocopiers without local exhaust, increasing the possibility of volatile organic compounds and ozone within the occupied space.

The basement photostat room contained several photocopiers, but had fans in the windows to exhaust fumes into the south courtyard. However, offices across the courtyard reported periodic odors that could be attributed to the photocopier exhaust. Occupants in the bindery room reported vehicle exhaust odors, possibly coming from vehicles idling in the north courtyard.

The building contains piping insulated with asbestos-containing materials. In several basement areas, the asbestos insulation appeared to be damaged, and investigators noted a pipe with a friable white, chalky material in the south mixing room. They were unsure whether this was asbestos and recommended further testing.

Recommendations

Because of the complicated situation, and an equally complicated solution, the investigators made both short-term and long-term recommendations for the facility. Among the short-term recommendations, they suggested using

operable doors and windows, as far as possible, to provide sufficient outside air, with the caveat of preventing damage to the heating system from freezing pipes.

They recommended scrupulous cleaning practices to eliminate or minimize indoor air contaminants, especially those that become worse during low humidity. The investigators also suggested occupants drink water during the day to help ease symptoms caused by a dry environment.

The short-term recommendations included using a HEPA vacuum cleaner to reduce airborne particulates, eliminating strong-scented air fresheners, reducing an excessive number of potted plants, and using potentially polluting products according to manufacturers' recommendations.

As far as short-term engineering controls, they recommended sealing the opened ceiling tiles, replacing inappropriate materials covering outdoor air intakes, operating the AHU in the 2nd Session court during occupancy, and reactivating unit ventilators in the other courtroom.

Long-Term Solutions

The investigators say that improving ventilation in the building may require extensive renovation and refurbishing. However, this is complicated by the presence of possible asbestos-containing material in the air shafts. Before any work could begin, officials would need to evaluate this situation and correct it if necessary.

Because duct cleaners cut the duct work in several places, it would be necessary to restore the integrity of the system before mechanical exhaust could be functional again. Before any work could be done, the system would require an evaluation by a ventilation engineer.

The report notes that in the event the ductwork is usable and officials wish to restore the old ventilation system, it would require repairing the vent motors in the old building attic and re-opening the south air shaft through the roof. This would require consultation with a structural engineer.

Other recommendations include:

- Once the mechanical exhaust is restored, remove plywood blocking exhaust vents.
- Determine whether a mechanical ventilation system can be installed in the 1952 addition.
- Examine the feasibility of providing local exhaust ventilation for the photostat room to exhaust air out the rear of the building instead of into the south courtyard.
- Consider installing local exhaust ventilation in the microfilm areas.
- Replace water damaged ceiling tiles.
- Lower the roof drain to prevent water pooling on the roof.

For more information, contact Michael Feeney, Chief of Emergency Response, BEHA, Department of Public Health, 250 Washington Street, Boston, MA 02108. Tel: (617) 624-5757.

News and Analysis

BP Amoco Confronts Cancer Cluster, Probes Possible IEQ Link

Indoor air pollution is among the causes being considered as investigators probe an unusual cluster of malignant brain tumors at a petroleum company research facility in Naperville, Ohio. Officials at the BP Amoco plant are awaiting a report, due out this month, that may tell whether the cluster is related to environmental conditions at the plant.

While most reports linking IEQ with cancer clusters prove to be unfounded, the occurrence at the BP Amoco plant has already been determined to be "unusual," and the company has been particularly aggressive in trying to determine whether the cases are related and, if so, whether they stem from either the chemicals with which the victims worked or some environmental conditions at the plant.