HETA 91-0160-2493
March 1995
DISTRICT OF COLUMBIA SCHOOL OF LAW
WASHINGTON, D.C.

NIOSH INVESTIGATORS:
Stan Salisbury, CIH
Max Kiefer, CIH

SUMMARY

On March 21, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at the District of Columbia School of Law (DCSL) building in Washington, D.C. The request was initiated by an authorized representative of the American Federation of State, County, and Municipal Employees (AFSCME), AFL-CIO Local 3634, which represents employees of the DCSL. The requestors asked NIOSH to investigate health problems experienced by some building occupants (both students and employees), including unspecified illness, fatigue, and dizziness, that were possibly related to inadequate ventilation. Classrooms 101 and 102 were specifically noted as areas of concern.

In response to this request, NIOSH investigators reviewed the results of a previous indoor environmental quality (IEQ) investigation conducted by the District of Columbia Office of Occupational Safety and Health (DCOOSH), and actions previously taken by building management to address occupant concerns with IEQ. On April 15-16, 1992, a site visit was conducted to inspect the DCSL facility, interview building occupants, inspect the building heating, ventilating, and air-conditioning (HVAC) system, and conduct environmental monitoring.

The 1990, DCOOSH investigation failed to identify a contaminant that would explain the symptoms experienced by building occupants. In response to DCSL concerns with inadequate ventilation, building management had modified the HVAC in 1989, and March 1992, to provide additional ventilation to occupied areas.

The building is serviced by two air-handler units (interior and exterior zone), both of which were fully operational during the NIOSH visit. The outside air damper settings had been manually placed in the fully open position - maximizing the amount of outside air provided to the facility. During the NIOSH investigation, return air pathways for nearly all areas of the building were found to be blocked by interior walls. Air is being effectively returned from the main corridors, but for other rooms air flow through the ceiling plenum is blocked off from the return air shaft by the extended interior walls. This configuration severely limits building air distribution and circulation. Air vents on some perimeter fan-coil units were found blocked, which further limits effective ventilation.

Environmental measurements, obtained when class was in session in rooms 101 and 102, found carbon dioxide (CO_2) concentrations of 900-925 parts per million (ppm), and 1300-1350 ppm, respectively. CO_2 is a commonly used "indicator" of the amount of outside air being provided to an occupied area. In general, when indoor CO_2 concentrations exceed 1000 ppm, inadequate ventilation is suspected. Indoor temperature and relative humidity was found to be

within acceptable ranges throughout the building, and no elevated sources of volatile organic compounds (VOCs), such as solvents, were identified. No carbon monoxide was detected in the building.

No unusual janitorial practices were noted, although it was noted that housekeeping was in need of improvement. It appears that pesticides may be being used inappropriately at the DCSL. The building is fogged on a monthly basis, and one pesticide labeled for outdoor use (Dursban), is being used inside the building. An IEQ management plan had not been established at this facility at the time of this investigation. Because the building has a common return air system, smoking should be restricted to dedicated smoking lounges that are under negative pressure with air exhausted directly to the outdoors. Suggestions for improving IEQ at the DCSL are provided in the Recommendation section of this report.

Health symptoms and complaints associated with poor indoor environmental quality (IEQ) were reported by some occupants at the DCSL. On the day of the NIOSH survey, measurement of standard IEQ parameters indicate, that except for classroom 102, sufficient outside air is provided to the building. CO_2 measurements in classroom 102 exceeded the 1000 ppm guideline, suggesting that inadequate outside air is being provided to this room. Temperature and relative humidity levels were within acceptable ranges, and no carbon monoxide (CO) or volatile organic compounds (VC) sources were identified. One important finding was that almost all return air pathways in this building have been effectively blocked by floor to slab interior walls. Although not verified through environmental monitoring, this configuration would likely limit proper air distribution and circulation. Housekeeping needs improvement throughout the building, and the air vents on some perimeter fan-coil units were found to be blocked. Although no chemical explanation for the reported symptoms was identified, pesticide use practices inside the DCSL should be re-evaluated. Recommendations include eliminating the return air path restrictions, establishment of an integrated pest management program, and implementing a proactive IEQ management plan.

KEYWORDS: SIC 8221 (Colleges, Universities, and Professional Schools) indoor environmental quality, ventilation, carbon dioxide, carbon monoxide

INTRODUCTION

On April 15-16, 1992, NIOSH investigators conducted a health hazard evaluation at the D.C. School of Law (DCSL) to investigate occupant health complaints associated with indoor environmental quality (IEQ). The requestors indicated there were numerous reports of illness, poor ventilation, visible particulate from overhead vents, and conditions of fatigue and dizziness affecting both students and employees. A primary concern involved reports of poor ventilation in the two classrooms located on the first floor. A recent incident when dusts from old roofing materials and heated asphalt volatiles were entrained into the building's heating, ventilation, and air-conditioning (HVAC) system, further heightened IEQ concerns among the DCSL students and faculty.

During the NIOSH site visit, the DCSL building, and the heating, ventilating, and air-conditioning (HVAC) system was inspected. Environmental monitoring to assess various IEQ parameters was conducted, and interviews were held with building management, maintenance, and employee representatives. An initial response letter describing the actions taken by NIOSH, as well as preliminary findings and recommendations, was issued to DCSL officials and the requestors on May 13, 1992.

BACKGROUND

The Washington D.C. School of Law is housed in a leased six-story building located in downtown Washington, D.C. The building was constructed in 1984, and has been occupied by the DCSL since 1987. Various interior modifications were made to accommodate the needs of the law school. Over 200 students are enrolled in the DCSL, and there are 40 staff members, including teaching and administrative personnel.

The building is serviced by two constant-volume air-handling units (AHUs) located in a penthouse on the roof. One unit supplies the exterior zone of the building, and delivers ventilation through high-pressure induction coil units located in each perimeter office or room. These units have individual controllers. The interior zone is serviced by a much larger AHU that supplies air through supply air ducts. Outside air (OA) for both systems is obtained through a grille on the side of the penthouse. The space above the false ceiling serves as the return air (RA) plenum, and conveys RA back to the AHUs via a vertical shaft located in the main corridors between the men's bathroom and elevator shaft. A thermostat in the RA shaft is used to control the temperature of the air supplied by the interior zone AHU.

There have been concerns with air quality among both staff and students in the DCSL building for several years. The primary complaint area was the two large classrooms (101, 102) located on the first floor. Occupancy load in these two rooms will vary considerably depending on class schedule. In 1989, in response to concerns voiced by the DCSL, the building management agency (Blake Real Estate) modified the ductwork to increase air flow to the classrooms and other areas. In October 1990, the Department of Employment Services, Office of Occupational Safety and Health, conducted an investigation at the DCSL in response to a health complaint concerning indoor air quality. Monitoring was conducted for a variety of substances, including carbon dioxide, carbon monoxide, hydrogen sulfide, ozone, formaldehyde, and various volatile organic compounds (VOCs). All measurements showed the concentrations to be within acceptable levels. An incident in February 1992, involving the entrainment of contaminants from a roof repair job into the building ventilation system, heightened awareness and concern about IEQ among employees and students. The Department of Consumer and Regulatory Affairs was contacted, and subsequently issued a "Stop Work" order to the roofing contractor. In March 1992, the building HVAC system was modified to provide additional air flow to occupied areas. Five perimeter fan coil units were also installed in room 102. These units are total recirculation systems and serve to recondition room air; no OA is provided by these units.

According to building management, the hallway carpet is shampooed monthly, and there is a janitorial service. Smoking is allowed in offices and in the teacher's lounge.

EVALUATION PROCEDURES

The NIOSH evaluation protocol consisted of the following:

1. Inspection of the building's HVAC systems and interviews with building management and maintenance representatives to understand how the system operates and determine air flow pathways. Documents describing some of the recent modifications made to the HVAC to improve air circulation were reviewed.

2. A building inspection and monitoring of selected IEQ parameters to measure indoor concentrations of carbon dioxide (CO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). Measurements of indoor temperature and relative humidity (RH) were also obtained to evaluate comfort parameters. These measurements included readings taken during class sessions of 40 students in room 101 and 64 students in room 102.

3. A review of janitorial chemicals and pesticides use practices in the building.

4. An estimate of the minimum percentage of outside air (OA) the HVAC system delivers to the building. This was obtained by setting the OA dampers to the minimum set point and measuring the CO_2 concentration in the return air (RA) duct, OA intake vent, and supply air (SA) duct.

Sampling and analytical methodology used during the survey was as follows:

Carbon Dioxide (CO_2)

Instantaneous measurements of CO_2 concentrations were obtained using a Gastech Model RI-411A Portable (direct reading) CO_2 monitor. The principle of detection is non-dispersive infrared absorption. The instrument was zeroed (zero CO_2 gas source) and calibrated prior to use with a known CO_2 source (span gas). The monitor provides CO_2 concentrations in 25 parts per million (ppm) increments with a range of 0-4975 ppm. Measurements were obtained at various intervals and locations throughout the building. Outdoor readings were taken to determine baseline CO_2 levels.

Temperature and Relative Humidity (RH)

Dry bulb temperature and RH levels throughout the building were determined at various intervals. Outdoor readings were obtained for comparison purposes. Instrumentation consisted of a Bendix Psychron Model 566 electrically aspirated psychrometer. Temperature and RH as determined via standard dry bulb, wet bulb, and psychrometric chart were recorded.

Non-specific VOC Monitoring

Instantaneous measurements to assess relative levels of VOCs were obtained in various indoor and outdoor locations. This monitoring was done with an HNu Systems Model PL 101 analyzer. This portable, non-specific, direct-reading instrument uses the principle of photoionization for detection. The sensor consists of a sealed ultraviolet light source that emits photons which are energetic enough to ionize many compounds. These ions are driven to a collector electrode where the current (proportional to concentration) is measured. A 10.2 electron volt lamp was utilized. This lamp will ionize a wide variety of organic compounds, yet exclude normal constituents of air such as nitrogen, oxygen, carbon dioxide, etc. Measurements were obtained with the instrument set on maximum sensitivity. This sampling was conducted to identify potential sources of solvent emissions or material that may be emitting VOC's.

Carbon Monoxide

CO measurements were obtained using an Industrial Scientific CO monitor. This hand-held, direct-reading, continuous monitor uses an electrochemical cell as the principle of detection. Air is sampled passively through a diffusion grid on the monitor. The unit's digital display reads in 1 ppm increments. The limit of detection is 1 ppm. Prior to use, the monitor was calibrated with known concentrations of CO.

EVALUATION CRITERIA

Indoor environmental quality (IEQ) is affected by the interaction of a complex set of factors which are constantly changing. Four elements involved in the development of IEQ problems are:

- sources of odors or contaminants,
- problems with the design or operation of the HVAC system,
- pathways between contaminant sources and the location of complaints,
- and the activities of building occupants.

A basic understanding of these factors is critical to preventing, investigating, and resolving IEQ problems.

The symptoms and health complaints reported to NIOSH by non-industrial building occupants have been diverse and usually not suggestive of any particular medical diagnosis or readily associated with a causative agent. A typical spectrum of symptoms has included headaches, unusual fatigue, varying degrees of itching or burning eyes, irritations of the skin, nasal congestion, dry or irritated throats, and other respiratory irritations. Usually, the workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[1-5] Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[6,7] Among these factors are imprecisely defined characteristics of heating, ventilating, and air-conditioning (HVAC) systems, cumulative effects of exposure to low concentrations of multiple chemical pollutants, odors, elevated concentrations of particulate matter, microbiological contamination, and physical factors such as thermal comfort, lighting, and noise.[8-13] Indoor environmental pollutants can arise from either outdoor sources or indoor sources.

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related to the occurrence of symptoms than any measured indoor contaminant or conditions.[14-16] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[16-19]

Less often, an illness may be found to be specifically related to something in the building environment. Some examples of potentially building-related illnesses are allergic rhinitis, allergic asthma, hypersensitivity pneumonitis, Legionnaires' disease, Pontiac fever, carbon monoxide poisoning, and reaction to boiler corrosion inhibitors. The first three conditions can be caused by various microorganisms or other organic material. Legionnaires' disease and Pontiac fever are caused by Legionella bacteria. Sources of carbon monoxide include vehicle exhaust and inadequately ventilated kerosene heaters or other fuel-burning appliances. Exposure to boiler additives can occur if boiler steam is used for humidification or is released by accident.

Problems NIOSH investigators have found in the non-industrial indoor environ-ment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from furnishings, machines, structural components of the building and contents, tobacco smoke, microbiological contamination, and outside air pollutants; comfort problems due to improper temperature and relative humidity conditions, poor lighting, and unacceptable noise levels; adverse ergonomic conditions; and job-related psychosocial stressors. In most cases, however, these problems could not be directly linked to the reported health effects.

Standards specifically for the non-industrial indoor environment do not exist. NIOSH, the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) have published regulatory standards or recommended limits for occupational exposures.[20-22] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recom-mended building ventilation design criteria and thermal comfort guidelines.[23,24] The ACGIH has also developed a manual of guidelines for approaching investi-gations of building-related complaints that might be caused by airborne microorganisms or their effluent.[25]

Measurement of indoor environmental contaminants has rarely been helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. The low-level concentrations of particles and mixtures of organic materials usually found are difficult to interpret and usually impossible to causally link to observed and reported health symptoms. However, measuring ventilation and comfort indicators such as CO_2, temperature and relative humidity, has proven useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and con-ference rooms, and 15 cfm/person for reception areas, and provides estimated maximum occupancy figures for each area.[23]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 ppm). When indoor CO_2 concentrations exceed 1000 ppm in areas where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased.

Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[24] This zone lies between 73°F and 77°F, and 30 to 60% relative humidity.

Carbon Monoxide

CO is a colorless, odorless gas that is a product of incomplete combustion. Engine exhaust, tobacco smoking, inadequately ventilated combustion products from heaters that use hydrocarbon fuel are sources of exposure to CO. Over-exposure to CO may cause initial symptoms such as headache, dizziness, drowsiness, and nausea. These symptoms may progress to vomiting, loss of consciousness or collapse if high exposures are encountered.[26] The NIOSH REL for CO is 35 ppm as a time-weighted average for up to 10 hours per day. NIOSH also recommends a ceiling level of 200 ppm for CO.[20]

RESULTS AND DISCUSSION

The return air pathways for almost all areas of the building are blocked by the interior walls. It was reported during the closing conference that local building code requires interior walls to extend from floor to slab (the slab is the concrete support for the floor above each floor, or the roof support for the top floor). This means that the space above the suspended ceiling which serves as the RA plenum is sectioned off by the interior walls. Air is returned to the HVAC air handlers (located in the penthouse mechanical room) from each floor through openings in the return air shaft. This shaft runs vertically through all floors and is located in the main corridors between the men's bathroom and elevator shaft. Air is being effectively returned from the main corridors but for other rooms, especially where doors are closed, air flow through the ceiling plenum is blocked off from the return air shaft by the extended interior walls. This configuration severely limits effective building air distribution and circulation.

Measurements taken in the first floor classrooms when class was in session showed CO_2 concentrations from 900-925 parts per million (ppm) in room 101, and 1300-1350 ppm in room 102 (Table 1 and 2). The wall units recently installed in the first floor class rooms are designed only to heat and cool recirculated air, and are not a source of outside air. Therefore they have little or no effect on room ventilation. Indoor CO_2 concentrations above 1000 ppm in room 102 (occupancy rate during measurements was 64 students) indicate potential ventilation problems may still exist for this larger class room. Although openings had been cut in the interior walls to alleviate the blocked air return problem described above, the room was still under a strong positive pressure relative to the corridor outside the classrooms. This indicates that the ceiling air returns are not pulling enough air from the classroom.

Both the exterior zone and interior zone air handlers are equipped with recircu-lating water spray air washers. Water spray air washers are used to help clean the air and provide for humidification during the winter heating season. The washer systems had recently been cleaned and serviced. Caution is advised in the use of such systems as they are subject to severe bacterial contamination if not serviced frequently.

The heating and cooling coils were in good condition. According to building management, the coils had recently received their annual pressure wash. No obvious sources of microbial contaminants were observed inside the air handling units.

Operating manuals for the HVAC system were not available, nor were a test and balance report. Building maintenance personnel were unable to fully explain the operation and set-points for the HVAC control system. To supply a greater than normal amount of OA to the building, the OA control dampers were manually configured to the full-open setting. The RA bypass damper was also open (under normal operation RA bypass damper is closed if the OA damper and relief dampers are open). Building maintenance representatives confirmed that HVAC control dampers would be returned to normal settings when outdoor air temperatures increased. This means that only the minimum outside air rates can be maintained during the summer months.

With the HVAC system configured for normal summertime operation (minimum setting of the OA damper), CO_2 measurements were obtained to determine the CO_2 concentration in the return, supply and OA sources. These measurements were used to calculate the percent OA (%OA) being delivered to occupied areas. The calculation used is based on the formula developed for determining %OA based on temperature.[27]

$$\%\ Outside\ air = \frac{CO_2r - CO_2s}{CO_2r - CO_2o} \times 100$$

Where:
CO_2r = concentration in the return air
CO_2s = concentration in the supply air
CO_2o = concentration in the outside air

These measurements indicated the delivered supply air contains about 11% OA. HVAC design specifications call for about 25% OA with dampers at the minimum set point. However, our 11% estimate was subject to considerable variability since time restraints limited us to taking only one set of CO_2 readings. Further influencing the results was the relatively low CO_2 concentration in the return air and CO_2 instrument's digital display which gave readings in 25 ppm increments. For example, if the CO_2 concentration in the supply air had been 25 ppm lower than indicated the estimated percentage of OA supplied by the HVAC would be 22%. After modifications were made to the air handling units on March 17, 1992, the reported air circulation rates (total supply air) for the interior and exterior air handling units were respectively 23,200 cubic feet per minute (cfm) and 4500 cfm. Based on our CO_2 measurements, we estimate the minimum OA supply rate is roughly 5,540 cfm or 20% of the total 27,700 cfm circulated through the building by the HVAC system. Assuming the HVAC supply air is uniformly distributed to all areas of the building, and the building contained 256 occupants, this OA ventilation rate would be about 22 cfm per person (cfm/p). This is only slightly below the original HVAC minimum designed OA rate (as shown on the original HVAC mechanical drawings) of 6,630 cfm or 26 cfm/p.

Measurements of CO_2 levels indicated the building was receiving an adequate supply of outside air (Table 3). Readings ranged from 435 ppm (which was also the reading obtained for outdoor air) to 575 ppm. Several readings were taken on each floor of the building from 8:30 a.m. to 10:30 a.m. on March 16. The direct reading instrument used to measure VOCs showed only trace concentrations that were no higher than the amounts detected outside the building. Psychrometer readings showed temperatures ranging from 70°-78° F and RH ranging from 45% to 50%. No CO was detected.

One pesticide labeled for outdoor use (e.g., Dursban) was being used indoors. The building maintenance engineer was also "fogging" the building monthly with ULD BP-300 insecticide. This chemical is being used full strength and the applicator uses a cartridge respirator. Because this individual has a beard, it's not possible to obtain a proper fit and face seal to insure adequate protection.

At least one office had books and papers covering the air vent of a perimeter fan coil unit. Unlike the new units installed in classrooms 101 and 102, the original wall units are induction blowers connected via high pressure ducts to the exterior air handling unit located in the penthouse mechanical room. These units there- fore do supply outside air ventilation, and blocking the air supply will limit the effectiveness of these units.

CONCLUSIONS

Ongoing health symptoms and complaints associated with IEQ have been experienced by some occupants at the DCSL. Reported symptoms include fatigue, dizziness, and unspecified illness. Measurement of standard IEQ parameters indicate that, with one exception, sufficient outside air is provided to the building. CO_2 measurements in classroom 102, obtained during a class session, exceeded the 1000 ppm guideline, suggesting that inadequate outside air is being provided to this room. Temperature and relative humidity levels were within acceptable ranges, and no CO or VOC sources were identified during the NIOSH survey.

Inspection of the building found that nearly all return air pathways have been effectively blocked by floor to slab interior walls. This significantly limits proper air distribution and circulation. Housekeeping was found to be in need of improvement throughout the building, and some of the perimeter fan-coil units were found to be blocked.

Although no chemical explanation for the reported symptoms was identified, pesticide use practices inside the DCSL should be re-evaluated. The building is routinely fogged (monthly), and one pesticide labeled for outdoor use is used inside the building.

An IEQ management plan has not been established at the DCSL. An effective IEQ program can serve to proactively address potential problems (e.g., roofing or other contractor work), communicate with occupants, and ensure the HVAC system is operating properly. These are all important factors in providing an acceptable work environment for occupants, and resolving IEQ issues.

RECOMMENDATIONS

Most of the following recommendations were provided at a closing conference during the NIOSH site visit and further discussed in a preliminary report issued in May 1992.

1. Restrictions in the return air plenum should be eliminated. This could probably be done by cutting a sufficient number of openings in all the interior walls that extend above the suspended ceiling. Taking this action should improve building ventilation by increasing air circulation, and will provide for more effective exhausting of indoor pollutants from occupied spaces. Building and fire codes should be assessed to determine if additional measures (e.g., fire dampers) are required.

2. All occupants should be reminded not to stack books or other materials on top of their HVAC wall units. If wall units are blowing air that is too hot or too cold, the wall unit thermostat should be adjusted. Units that will not respond to these adjustments should be reported to the building's maintenance engineer.

3. The metal rim on several floor inspection plates were not seated properly or were bent or damaged. These rims should be replaced or removed to prevent an obvious tripping hazard.

4. Housekeeping could use improvement. Most of the interior walls, especially in the main corridors need repainting. A full-floor cleaning of the carpets should also be accomplished. The odor of stale smoke is very noticeable on the third. floor. Cleaning the carpet may help to eliminate this odor. Because all areas of the building are served by the same HVAC system, smoking should not be permitted in the building.

5. There is considerable concern among the students and staff that the building was severely contaminated from the roofing materials and asphalt emissions that entered the HVAC system on February 4, 1992. Our inspection of the HVAC system and indoor VOC readings found no evidence to support that concern. However, because our inspection of the HVAC system was mostly limited to the air handling units, a visual inspection inside the interior zone air supply ducts should be done on each floor. If this inspection finds roofing materials have accumulated in the ducts, having the ducts cleaned by a professional duct cleaning contractor may help to diffuse the health concerns of building occupants.

6. The DCSL should consider establishing an Integrated Pest Management (IPM) program for the building. IPM is a low-cost approach to pest control based upon knowledge of the biology and behavior of pests. Adoption of an IPM program can significantly reduce the need for pesticides by eliminating conditions that provide attractive habitats for pests. IPM methods include:
   - improved sanitation (e.g., removing food from desks, cleaning)
   - inspection and monitoring of pest population sites
   - managing waste (e.g., keeping refuse in tight containers, locating waste containers away from building if possible)
   - maintaining structures (e.g., fixing leaking pipes promptly, sealing cracks)
   - adding physical barriers to pest entry and movement (e.g., screens for chimneys, doors, and windows; air curtains)
   - modifying habitats (e.g., removing clutter, relocating outside light fixtures away from doors)
   - using traps (e.g., light traps, snap traps, and glue boards)
   - using pesticides judiciously

7. Because the building has a common return air system, smoking should not be permitted inside the building except in dedicated smoking lounges that are under negative pressure with air exhausted directly to the outdoors. NIOSH considers environmental tobacco smoke (ETS) to be a potential occupational carcinogen, and the Environmental Protection Agency has concluded that ETS should be treated as a Class A carcinogen.[28,29] Indoor air ETS exposures should be controlled to the lowest feasible concentration.

8. Implement an IEQ Management Plan for the DCSL building. An IEQ manager with clearly defined responsibilities, authority, and resources should be selected. This individual should have a good understanding of the building's structure and function, and should be able to effectively communicate with occupants. The elements of a good plan include the following:

   - Proper operation and maintenance of HVAC equipment.
   - Overseeing the activities of occupants and contractors that affect IEQ (e.g., housekeeping, pest control, maintenance, food preparation).
   - Maintaining and ensuring effective and timely communication with occupants regarding IEQ.
   - Educating building occupants and contractors about their responsibilities in relation to IEQ.
   - Pro-active identification and management of projects that may affect IEQ (e.g., redecoration, renovation, relocation of personnel, etc.).

   The NIOSH/EPA Building Air Quality Guidance Document should be consulted for details on developing and implementing IEQ management plans.[30]

9. After removing the return air restrictions, conduct a complete test and balance to verify the system is operating properly. Additional ventilation to classroom 102 may be necessary to ensure sufficient ventilation during high class load periods. Personnel responsible for operation and maintenance of the HVAC system should be fully trained. Current documentation and operating guidelines should be maintained.

REFERENCES

1. Kreiss KK, Hodgson MJ [1984]. Building associated epidemics. In: Walsh PJ, Dudney CS, Copenhaver ED, eds. Indoor air quality. Boca Raton, FL: CRC Press, pp 87-108.

2. Gammage RR, Kaye SV, eds. [1985]. Indoor air and human health: Proceedings of the Seventh Life Sciences Symposium. Chelsea, MI: Lewis Publishers, Inc.

3. Woods JE, Drewry GM, Morey PR [1987]. Office worker perceptions of indoor air quality effects on discomfort and performance. In: Seifert B, Esdorn H, Fischer M, et al, eds. Indoor air '87, Proceedings of the 4th International Conference on Indoor Air Quality and Climate. Berlin Institute for Water, Soil and Air Hygiene.

4. Skov P, Valbjorn O [1987]. Danish indoor climate study group. The "sick" building syndrome in the office environment: The Danish town hall study. Environ Int 13:399-349.

5. Burge S, Hedge A, Wilson S, Bass JH, Robertson A [1987]. Sick building syndrome: a study of 4373 office workers. Ann Occup Hyg 31:493-504.

6. Kreiss K [1989]. The epidemiology of building-related complaints and illness. Occupational Medicine: State of the Art Reviews. 4(4):575-592.

7. Norbäck D, Michel I, Widstrom J [1990]. Indoor air quality and personal factors related to the sick building syndrome. Scan J Work Environ Health. 16:121-128.

8. Morey PR, Shattuck DE [1989]. Role of ventilation in the causation of building-associated illnesses. Occupational Medicine: State of the Art Reviews. 4(4):625-642.

9. Mendell MJ, Smith AH [1990]. Consistent pattern of elevated symptoms in air-conditioned office buildings: A reanalysis of epidemiologic studies. Am J Public Health. 80(10):1193-1199.

10. Molhave L, Bach B, Pedersen OF [1986]. Human reactions during controlled exposures to low concentrations of organic gases and vapours known as normal indoor air pollutants. Environ. Int., 12, 167-175.

11. Fanger PO [1989]. The new comfort equation for indoor air quality. ASHRAE J 31(10):33-38.

12. Burge HA [1989]. Indoor air and infectious disease. Occupational Medicine: State of the Art Reviews. 4(4):713-722.

13. Robertson AS, McInnes M, Glass D, Dalton G, Burge PS [1989]. Building sickness, are symptoms related to the office lighting? Ann Occup Hyg 33(1):47-59.

14. Wallace LA, Nelson CJ, Dunteman G [1991]. Workplace characteristics associated with health and comfort concerns in three office buildings in Washington, D.C. In: Geshwiler M, Montgomery L, and Moran M, eds. Healthy buildings. Proceedings of the ASHRAE/ICBRSD conference IAQ'91. Atlanta, GA. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

15. Haghighat F, Donnini G, D'Addario R [1992]. Relationship between occupant discomfort as perceived and as measured objectively. Indoor Environ 1:112-118.

16. NIOSH [1991]. Hazard evaluation and technical assistance report: Library of Congress Madison Building, Washington, D.C. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HETA 88-364-2104 - Vol. III.

17. Skov P, Valbjørn O, Pedersen BV [1989]. Influence of personal characteristics, job-related factors, and psychosocial factors on the sick building syndrome. Scand J Work Environ Health 15:286-295.

18. Boxer PA [1990]. Indoor air quality: A psychosocial perspective. J Occup Med 32(5):425-428.

19. Baker DB [1989]. Social and organizational factors in office building-associated illness. Occupational Medicine: State of the Art Reviews. 4(4):607-624.

20. CDC [1992]. NIOSH recommendations for occupational safety and health: Compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 92-100.

21. Code of Federal Regulations [1989]. OSHA Table Z-1-A. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

22. ACGIH [1991]. 1991-1992 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

23. ASHRAE [1990]. Ventilation for acceptable indoor air quality. Atlanta, GA: American Society of Heating, Refrigerating, and Air-conditioning Engineers. ANSI/ASHRAE Standard 62-1989.

24. ASHRAE [1981]. Thermal environmental conditions for human occupancy. Atlanta, GA: American Society for Heating, Refrigerating, and Air-conditioning Engineers. ANSI/ASHRAE Standard 55-1981.

25. ACGIH [1989]. Guidelines for the assessment of bioaerosols in the indoor environment. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

26. NIOSH [1977]. Occupational diseases - a guide to their recognition. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health; DHHS (NIOSH) Publication No. 77-181.

27. NIOSH [1991]. Current intelligence bulletin 54: Environmental tobacco smoke in the workplace: lung cancer and other health effects. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-108.

28. EPA [1992]. Respiratory health effects of passive smoking: lung cancer and other disorders. Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development. EPA Publication EPA/600/6-90/006F.

29. Hughes RT, Obrien DM [1986]. Evaluation of building ventilation systems. Am Ind. Hyg. Assoc. J. 47(4):207-213.

30. NIOSH/EPA [1991]. Building air quality, a guide for building owners and facility managers. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 91-114.

AUTHORSHIP AND ACKNOWLEDGMENTS

Evaluation Conducted and Report Prepared By:	Stan Salisbury, CIH Regional Program Consultant NIOSH, Atlanta Regional Office PHS Region IV, Atlanta, GA
	Max Kiefer, CIH Regional Industrial Hygienist NIOSH, Atlanta Regional Office PHS Region IV, Atlanta, GA
Originating Office:	NIOSH Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations, and Field Studies NIOSH Cincinnati, Ohio

REPORT DISTRIBUTION AND AVAILABILITY

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-addressed mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. D.C. School of Law (Dean)
2. AFSCME Local 3634
3. D.C. Dept. of Employment Services, Office of Occupational Safety and Health
4. Department of Labor/OSHA Region III
5. NIOSH Washington Office

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

IEQ Monitoring Results

Washington, D.C. School of Law
HETA 91-0160, April 16, 1992

Table 1: Room 101 (40 occupants) - 3:20 p.m.

Location	CO_2 (ppm)	% RH	°F
Back of Classroom, Right Side	900	51	72
Front of Classroom, Right Side	925	51	73
Center of Classroom	925	50	73
Back of Classroom, Left Side	925	50	73
Front of Classroom, Left Side	925	73	51

Table 2: Room 102 (64 occupants) - 3:40 p.m.

Location	CO_2 (ppm)	% RH	°F
Back of Classroom, Left Side	1350	50	72
Front of Classroom, Left Side	1325	49	74
Center of Classroom	1350	49	73
Front of Classroom, Right Side	1225	49	74
Back of Classroom, Right Side	1300	49	73
Back of Classroom, Center	1350	49	74

NOTES:

CO_2 = carbon dioxide
ppm = parts of gas or vapor per million parts of air
%RH = percent relative humidity
°F = degrees fahrenheit

Table 3: IEQ Monitoring Results
Washington, D.C. School of Law
HETA 91-0160, April 16, 1992

Location	Time	°F	%RH	CO_2	VOC	CO
3rd Fl. Deans Conf. Rm.	8:35	72	49	525	1.8	ND
Outside - Street Level	8:45	55		425	1.7	ND
Center Hall, 1st. FL.	8:55	72	48	500	1.8	ND
Outside Room 101	9:05	72	48	425	1.8	ND
Room 102 (empty)	9:10	70	49	425	1.7	ND
Elev. Lobby, 4th. Fl.	9:25	73.5	45	525	1.7	ND
Library, 4th. Fl.	9:27	72.5	48	425	1.6	ND
Main Office, 2nd. Fl.	9:40	75	48	475	1.8	ND
Library, 2nd. FL.	9:42	75	43	475	1.8	ND
Adjacent Rm. 205	9:45	75	43	525	1.9	ND
Adjacent Rm. 224	9:47	76	43	475	1.7	ND
Rm. 227	9:50	76	43	475	1.8	ND
Library, 3rd. Fl.	9:52	73	46	425	1.7	ND
Outside Staff Lounge	9:54	76	44	475	1.7	ND
Inside Staff Lounge	9:56	78	42	450	1.9	ND
3rd. Fl. Corridor	10:00	75	46	525	1.7	ND
3rd. Fl. Admissions	10:02	73	50	525	1.8	ND
3rd. Fl. Deans Sec.	10:04	72	47	450	1.7	ND
Rm. 303	10:06	72	50	575	1.9	ND
Elev. Lobby, 5th. Fl.	10:10	74	45	525	1.8	ND
Library, 5th. Fl.	10:12	72	47	450	1.7	ND
Training Rm. 5th. Fl.	10:15	71	51	525	1.7	ND
Library Study, 5th. Fl.	10:17	71	52	475	1.8	ND
Elev. Lobby, 6th. Fl.	10:20	74	45	500	1.8	ND
Copier Rm. 6th. Fl.	10:22	73	46	500	1.7	ND
Library, 6th. Fl.	10:24	71	50	475	1.7	ND

NOTE:

°F = Temperature in degrees fahrenheit
%RH = percent relative humidity
CO = carbon monoxide
CO_2 = carbon dioxide
CO and CO_2 readings are in ppm (parts of gas or vapor per million parts of air)
VOC = volatile organic compounds. Readings were obtained with a direct reading photoionization detector. The units are arbitrary and do not reflect an actual concentration. Monitoring was conducted to compare outside vs. inside levels.