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SUMMARY

In April 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from employees at the Kenton County Department for Social Insurance (DSI), Covington, Kentucky. The request concerned alleged work-associated symptoms such as dry, irritated eyes, headache, runny nose and head congestion, tiredness, and dry skin among employees located on the third floor. Other concerns included cigarette smoke, dust, insufficient air movement, and temperature fluctuations.

Private medical interviews were conducted with 12 of the approximately 60 DSI employees currently working on the third floor. Workers were concerned about cigarette smoke in the workplace, dust, inadequate air movement, and temperature fluctuations. In addition, a few DSI employees believed there were pigeons roosting inside the north wall of the employee breakroom. Except for these issues, 11 of the 12 interviewed were very satisfied with their work.

Carbon dioxide (CO_2) levels increased slightly on the third floor during the work day; however, the highest concentrations measured (800 parts per million [ppm]) were well below the 1,000 ppm guideline which NIOSH investigators use as an indicator of the adequacy of outside air supplied to occupied areas. Levels of CO_2 outside the building ranged from 375 to 425 ppm. Temperature and relative humidity levels ranged from 74 to 76^{o}F and 35 to 39%, respectively. These conditions were within the operative temperatures recommended to maintain a thermally acceptable environment for at least 80% of the occupants. Elemental analysis of two bulk samples of paint and settled dust identified calcium, aluminum, magnesium, iron, zinc and sodium as the principle components. Microscopic fiber analysis of these same samples identified cellulose, glass fibers, and synthetics. None of these bulk sample results suggest the presence of any unusual or hazardous metals, minerals, or fibers which would warrant a special health concern. No asbestos was found in either bulk sample. Quantitative air flow measurements performed by NIOSH investigators indicated that the ventilation systems supplying the third floor were not balanced.

NIOSH investigators have concluded that a health hazard exists at the Kenton County Department for Social Services. Given the lack of an effective smoking policy, exposure to tobacco smoke could explain many of the symptoms described by the DSI employees. Other environmental parameters typically measured in an indoor environmental quality assessment, such as carbon dioxide, temperature, and relative humidity were within acceptable ranges. The ventilation systems servicing this area were verified to be unbalanced, a condition which occassionally may contribute to such worker complaints as tiredness, headache, thermal comfort problems, and "stagnant air." Some of the recommendations included in this report regard the need for an effective smoking policy and a balancing of the ventilation systems.

Keywords: SIC 9441 (Administration of Social, Human Resource and Income Maintenance Programs), indoor air quality, ventilation, carbon dioxide, temperature, relative humidity.

INTRODUCTION

In April 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) submitted by three Kenton County Department for Social Insurance (DSI) employees located in Covington, Kentucky. These DSI workers were concerned about headaches, nausea, sinus infections, bronchial problems, breathing problems, unpleasant odors, dust, and other items generally thought to be related to the quality of their indoor working environment.

On April 29, 1992, an initial site visit was conducted during which NIOSH investigators met with management and employee representatives and performed a walk-through survey of the work place. Employees with medical complaints or concerns were interviewed, and an evaluation of the work environment with emphasis on the ventilation system was performed. Assistance was obtained from the representative of the private building management agency which serviced the office building.

During a follow-up survey conducted on May 5, 1992, various environmental measurements, such as carbon dioxide, temperature, and relative humidity, were collected throughout the workday at various locations in the third floor office. In addition, quantitative air flow measurements were made at all of the supply air diffusers on the third floor.

BACKGROUND

DSI is located in a seven-story, brick and concrete building believed to have been built in the 1920's. The building has an "L"-shape design, with the longer leg containing seven stories and the shorter leg four. Situated in downtown Covington, Kentucky, this DSI office is responsible for the processing of social benefits in the Northern Kentucky area, including medical benefits, aid for dependent children, and food stamps. Approximately 60 non-union DSI employees occupy the third floor, an area which was completely renovated in 1990 with new carpeting, windows, painting of walls, and some asbestos removal. During this renovation, DSI employees continued to occupy the floor, and the ventilation systems were kept operational. The building is owned by the City of Covington, and a local real estate management company is responsible for providing routine maintenance and coordinating general service for the building.

Office Description

The DSI employees located on the third floor work as clerks, secretaries, case workers, data entry persons, and supervisors. Most employees work in cubicles with approximately five foot high partitions. Each cubicle is approximately 10 feet by 12 feet, carpeted, with a desk, computer terminal, and two chairs where clients sit while undergoing interviews. There were four groups of printers and photocopiers located on the third floor. Additionally, there were approximately ten enclosed areas (offices or conference rooms) around the perimeter of the floor with doors opening to the central work area. Secretaries who were located in the eastern one-third of the floor were situated at desks arranged in an open area (without cubicles). In the southeast corner there was a large public waiting area for clients. An employee eating area with a microwave oven was located in the northeast corner. Figure 1 shows the layout for the DSI offices on the third floor.

Ventilation Description

1. Outside Air Systems

Two air handling units (AHUs) serviced the third floor offices. These systems, which typically operated from 5:00 AM to 7:00 PM, were equipped with a Freon® cooling coil, a hot water heating coil, and air-side economizer systems and supplied air to the office space through ceiling-mounted 2 ft. x 2 ft. four-way diffusers. As shown in Figures 1 and 2, the larger AHU, a floor mounted model, serviced the office areas in the long leg of the building. The smaller AHU was a ceiling-mounted unit and serviced the areas in the short leg of the building. Both AHUs were located in separate rooms on the perimeter of the floor.

No mechanical plans on these two AHUs were available for review. Both had electronically-controlled economizer systems and the outside air (OA) dampers were set, according to the building mechanic, so that they remained at least 40% open. Control of the supply air temperature was via thermostats in the occupied space. Both systems used the ceiling plenum (the area between the suspended ceiling and the bottom of the floor above) for a common return air path. Egg-crate grilles located in the ceiling throughout the floor area allowed air from the space into the ceiling plenum. The larger air handling unit pulled return air from the mechanical room which was open to the ceiling plenum. The smaller air handling unit's had a return duct which extended into the ceiling plenum of the short leg of the building (but not directly connected to any return air grilles).

2. Recirculating Air Systems

Two ceiling-mounted, totally recirculating AHUs (no OA is introduced by these systems into the office space) provided a constant volume of air to the enclosed and open office areas along the south wall. These units, which also had Freon® cooling coils and hot-water coils, removed air from the ceiling space, conditioned it, and returned it to the office areas through ceiling-mounted 2 ft. x 2 ft. four-way diffusers. The recirculation units were reportedly added within the last two years as part of the previously mentioned renovation.

3. Other Comments

The main branch ducts were metal and not insulated. Flexible ducts (composed of plastic and spiral wire) connected the main branches to the diffusers. Each bathroom was equipped with a ceiling mounted exhaust fan ducted to the outside of the building.

Smoking Policy

Employees were permitted to smoke at their discretion in their office cubicles and employee breakroom. Non-smoking DSI employees could designate their immediate work space as "no smoking." Clients were permitted to smoke while on the floor.

EVALUATION CRITERIA

NIOSH investigators have completed over 1100 investigations of the occupational indoor environment in a wide variety of non-industrial settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported to NIOSH by 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. Typically, the work place 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.[14]

There are also reports describing results which show that occupant perceptions of the indoor environment are more closely related than any measured indoor contaminant or condition to the occurrence of symptoms.[15-17] Some studies have shown relationships between psychological, social, and organizational factors in the work place and the occurrence of symptoms and comfort complaints.[17-20]

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 environment have included poor air quality due to ventilation system deficiencies, overcrowding, volatile organic chemicals from office 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.[21-23] With few exceptions, pollutant concentrations observed in the office work environment fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[24,25] The ACGIH has also developed a manual of guidelines for approaching investigations of building-related complaints that might be caused by airborne living organisms or their effluents.[26]

Measurement of indoor environmental contaminants has rarely proved to be helpful in determining the cause of symptoms and complaints except where there are strong or unusual sources, or a proven relationship between a contaminant and a building-related illness. The usual low-level concentrations of particles and variable mixtures of organic materials found are troublesome to understand. However, measuring ventilation and comfort indicators such as carbon dioxide (CO_2), temperature and relative humidity, is useful in the early stages of an investigation in providing information relative to the proper functioning and control of HVAC systems.

Carbon Dioxide

Carbon dioxide (CO_2) is a normal constituent of exhaled breath, and if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. The American Society of Heating, Refrigerating, and Air Conditioning Engineers' (ASHRAE) most recently published Ventilation Standard, ASHRAE 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 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[24] Maintaining the recommended ASHRAE outdoor air supply rates when the outdoor air is of good quality, and there are no significant indoor emission sources, should provide for acceptable indoor air quality.

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million [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 also suggest that other indoor contaminants may be increased. It is important to note that CO_2 is not an effective indicator if the ventilated area is vacated or sparsely populated.

Temperature and Relative Humidity

Temperature and RH measurements were collected in the office because these parameters affect the perception of comfort in an indoor environment. The perception of thermal 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 acceptable.[25] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68-74^{o}F in the winter, and from 73-79^{o}F in the summer. The difference between the two is largely due to seasonal clothing selection. In a separate document (ASHRAE Standard 62-1989), ASHRAE also recommends that RH be maintained between 30 and 60 percent.[24] Excessively high RH can support the growth of microorganisms, some of which may be pathogenic or allergenic. Low RH, not uncommon in a heated building, may possibly cause the dryness of the skin, eyes and upper respiratory tract, which could result in irritative symptoms.

EVALUATION METHODS

Industrial Hygiene

Measurements for CO_2, dry bulb temperature, and RH were made during the work day on May 5 at 12 sites located throughout the third floor office area and outside the office building. Real-time CO_2 levels were determined using Gastech Model RI-411A, Portable CO_2 Indicator. This portable, battery-operated instrument monitors CO_2 via non-dispersive infrared absorption with a range of 0-4975 ppm, and a sensitivity of 25 ppm. Instrument zeroing (using a filter to remove CO_2 from the ambient air) followed by calibration using a known concentration of CO_2 span gas (800 ppm) was performed daily. Side-by-side CO_2 measurements were also made using a Gaztec® Telaire™ Model 1053 monitor at one of the sampling locations on the third floor. This device, which also measures CO_2 via infrared absorption technology, has data-logging capability. Real-time temperature and RH measurements were conducted using a Vaisala, Model HM 34, battery-operated meter. This meter is capable of providing direct readings for dry bulb temperature and RH ranging from -4 to 140^{o}F, and 0 to 100%, respectively.

Two bulk samples were collected on May 5, 1992, from two locations on the third floor and submitted for the quantitative determination of 30 different elements and for the microscopic analysis for fibers. NIOSH Sampling and Analytical Method No. 7300 (inductively-coupled plasma/atomic emission spectrophotometry) was used to analyze for metals and minerals. NIOSH Method No. 9002 (polarized light microscopy) was used to microscopically identify any fibers which may be present in these samples. One bulk sample consisted of several loose paint chips which had fallen on top of a suspended ceiling panel. The second bulk sample was dust collected from the return air damper of the larger AHU.

Medical

Private medical interviews were conducted with 12 employees who had had medical symptoms or complaints and were present during the site visit. The interviews attempted to identify problems or conditions in the workplace which may contribute to adverse health effects and to identify the medical symptoms experienced by the workers.

Ventilation

The two main AHUs and one of the two recirculating air handling units were inspected. The OA systems (main AHUs only), filtration systems, coils, and condensate pans were the major areas of concern for the inspection. In addition, the flexible duct (connecting the diffusers to the main branch duct), was removed in one location so the interior of the main duct could be examined for debris. An eight inch level was used to evaluate the tilt of condensate pans and drain pipes.

Air flows at the diffusers were measured using a Shortridge Flow Hood™ equipped with the 2 ft. x 2 ft. top frame assembly. Because this instrument compensates for local barometric pressure and air temperature, actual air flow measurements were made (as opposed to standard air flow). A smoke tube was used at the doors of all rooms on the third floor to determine whether the rooms were under positive or negative pressure (air flow out of or into the rooms, respectively). This information is useful in plotting the movement of contaminants inside a space.

RESULTS

Industrial Hygiene

1. Carbon Dioxide Levels

Table 1 shows the CO_2 levels measured at 11 different locations on the third floor. The measurements, taken throughout the work day, show a slight increase in CO_2 levels throughout the office. However, the highest concentrations measured (800 ppm) were below the 1,000 ppm guideline which NIOSH investigators use as an indicator of the adequacy of outside air supplied to occupied areas. Concentrations of CO_2 outside the building ranged from 375 to 425.

Results from a series of side-by-side measurements for CO_2 are shown in the Table 2. The data were collected throughout the day using two different direct-reading instruments at Location I on the third floor. The results from the Gastec Model RI-411A infrared analyzer were based on one-minute averages. The data shows very good correlation between the two instruments.

2. Temperature and Relative Humidity

Temperature and RH levels ranged from 74 to 76^{o}F and 35 to 39%, respectively. These conditions were within the operative temperatures recommended by ASHRAE to maintain a thermally acceptable environment for at least 80% of the occupants.

3. Bulk Sample Analysis for Elements and Fibers

Two bulk samples were collected and analyzed for various elements and for fibers. The results are shown in the following table.

Sample Type	Physical Appearance	Elemental Content[a]	Fibers Present
Settled dust from return air damper	Brown dust with white particles	Calcium, Iron, Aluminum, Magnesium, Sodium, Zinc	Cellulose (10-15%) Glass Fibers (<1%) Synthetics (2-3%)
Paint chips from above the suspended ceiling	Green paint chips with brown and ecru plaster	Calcium, Iron, Zinc, Magnesium, Aluminum, Sodium, Barium	Cellulose (<1%)

[a] Only the top six elements identified in each sample are listed from the highest to lowest percentage. In both bulk samples the major element identified was calcium (4 to 5%). Toxic *heavy* metals (such as lead, chromium, and cadmium) were not present in detectable amounts.

Medical

Private medical interviews were conducted with 12 current employees working on the third floor. Six worked in the secretarial area while the remaining six worked in cubicles in the middle portion of the floor. Symptoms most commonly associated with work were: (1) dry, irritated eyes; (2) headache; (3) runny nose and head congestion; (4) feeling of tiredness; and (5) dry skin.

The employees voiced strong concerns regarding the amount of cigarette smoke in the workplace. Most described smoke accumulation by the afternoon as being so heavy that it layered in the air just above the cubicles. They attributed this to the lack of a "*no smoking*" policy and to heavy accumulations of cigarette smoke from their clients. Eleven of the twelve described their work area as dusty or very dusty. Despite frequent cleaning, most described a layer of dust on their desks and VDT screens within 24 to 48 hours of cleaning. Most felt there was too little air movement by the ventilation system and the temperature was frequently too hot or too cold. The breakroom was described by many as dirty with odors or cigarette smoke. A few employees believed there were pigeons roosting inside the north wall of the breakroom. Despite their concerns, eleven of the twelve were very satisfied with their work.

Ventilation

The following results were obtained from an inspection of the AHUs located on the third floor on May 5, 1992.

1. Outside Air Systems

The OA inlet for the largest AHU was located in a side wall and was situated over the roof of an adjoining two story building. The OA inlet for the smaller AHU was located in another side wall approximately 30 feet above an adjacent parking lot.

There was no interior access to the OA intakes or dampers for either AHU. The OA inlet for the large AHU, however, could be seen from a window above the OA inlet. From this perspective there was no standing water visible near the OA inlet on May 5, 1992. However, debris on the roof near this inlet was observed, making standing water appear a possibility under wetter conditions. A water puddle was observed on the floor of the duct leading from the OA intake to the larger AHU. This AHU did have intact 1/2" hardware cloth covering the OA inlet. No visual examination was possible for the OA intake on the smaller AHU.

Both AHUs had economizer systems which were operable. The controls were maintained by a manufacturer's representative. The building mechanic was unsure of how the minimum OA air was set, and no holes were present in the ducts for measuring the amount of OA being introduced into the building.

2. Return Air Systems

The return air damper on the larger AHU, visible from the mechanical room, was heavily loaded with dust. The return air damper on the smaller AHU was not accessible. Judging from the damper motor movement, both dampers were operable.

3. Air Flow Measurements

As shown in Figure 2, the NIOSH investigators measured air flows averaging 216 actual cubic feet per minute (acfm) for the diffusers on the large AHU (range 65 to 434 acfm; standard deviation (SD) = 91 acfm). The measured air flows averaged 175 acfm for the diffusers on the smaller AHU (range 41 to 257 acfm; SD = 71 acfm). The wide range of air flow indicates that both systems were not balanced. Air flow into the perimeter offices in the short leg of the building was also less per diffuser than into the offices in the long leg of the building.

The design air flow for each diffusers serviced by the two recirculation units was 290 acfm. The measured air flows averaged 258 acfm for the diffusers serviced by the western recirculation unit (range 32 to 283 acfm; SD = 18 acfm). The measured air flows averaged 161 acfm for the diffusers serviced by the eastern recirculation unit (range 14 to 288 acfm; SD = 18 acfm). As in the case with the main AHUs, the wide range of the air flows indicates that these systems were also not balanced.

Total air flows for the large and small AHUs were 5506 and 1971 cfm, respectively. Assuming that the minimum OA is 40% of the total air flow, the number of persons who could occupy the space and still meet ASHRAE recommended criteria of 20 cfm of OA/person is 110 and 39, respectively. On the day of this survey, the largest number of people (employees + public) on the floor was estimated to be 39. Employees reported, however, that the number of people (primarily clients) was lower than anticipated.

Room pressure checks showed that some areas served as paths for air returning to the AHUs because the rooms were under negative pressure. Other offices were under positive pressure despite their having a return grille. Rooms which serve as a return path for other areas could have greater concentrations of contaminants or odors.

4. Filtration Systems

All air filters in all of the systems inspected on May 5, 1992, were in place with the exception of a filter which had become dislodged and was trapped against the upstream face of the cooling coil in the smaller AHU. Both of the main AHUs used cardboard-frame panel filters; however, the bypassing of unfiltered air was apparent on both AHUs based on the dust accumulation observed inside the filter frame and on the access door for each system. Filters for the larger AHU were accessible (with difficulty) through a small panel on one side of the unit. Access to the panel on the other side of the unit was not possible. Access to the smaller AHU was more difficult since the filter could only be reached from a ladder. Even with a ladder, the NIOSH investigator could barely fit between the AHU access panel and the wall of the mechanical room.

Filters on both recirculation units were the 1/2" metal-mesh washable type. While the filter access panels on the inspected unit were accessible (with a ladder), the actual filters were not removable because of an interference from a nearby ceiling beam and piping.

5. Accessibility of Cooling Coils and Condensate Pans

Access to the upstream face of the cooling coil on the larger AHU was only through the return air damper opening after the filters were removed. There was limited access to the downstream heating coil face and condensate pan of this system. Access to the downstream cooling coil face and the upstream heating coil face was not apparent.

Access to the upstream side of the cooling coil on the smaller AHU was also limited due to the mixed air duct entering the rear of the unit. Access to the downstream cooling coil face and the upstream heating coil face was through a side panel and could only be accomplished from a ladder. Even if the panel was removed, access was difficult because of obstacles such as armored cables and the lack of space between the unit and the wall.

Access to the upstream cooling coil face on the recirculation unit was only possible by removal of the filters. Since these filters were not removable (see previous section), the upstream coil face was not accessible. The downstream coil faces of the cooling and heating coils and the upstream side of the heating coil face on the recirculation unit were accessed (with a ladder) by removing side panels. However, the space between the heating and cooling coil was about 4 inches, making cleaning the coils difficult.

6. Condition of Cooling Coils and Condensate Pans

The upstream cooling coil face of the larger AHU was moderately dirty. In contrast, the upstream cooling coil of the smaller AHU had notable debris on the coil face, particularly in the area where a panel filter had become dislodged. The upstream cooling coil face of the recirculation unit, as noted, was not accessible.

All of the condensate pans which were examined in this evaluation had trapped drains and the drain lines were tilted away from the unit. In addition, all lines were wrapped with insulation to prevent condensation. The building mechanic reported that he cleaned the coils in all of the units at least once per year. Condensate pans on the downstream side of the cooling coils in the larger AHU were moderately clean. Some dry debris was observed (using a mirror) in the condensate pan of the smaller AHU. The condensate pan on the recirculation unit, which was tilted toward the drain, was free of debris.

7. Plenum Interiors

Since all of the ventilation systems on the third floor were pull through units, any loose interior insulation could be drawn into the fan, shredded, and possibly blown downstream and distributed into the occupied space. On inspection, the interior insulation on the larger AHU had some tears, with the worst damage observed on the access door liner where the insulation may have contacted water when the coil pan overflowed. Wood flooring beneath the front edge of the unit showed signs of water damage, also indicating past problems with an overflowing condensate pan. In addition, the insulation was not pinned and edges exposed to the air stream were not sealed. The insulation on the access panel of the recirculating unit was partially torn away from layers glued to the metal of the panel. The insulation in this unit was also not pinned and edges exposed to the air stream were not sealed.

8. Fans, Ductwork, and Ceiling Tiles

All fans were operating normally and no loose belts on the fans were apparent. Inspection of the duct system revealed a dust loading consistent with the age of the ductwork on the third floor. The dust loading did not appear to be heavy enough to be jarred loose and blown out or the diffuser.

Many of the diffusers on the third floor had a brown stain and some dust accumulation on their exterior surface. This staining was heavier toward the center of the diffuser. No stains or dust accumulations on ceiling tiles surrounding the diffusers was apparent. These observations along with the lack of significant dust accumulation in the ducts, suggests that the staining and dust accumulation result from activities in the space, such as smoking and people traffic.

During this NIOSH inspection, some dust was generated when a 2 ft. X 4 ft. ceiling tile was accidentally dropped. One employee reported later that afternoon that the dust had caused respiratory irritation similar to the time when the space was renovated. It was observed by NIOSH investigators that debris from the original ceiling above the suspended ceiling, consisting of paint chips, gypsum, and a concrete-like material, had accumulated on numerous ceiling tiles.

9. Employees' Restrooms

The exhaust fan in the men's restroom was not operating and this area was found to be under positive pressure (air being pushed from the restroom) on the day of the evaluation. The fan enclosure, as well as the one in the woman's restroom, was heavily covered with lint and dust. Furthermore, the fan in the men's restroom was ducted into a plenum above the women's restroom. A duct connected this plenum to a larger duct which connected to an exterior window above the OA intake of the smaller AHU. With this arrangement, recirculation of the restroom exhaust into the OA intake was possible. In addition, the connection of the exhaust ducts between the two restrooms creates a situation where exhausted air from one restroom could be blown into the other restroom if one of the exhaust fans should fail. In addition, dust streaks originating from the connection between the men's restroom's exhaust duct and the women's exhaust duct plenum suggested that exhaust air had been pushed into the surrounding ceiling plenum where it could be recirculated into the office areas.

DISCUSSION AND CONCLUSIONS

Reports from the Surgeon General and the National Research Council have concluded that exposure to environmental tobacco smoke (ETS) may be associated with a wide range of health (e.g. lung cancer) and comfort (e.g. eye, nose, and throat irritation and odor) effects.[27-32] NIOSH has determined that ETS may be related to an increased risk of lung cancer and possibly heart disease in occupationally exposed workers who do not smoke themselves.[33] During the initial site visit on April 29, 1992, NIOSH investigators were advised by employees and management that it was a "slow" day (fewer clients in the waiting area) and, therefore, the level of cigarette smoke was not as high as on other days. During the follow-up visit conducted on May 5, more clients were present on the floor. On both occasions clients in the waiting were observed smoking. Given the lack of an effective smoking policy in the DSI office, NIOSH investigators have concluded that exposure to tobacco smoke could explain many of the symptoms described by the DSI employees.

The complaints of tiredness, headache, and the perception of "stagnant air" (particularly in the afternoon), may be partially related to the unbalanced ventilation systems on the third floor. As noted, quantitative air flow measurements made by NIOSH investigators during this evaluation verified that the ventilation system was not balanced, suggesting that thermal comfort problems could occassionally exist.

Analysis of the bulk samples collected from the third floor did not identify the presence of any unusual or hazardous metals, minerals, or fibers which would warrant a special health concern. No asbestos was found in either sample. Although no air samples were collected during this evaluation for respirable particulates or fibers,[‡] potential dust exposure was a concern among many workers. According to DSI management and the building maintenance engineer, all asbestos containing materials had been removed from the building during previous renovations. Dust observed on the ceiling tiles, as well as from the inside the air handling units, can potentially enter the work space and irritate the eyes and respiratory tract of the occupants. The filters in the air handling units are only partially successful in filtering out particulates in the air.

‡ Respirable particulate levels in non-industrial work environments are typically far below any existing occupational exposure criteria. It was the opinion of the NIOSH investigators that personal breathing-zone or general area air sampling for respirable particulates was not needed to evaluate this office area.

While certain aspects of the existing ventilation system servicing the third floor appeared adequate (for example, based on the reported system settings there was sufficient OA being introduced to meet ASHRAE criteria), the absence of an effective smoking policy negated any benefits derived from the ventilation system. Additionally, employees also reported thermal comfort problems. Quantitative air flow measurements verified that the ventilation system was not balanced, suggesting that thermal comfort problems due to poor air distribution could occassionally exist. Circumstances contributing to such thermal problems might be solar heating along the south side of the office on a warm, sunny day.

Finally, employee exposure to pigeon droppings from birds nesting in the wall of the breakroom appears to be negligible. While exposure to bird droppings and feathers can cause illness, the walls in the breakroom appeared to be intact and dry. If pigeons are found on inspection, they could be removed and the wall properly sealed to eliminate this problem. In regard to the complaints of dirt, odors, and smoke in the breakroom, these could be remedied by increased housekeeping and elimination of smoking.

RECOMMENDATIONS

1. Exposure to environmental tobacco smoke is one of the most important indoor air quality problems, contributing both particulates and gaseous contaminants. With this in mind, the existing smoking policy (which permits employees to smoke at their work stations) should be changed. The use of air purifiers or "Smoke Eaters" is not effective in removing all the constituents of cigarette smoke from the air. A smoking cessation program may be necessary to assist those employees who are current smokers.

   If smoking is permitted, it should be restricted to designated smoking lounges.[34] These lounges should be provided with a dedicated exhaust system (room air directly exhausting to the outside), an arrangement which eliminates the possibility of re-entrainment and recirculation of any secondary cigarette smoke. In addition, the smoking lounge should be under negative pressure relative to surrounding occupied areas. The ventilation system supplying the smoking lounge should be capable of providing at least 60 cfm of outdoor air per person.[‡‡] Clients should not be permitted to smoke in the work areas, including the waiting areas, since DSI employees would also be exposed to smoke from this area. This should be posted and enforced.

2. Since the last site visit to this office, several DSI employees have contacted NIOSH and expressed their increasing concern with the integrity of the walls and ceiling on the third floor. According to these workers, on at least two recent occasions (June 12 and 18, 1992) sections of the wall and/or ceiling have fallen. These pieces have been large enough to break through one or more of the ceiling panels. This was not an item which NIOSH investigators examined during two site visits to the building, so DSI management should obtain an independent evaluation of this area to determine if a problem exists with the plaster coating

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‡‡ This air can also be obtained from the surrounding spaces (transfer air) if it is relatively uncontaminanted.

which comprises the walls and ceiling. Results from this evaluation should be shared with all interested employees.

3. Air flows from the diffusers should be balanced according to design or current parameters. If the required flows are unknown, a mechanical firm should be consulted to develop air flow recommendations. Balancing of the air flow should be performed by a person certified by the National Environmental Balancing Bureau (NEBB) or an equivalent organization. The balancing work should be supervised by the building mechanic or other representative.

4. Outside air flows should be measured at the minimum outside air damper position to assure that rate of outside air meets current ASHRAE criteria. Periodic checks of the damper operation should be made to assure that the minimum damper position does not change.

5. Interior insulation in all air handling units should be inspected for tears or loose panels. Damaged insulation should be repaired or replaced to prevent the insulation from tearing off and entering the workspace. Edges of the insulation exposed to the air stream should be sealed to prevent shedding of fiberglass fibers or tearing of the insulation.

6. The dampers and interiors of the air handling units should be cleaned to remove any dust accumulations. Cleaning should be performed with the units not working and at a time when the floor is not occupied. A high-efficiency particulate air (HEPA) vacuum should be used for initial dry vacuuming, followed by a wet-cleaning. Any puddles remaining from wet-cleaning should be vacuumed up using a wet-dry vacuum. All chemical cleaners should be allowed to dissipate before the units are placed in operation.

7. The frequency and extent of housecleaning should be increased, with emphasis on the employees' breakroom.

8. The current filtration efficiency for all AHUs should be upgraded to a system which uses filters that are at least 35% efficient (according to the ASHRAE dust spot test) and does not allow bypassing of the filters. A more effective filtration system will lower the particulate levels in the office. Consideration should be given to removing the dust and debris currently on the top surface of the ceiling tiles. The current dust and debris has a chance to enter the workspace without being filtered out by the air handling system.

9. Supply and return diffusers should be periodically cleaned to remove visible stains, dust, etc.

10. The exhaust system for the bathrooms could be replaced with a central system which has a single fan ducted to all bathrooms. In addition, the exhaust system should be designed to maintain the bathroom under negative pressure in relation to the office areas. This exhaust system, if properly designed, could be connected to a smoking lounge area.

11. Access to the two main air handling systems should be improved to make maintenance easier and safer. Access panels or doors should be placed in the units, where needed, to provide easy access to the dampers, coils, filters, fans, and other critical components.

12. To help ensure a more comfortable environment, temperatures at various locations should be monitored over time to determine how well the HVAC system controls the temperature. The system should be able to maintain the temperature within plus or minus 1 degree. If the system doesn't, the reason for the change should be investigated first by the controls firm to rule out a control problem. If the problem is not control related, then a mechanical firm may need to investigate the problem. In resolving any problems, condensation on the ductwork from lowering of the supply air temperature should be considered because the ductwork is not lined.

13. Any pigeons present within the building should be removed and the outer and inner walls sealed to prevent their re-entry.

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