October 26, 2000
HETA 99-0324

Mr. Gary Peacock
U.S. Department of Interior
1849 C Street, NW
Washington, DC 20240

Dear Mr. Peacock:

On August 20, 1999, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request to evaluate various symptoms (including sinus infection, respiratory problems, eye irritation, and burning in the chest and nose) and their possible relationship to environmental factors in the U.S. Department of the Interior (DOI) Main Building in Washington, D.C. Specific concerns included smoke from a food smoker in the cafeteria entering the building ventilation system through the outside air intakes, microbial contamination of water reservoirs, and water treatment chemicals used in the air-conditioning system and cooling tower.

In response to this request, we visited the Main Interior Building (MIB) on September 13-14, 1999 and September 27-28, 1999. We also reviewed a report, "Extended Scope Investigation of Rooms 6611 through 6615" prepared by Mantech Environmental Corporation.[1] This letter describes our findings, interpretations, and recommendations. A one page summary is enclosed with this letter.

BACKGROUND

The DOI Main Building is a large government office building covering two city blocks. Below ground is a basement housing a cafeteria and parking garage, as well as office and mechanical space. Above the basement rises an eight-story structure consisting a six wings with a large, office-lined, central corridor. Seven floors are occupied office space, accessible to the public and employees. The air handlers and main, horizontal, distribution ductwork for the ventilation system occupy an entire floor between the fifth and sixth floors of office space. Built in the 1930's, before the development of the modern heating, ventilating and air-conditioning (HVAC) systems, the building has an air-conditioning system which uses an established technique for that time, passing the supply air through a chamber showered with a water mist to clean the air and control its temperature and humidity.

In June of 1984, NIOSH conducted a Health Hazard Evaluation of a wing on the 6th floor of the MIB in response to reports of eye irritation and other eye problems. Medical complaints by building occupants go back at least to 1979, when some of these workers first reported eye problems.[2] Discovering insufficient amounts of outdoor air being brought in by the HVAC system, NIOSH concluded that irritative symptoms could possibly be related to inadequate ventilation. Although elevated levels of bacteria were present in the supply duct downstream of one of the air handlers, low levels of bacteria and fungi were found in the rooms occupied by workers. The levels of asbestos fibers in the air in the rooms were also low. Air temperatures and relative humidity were too high in some rooms.

Concerns about indoor environmental quality in the MIB have continued since 1984. In less than a 2 year period prior to this most recent NIOSH investigation, at least 32 different documents were written about some aspect of the indoor environment in the MIB. According to a summary of these documents, written by the Safety and Occupational Health Manager of the U.S. Department of Transportation, the content of the documents focused on the HVAC system design and operation, aspects of perceived and measured air quality, and carpet dust sample results. She concluded that water intrusion had caused many of the problems, including fungal contamination of the carpet; that soot was present throughout the ductwork; and that during certain periods and in certain locations, air quality was unsatisfactory.

The report of the *Extended Scope Investigation of Rooms 6611 through 6615*, conducted by ManTech Environmental Corporation from December 12, 1998, through January 29, 1999, noted that all carpet dust samples yielded "fungi-of-concern" up to half the total sample, including *Penicillium, Aspergillus flavus, A. fumigatus, A. niger, A. sydowii, A. versicolor, Mucor,* and *Pithomyces chartarum*. However, samples from Room 6614 contained higher levels of *Penicillium, Aspergillus flavus,* and *Mucor*, than samples from other locations. Additionally, the front office space of Room 6614 yielded the highest bacterial dust sample. ManTech reported that of all carpet dust samples collected in this building over a 2-year period, the samples collected in December 1998 in Rooms 6614 and 6615 rank in the top 10% for highest concentrations of total fungi of concern, especially *Aspergillus flavus, A. versicolor, A. fumigatus,* and *Penicillium*. Additionally, results of the bacteria-in-carpet dust samples revealed a very high (approximately 200,000 colony forming units per gram) concentration of thermophilic bacilli. ManTech pointed out that since the carpet was reportedly replaced about a year before their investigation, the high levels of fungi-of-concern may have indicated that the spores survived in the adhesive and cork substrate. In their report, ManTech recommended replacing the carpet in this area and replacing or disinfecting the carpet substrate at the same time. They also recommended that the carpets be vacuumed regularly with a vacuum cleaner equipped with a rotating beater brush and a high efficiency particulate air (HEPA) filter, and that the carpets be professionally cleaned periodically.[1]

The ManTech report generally found the indoor airborne fungi and bacteria levels to be no greater than outdoor samples. Exceptions were levels of *Penicillium* fungi in Rooms 6613/11 and 6615.[1]

We were also concerned with the possibility of bacterial overgrowth, especially *Legionella*, in the water reservoir for the air-conditioning system. To prevent bacterial overgrowth from occurring, biocides have been added to the water monthly. The compounds that have been added (and their health effects according to the manufacturers' MSDS) included: Spectrus NX114, which is composed of 2-bromo-2-nitropropane-1,3-diol (an eye irritant and potential skin sensitizer), magnesium nitrate and magnesium chloride (both potential irritants) and 5-chloro-2-methyl-4isothiazolin-3-one (a corrosive, skin sensitizer, and toxin by ingestion and skin absorption), and Betz Entec® 345A, which is composed of 2,2-dibromo-3-nitrilpropionamide (corrosive to the eyes and a potential sensitizer) and sodium bromide (an irritant).

In addition to the biocides, surfactants and anti-corrosives have been added to the chilled water system monthly to prevent corrosion of the pipes. These included: Steamate®, an anticorrosive compound composed of deithylaminoethanol (DEAE) and cyclohexamine (both of which are irritants0, and Betz Entec 329, a dispersant composed of nonylphenoxypoly (ethyleneoxy) ethanol (an eye irritant).

Other potential sources of irritant exposures were noted in the building, such as a meat smoker used daily in the cafeteria kitchen to prepare chicken with a smoked flavor and wood-burning fireplaces in some executive offices. Although the smoke from these sources was conveyed out of the building through roof-top vents and chimneys, there was concern that some of the smoke could reenter the building's ventilation system.

METHODS

We conducted a limited medical evaluation and a ventilation/indoor environmental quality (IEQ) assessment. These included a walk-through tour of the building, discussions with safety staff, confidential employee interviews, a review of mechanical drawings of the building's ventilation systems; observation of air movement, environmental sampling and measurement of IEQ parameters.

Medical

On September 13th and 14th, thirteen employees – eleven women and two men -- were interviewed by the NIOSH medical investigator. The interviews consisted of all employees from the 6th floor with known symptoms, and were arranged by the requestor and building management. In addition, interviewed employees were asked if they were aware of any other persons with similar symptoms who were willing to be interviewed. These employees also were interviewed.

Environmental

During the afternoon of September 27th, the direction of air movement was visualized (with a thin trail of a chemical "smoke" from a small glass tube about the size of a ball-point pen) at the doorways to the basement courtyards, to the parking garage, to the recycling center, to the cafeteria, to the tunnel, and at a main entry door in the front lobby. Wipe samples of soot were collected from the inside surface of the hood above the food smoker, from horizontal surfaces in four offices (1222, 1223, 6614 and 6628B) and from surfaces inside the outside air intake plenum and bypass duct for two air handlers (2EN and 6ES) to be analyzed for organic and elemental carbon and for polynuclear aromatic hydrocarbons. NIOSH Method 5040[3], which is based on a thermal-optical technique, was used to quantify the carbon types in the soot samples. High-pressure liquid chromatography, using NIOSH Method 5506[3], was used to determine the presence and composition of polynuclear aromatic hydrocarbons associated with the soot particles.

Air in the kitchen near the food smoker, in Room 6614, and in the Loading Dock area, was analyzed for aerosolized particle size distribution using a Grimm model #1.105 (Grimm Labortechnik GmbH & Co. KG, Ainring, Germany). Water samples were collected from air-washer reservoirs and the cooling tower sump and were analyzed for different species of *Legionella* bacteria, total bacteria and endotoxins. Water samples were also collected from a lavatory cold water tap to provide background data for the building water supply.

During the morning of September 28th, temperature, relative humidity and carbon dioxide (CO_2) were measured at a number of locations throughout the building using a TSI Q-Trak instrument (TSI Instruments, Inc. Minneapolis MN). The concentrations of CO_2, carbon monoxide (CO), and volatile organic compounds were measured at a number of locations and times throughout the day using a B&K 1302 Multi-Gas Monitor (Bruel and Kjaer, Naerum, Denmark).

RESULTS

Medical

The most prevalent symptoms experienced on the job by the interviewed employees were headache; stuffy or runny nose; sinus problems; skin rash or itching; central nervous system symptoms, including concentration problems, "brain fog," or lightheadedness; and hoarseness. Some employees also reported sore throat, eye irritations, and asthma. Employees did not report decreased symptoms during any season.

Environmental

One employee reported that the work area smelled of smoke from the food smoker, even though the work area was many floors above and on the other side of the building from the kitchen. In the kitchen, we observed that, when the smoker was opened, a large amount of smoke was released from the unit. This smoke was mostly removed by a ventilated hood over the unit or by exhausts in the kitchen. According to building management, the hood was exhausted directly outside the building through a short stack on the roof. We examined the location of this kitchen exhaust discharge on the roof. There was no stack. The discharge was less than 4 feet above the surface of the roof on the west side of the building. Prevailing winds with a westerly component, common for this region of the country, could carry the exhausted smoke in the direction of the outdoor air intakes for the ventilation system serving the portion of the building in which the smell of smoke was detected.

Air Movement

Visualizing the direction of air movement inside the building showed that airflow was out of the building at all tested locations. This outward movement indicated that unfiltered, unconditioned air was unlikely to enter the building through open windows or cracks around windows and doors.

Soot

The food smoker soot sample was difficult to evaluate because the sample was overloaded with soot. The reported carbon loading, almost entirely organic carbon, was so high that it exceeded the linear range of the detector used for the laboratory analysis. The other eight wipe samples for soot consisted of unevenly deposited, loose particles. Quantitatively, three of the office samples had between 80 and 85 percent organic carbon. One office sample, with a similar profile of carbon composition to the other three, was reported to have 100 percent organic carbon because, during the analysis, the filter transmittance did not return to the initial value until all of the carbon had been oxidized from the filter. The other four samples, taken from the outside air plenum and bypass ducts, consisted of over 98 percent organic carbon, also with similar profiles of carbon composition.

In a separate analysis, no polynuclear aromatic hydrocarbons were detected in any of the soot samples. Detection limits were less than 1 microgram per sample.
Appearance times of the peak values of particle counts in Room 6614 were not synchronized with peaks of particle counts recorded in the kitchen. No correlation of particle size distribution was noted among the various peaks.

Temperature and Humidity

Except for readings in the kitchen, the indoor temperatures on September 28th ranged from 68°F in room 6628B at 9:00 a.m. to a high of 75°F at the north entrance at 6:30 a.m. and relative humidity ranged from 53% at the north entrance at 10:45 a.m. to 70% in Room 1223 at noon. In the kitchen, temperatures ranged from 74°F to 83°F; relative humidity ranged from 40% to 51%.

Indoor Air Quality

Indoor CO_2 levels were in the 400 ppm - 650 ppm range, except for two samples in the kitchen on September 28th: 900 ppm at 10:13 a.m., and 2100 ppm at 10:17 a.m. No measured values of CO concentration were greater than 1.4 ppm, far below the NIOSH recommended time-weighted average exposure limit of 35 ppm. The highest individual value, 1.4 ppm, was measured in the kitchen at 10:10 a.m. on September 28th.

Bacteria

Some water samples were analyzed for total culturable bacteria and other water samples were specifically analyzed for *Legionella*. All four samples from the 6ES airwasher reservoir had from 100,000 to 400,000 colony-forming units per milliliter (cfu/ml) of Gram-negative rod bacteria, and all four samples from the cooling tower had from 10,000 to 70,000 cfu/ml of Gram-negative rod bacteria, and one sample also had 2700 cfu/ml of Gram-variable rod bacteria, no species identified. There was no growth of bacteria in the four samples taken from the water tap in room 1222.

Some species of *Legionella* other than *L. pnuemophila*, were detected in two of four water samples from the 6ES airwasher reservoir. No *Legionella* species were isolated from the other two airwasher samples or three tap water samples from room 1222. However, three of the four water samples from the cooling tower contained *L. pnuemophila*, and the fourth contained some species of *Legionella* which could not be identified by serogroup typing.

Water samples were also analyzed for endotoxins. The four samples from the cooling tower contained from 340 to 480 endotoxins units per milliliter (EU/ml); the four samples from the airwasher reservoir contained from 85 to 97 EU/ml; and four samples from the tap water in room 1222 contained from 10 to 13 EU/ml.

DISCUSSION

There are possible sources of substances that may have contributed to some of the symptoms reported at the DOI Main Building. The water spray in the air-conditioning system may convey aerosolized water treatment chemicals, bacteria and/or endotoxins from the water reservoirs, and fungi may be released from the carpet and/or other sources. A fine, black soot of unknown origin covers horizontal surfaces in many offices. Smoke from the meat smoker and/or a wood-burning fireplace may add chemical substances or particulate matter to the air drawn into the outside air intakes of the ventilation system. Finally, low relative humidity is common in buildings during the heating season.[4]

Water Treatment Chemicals

Employees were concerned that they had a long-term exposure to chemicals added to the air-conditioning

water reservoirs. Air-conditioning of the building is accomplished by passing air through a water spray in large air-washer units. Water treatment chemicals are added to the water in the air washers, and the mixing of the ventilation air with the water in the air washers creates a possible exposure hazard for the building occupants. These water treatment products – NX114 (and NX102) and DN303 -- contain biocides, surfactants and anti-corrosives which may irritate mucous membranes and eyes.

For the chemicals in the air-conditioning system to be a constant long-term problem, there would need to be a year-round exposure to the water in the air-conditioning system. However, the ventilation air does not pass through the air washers in the winter, and employees did not report decreased symptoms during that time, so the role played by water treatment chemicals in symptom generation or exacerbation is not clear.

It is unlikely that exposures from the cooling tower water are contributing to employee symptoms. Although it is possible that water spray from the cooling towers could be drawn into some outdoor air intakes for the building ventilation systems, depending on the speed and direction of the prevailing winds, airborne concentrations of water treatment chemicals would be greatly diluted and, thus, less likely to cause symptoms. Also, since the cooling tower is not operated during the winter, symptoms occurring during this time would be unrelated.

Bacteria

Legionnaire's disease, a form of pneumonia, and Pontiac fever, a flu-like illness, are both caused by *Legionella pneumophila*, a bacteria present in the cooling tower reservoir water on the roof of the DOI Main Building. Other species of *Legionella,* found in the HVAC air washer reservoirs, as well as the cooling tower water, could cause other forms of legionellosis (the general term for diseases caused by *Legionella* bacteria) in susceptible individuals.[5]

It is not uncommon to find *Legionella* bacteria in cooling tower water, and this finding often is not associated with disease. Interviewed employees did not report a pattern of symptoms suggestive of either Pontiac fever or Legionnaire's disease, nor has there been any documented cases. Moreover, *L. pneumophila* was not found in the air washer reservoirs, and the ventilation air does not pass through the air washers in the winter.

Although fungi and bacteria were found in the carpet by a consultant, the relationship between these findings and employee symptoms is uncertain. Many microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an ample supply of a nutrients. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can increase in number. Through various mechanisms, these organisms can then be spread through the air, water, and solid objects as individual cells or in association with soil, dust or water particles. In the outdoor environment, the numbers and types of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. In a "normal" indoor environment, the numbers and types of microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. Generally, the indoor levels are expected to be below the outdoor levels (depending on HVAC system filter efficiency) with a consistently similar composition of microbial species.[6,7]

Some individuals have an allergic reaction to one or more types of airborne microorganisms. The potential for allergic reactions may be inherited, at least in part, from one or both parents.[8] Individuals vary in their

susceptibility to allergic sensitization. In affected persons, the symptoms may include one or more of the following: episodes of sneezing; itching of the nose, eyes, palate, or throat; nasal stuffiness; "runny nose"; postnasal drainage. prolonged wheezing; progressive shortness of breath with or without weight loss: difficulty breathing; coughing; low-grade fever; chills; and feeling a general sense of weariness or discomfort.[9,10,11]

Most of the time, no particular disease can be identified. Many of the symptoms listed above are general in nature and may have many possible causes, such as the common cold or breathing air which does not contain enough humidity. The levels of the agents causing the symptoms may vary considerably from one day to the next, and some individuals may be affected one day, but then not for a few days or weeks or months or, possibly, never again.

Acceptable levels of airborne microorganisms have not been established, primarily because there are no standardized procedures for collecting and analyzing samples or interpreting the results; allergic reactions can occur even with relatively low air concentrations of allergens; and individuals differ in unknown ways with respect to susceptibility to the vast array of microorganisms.[12]

Soot

The soot in the ducts and on horizontal surfaces in many offices may be related to the irritant symptoms. One theory was that soot may be coming from combustion sources such as the food smoker in the cafeteria or wood-burning fireplaces. However, a quantifiable relationship between the soot in the offices, air handler ducts and the food smoke exhaust hood was neither proven nor negated during the survey. The soot may also have accumulated in the ducts over the many years of operation of the HVAC system.

Most of the carbon in the soot samples was organic, indicating that the contribution from diesel exhaust was small. The carbon profiles of the office soot samples are similar to the carbon profiles of the ventilation system soot samples, indicating that they may have come from the same source. The profile of the food smoker soot sample appears somewhat different from the others; however, some of the differences could be due to the overloading of the sample. Thus, the results do not prove that the soot in the offices came from the smoker, only support the conclusion that wood smoke is a possible source.

Substances in the wood smoke from the food smoker may cause health problems if the exhaust enters the work space. Wood smoke may contain the carcinogen benzo[a]pyrene as well as other polynuclear aromatic hydrocarbons.[13,14] When the door to the food smoker was opened, a substantial amount of smoke escaped. Almost all of this smoke was captured by the exhaust system in the kitchen. This exhaust was discharged on the roof. Because the discharge point is so close to the roof surface (within 4 feet), the exhaust would not escape the rooftop air recirculation region; and some of the exhausted smoke may be drawn into some of the outside air intakes for the building ventilation systems, depending on the speed and direction of the prevailing winds.[15]

Although the wood-burning fireplaces were not investigated, the same would be true for smoke from a wood-burning fireplace. Fireplace smoke could be a source of both the soot and the airborne substances causing mucous membrane and eye irritation during the cool months of the year from autumn to early spring.

Prevailing winds in the mid-Atlantic region of the United States often have a westerly component, coming

either from the southwest, due west or northwest. The kitchen exhaust is located on the west side of the building, and wood-burning fireplaces are located in the southwest corner of the building. The possibility of smoke entering the outside air intakes of a building ventilation system clearly exists, even though this was not demonstrated on the day of the survey.

Temperature and Humidity

Except for readings in the kitchen, the indoor temperatures ranged from 68°F in room 6628B at 9:00 a.m. on September 28th, to a high of 75°F at the north entrance at 6:30 a.m. and relative humidity ranged from 53% at the north entrance at 10:45 a.m. to 70% in 1223 at noon. In the kitchen, temperatures ranged from 74°F to 83°F; relative humidity ranged from 40% to 51%. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommendations for temperature and relative humidity are 70-74°F with 20-30 % RH in the winter and 74-78°F with 50-60 % RH in the summer.[16] Considering that this survey was conducted during a transition from summer to winter, a range of 72-76°F with 35-45 % RH might be appropriate. Applying the ASHRAE range of desired values, some of the temperatures were too cool at times and all measured relative humidity values were too high. *(Note that the ManTech report documented low relative humidities during measurements taken in January, 1999.[1])*

Winter heating usually results in low relative humidity in the heated space. The dry air can contribute to dehydration and discomfort and cause injury to skin, eyes, nose, throat, and mucous membranes. These dry tissues may be less resistant to infection. While the low humidity may not have a direct pathological effect, it may be a factor contributing to disease.[4]

Indoor Air Quality

CO_2 concentrations less than 1000 ppm are expected for office space where light work is performed[17]. *(Note: NIOSH recommends 800 ppm as a trigger value to evaluate ventilation system operation and adequacy.[18])* The fact that all measured CO_2 concentrations, except two measurements in the kitchen, were less than 800 ppm indicates that, generally, an adequate amount of outside air was being supplied for the (number of) occupants in the offices.

CONCLUSIONS

Environmental conditions at the DOI Main Building may account for some of the symptoms reported by employees in the building. Not only is there a risk of bacteria and endotoxin exposure from the use of chilled water spray to provide air-conditioning for the building, but also the use of biocides, surfactants and anti-corrosives in the water reservoirs may cause mucous membrane and eye irritation. The carpet and its substrate may be sources of fungi, especially in Rooms 6614 and 6615. The fine black soot present in many of the offices may be irritating to mucous membranes and eyes. The duct work in the building dates back to approximately 1936 and may be a possible source of accumulated soot. Smoke from a food smoker in the kitchen and wood-burning fireplaces could enter outside air intakes for the building's ventilation system and be another possible source of substances irritating to mucous membranes and eyes. The low relative humidity during the heating season may cause eye and mucous membrane irritation and increased susceptibility to respiratory infection.

RECOMMENDATIONS

1. Clean and disinfect the cooling tower at least twice a year using the "Wisconsin Protocol" or an equivalently effective procedure. Consult the OSHA Technical Manual on Legionnaires' Disease, paragraph V. B. 5 for details. (Note: the other paragraphs in section V. B. contain information on the design and operation of cooling towers, condensers and fluid coolers; and section V. E. contains information on the design and operation of HVAC systems.)[5]

2. Whenever water reservoirs are treated with chemicals, add the chemicals Friday evening or Saturday morning; then run the ventilation continuously for the remainder of the weekend to dissipate the high concentrations of the chemicals in the air. Post signs throughout the building at least a week in advance and during the water treatment process to inform building occupants.

3. Extend the height of the kitchen exhaust discharge. A ventilation engineer with experience in this area should be consulted to specify the height and diameter of each stack. Auxiliary fans may be needed to increase the velocity of the smoke exhaust plume to propel it vertically above the air recirculation zone on the top of the roof. These auxiliary fans, which use unconditioned air on the top of the roof, do not add to heating or air-conditioning air requirements.

4. Future renovations should include an HVAC system that does not involve a recirculated water spray and does not require the addition of water treatment chemicals. During the installation, relocate the outside air intakes as much as possible to the west face of the building.

5. When installing a new HVAC system, carefully consider heating season humidification. If humidification is installed, consider "dry-steam" humidification using non-recirculated water with properly designed and regularly maintained condensation collection/drainage.[19]

6. Vacuum all carpets regularly with a vacuum cleaner equipped with a rotating beater brush and a high efficiency particulate air (HEPA) filter, and follow the ManTech recommendation to periodically have the carpets cleaned professionally.[1]

7. Clean the existing ductwork to remove as much soot as possible without disturbing the asbestos inside and around the ductwork.

8. Replace wood-burning fireplaces with gas fireplaces.

We hope the information in this letter is helpful. This letter closes our investigation. For the purpose of informing the affected employees of our determination as required by the Occupation Safety and Health Act of 1970, you are [the employer is] required to promptly post copies of the report for a period of 30 calendar days at or near their workplaces. If you have any questions, please do not hesitate to contact us at (513)841–4307 (Mr. Mortimer) or (513)841-4585 (Dr. Malkin).

Sincerely yours,

Vincent D. Mortimer, P.E.
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cc:
Confidential Requestor

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HETA 99-0324(Close-out)
SIC Code: SIC 9512
Key Words: IAQ, indoor environmental quality, ventilation, smoke, soot, Legionella, respiratory problems, eye irritation, air washer, carpet dust biocides, surfactants, anti-corrosives.
Toxicity Det: Undetermined