HETA 92-180-2246
AUGUST 1992
OHIO STATE AUDITORS OFFICE
SHARONVILLE, OHIO

NIOSH INVESTIGATORS:
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I. SUMMARY

On March 18, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Sharonville, Ohio, Department of Health, to conduct a Health Hazard Evaluation (HHE) at the Ohio State Auditors Office in Sharonville, Ohio. The Health Commissioner asked that NIOSH assist with the identification and source of an odor in the State Auditors Office.

On March 26, and March 30, 1992, NIOSH investigators collected general area air samples for volatile organic chemicals (VOCs) within the State Auditors Office located on the ground floor, in an office on the second floor of the building, and in the adjacent office suite. An HNu® Photoionization Analyzer (Model PI 101) was also used to locate sources of VOCs within the office and hallway areas of the building. On April 9, 1992, NIOSH investigators returned to conduct employee interviews and further sampling using the HNu® photoionization analyzer.

Several of the seven employees interviewed reported that they had occasionally noted a petroleum-like odor when they first moved to the office in August 1991, but most first noticed the odor in the late fall. When questioned regarding specific symptoms experienced while at work during the preceding month, 5 employees reported frequently experiencing one or more symptoms (headache, eye irritation, fatigue, etc.). In general, the symptomatic respondents felt that symptoms were more severe on days when the odor was stronger and that symptoms were more likely to occur after spending several consecutive days in the office.

Results indicated that the air contained a complex mixture of hydrocarbons ranging from C_4 - C_{12} and that the total airborne hydrocarbon concentrations within the State Auditors Office, on March 26 and March 30, 1992, were much greater than total airborne hydrocarbon concentrations in the adjacent ground floor office and in one office suite on the second floor office of the building. On March 26, a total airborne hydrocarbon concentration of 7.5 milligrams per cubic meter (mg/m^3) was found in the conference room, and on March 30, a total airborne hydrocarbon concentration of 17.5 mg/m^3 was found in the conference room.

The results of measurements using the HNu® Photoionization Analyzer showed that airborne VOC concentrations within the State Auditors Office ranged up to 160 parts per million and were greater than measured VOC concentrations outdoors or in other office suites. VOC concentrations detected at a gap between a sewer drain pipe and the concrete floor, and at the east wall/floor gap in the conference room, were much greater than anywhere else inside the Auditors Office, including inside the sewer drain piping, ruling out sewer gases as the source of the odor.

In addition to the NIOSH investigation, the building management retained the services of an environmental consulting firm to conduct a subsurface investigation of the property. The firm concluded that the "soils beneath the site appear to be contaminated with

petroleum hydrocarbon" and that further investigations should be conducted to "define the limits of the contamination."

The air sampling data collected during this investigation suggests that the subsurface of this property may be contaminated with a complex mixture of hydrocarbons and indicates that the mixture is volatilizing and is most likely entering the building through cracks and gaps in the concrete flooring and foundation. The data showed that instantaneous measurements of volatile organic chemical (VOC) concentrations in the Auditors Office suite ranged up to 160 parts per million (ppm) with TWA concentrations of total airborne hydrocarbons ranging from 5.9 to 17.5 milligrams per cubic meter (mg/m^3). The TWA concentrations of total airborne hydrocarbons found in the Auditors Office are far less than the relevant standards for industrial exposures; however, the concentrations detected are more than 20 times greater than airborne concentrations detected in two other office suites located in the building. While there is inconclusive evidence that the employee symptoms are due to the total airborne hydrocarbon and VOC concentrations found, there is one study which showed that test subjects exposed to solvents, in chamber studies, at levels comparable to those found in the Auditors office experienced symptoms similar to those reported by the employees in this evaluation. Therefore, it is recommended that further soil studies be conducted to determine the source of the contamination and that efforts be initiated to lower the concentration of total airborne hydrocarbons and VOCs in the office space. RECOMMENDATIONS are contained in Section VIII of this report (please see pages 11-12).

KEYWORDS: SIC 9199 (General Government, Not Elsewhere Classified), IAQ, hydrocarbons, VOCs, underground storage tanks, UST.

II. INTRODUCTION

On March 18, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Sharonville Department of Health, to conduct a Health Hazard Evaluation (HHE) at the Ohio State Auditors Office in Sharonville, Ohio. The Health Commissioner asked that NIOSH assist in locating the source and identifying an odor in the State Auditors Office.

On March 26 and 30, 1992, an environmental evaluation was conducted. Samples were collected to qualitatively screen and identify airborne volatile organic chemicals (VOCs) present in the general workroom air. On April 7, 1992, the results of air sampling were verbally reported to representatives of the building management, the State Auditors Office, and the Sharonville Health Department.

On April 9, 1992, NIOSH investigators returned to conduct employee interviews and to collect more air samples.

III. BACKGROUND

In August 1991, District IV, Southwest Region of the Ohio State Auditors Office was relocated from an office building in downtown Cincinnati, Ohio to its present location in Sharonville, Ohio. The State Auditors Office is responsible for conducting audits of State and Local Governmental Agencies in the seven- county area near Cincinnati, Ohio. The permanent office staff consists of the district audit manager, a secretary, and four Medicaid compliance officers. These six employees spend most of the 40-hour work week in the office. A field staff of 55 employees reports to the office on a weekly basis; however, most spend only a few hours per week in the office. Six of the 55 field staff are supervisors who spend one to two days per week in the office.

The State Auditors Office is presently located in the south building of a two-building rental office complex. The structure is built on a graded lot and the eastern half of the office is located below grade level. The Auditors Office currently occupies the southernmost suite of the ground floor.

The building is constructed of brick, with all electric utilities. Each office suite is equipped with a dedicated heating and cooling system. A Carrier® heat pump is used for heating and cooling the State Auditors suite.

The air handling unit (AHU) for the heat pump is located in a closet in the middle of the suite and contains a coil, fan, and electric heating element. Return air enters the base of the AHU through floor level openings in the plenum and adjoining walls of the closet. The outside air intake is located on the south side of the building about 8 to 10 feet above the pavement. Outside air is provided through a six-inch air duct connected to the AHU and enters the AHU through another face of the plenum.

Water from the cooling coil condensate pan drains to a small sump pump. The sump pump outlet was connected to a sewer pipe located in the closet. This pipe ran from the floor of the suite on the second floor through the floor of the Auditors Office suite. A

cleanout was located in the sewer drain pipe about 3 feet above the floor. Plumbers putty and oakum were used to seal the gap between the sewer drain pipe and concrete floor slab.

In the late fall of 1991, employees began to notice a "petroleum" like odor, which continued to worsen with time. In January 1992, the Sharonville Health Commissioner was asked to investigate the problem, and in February, the Health Commissioner requested the assistance of the Cincinnati Health Department. In March 1992, the building management installed an exhaust fan in the State Auditors Office suite to remove the odors. The exhaust fan was vented directly to the outside of the building.

IV. EVALUATION DESIGN AND METHODS

On March 26, and March 30, 1992, NIOSH investigators conducted general-area air sampling for VOCs. To evaluate airborne concentrations of VOCs present in the general workroom air, samples were collected at two locations within the State Auditors Office, in an office on the second floor of the building, and in the adjacent office suite. At each sample location two samples were collected; one thermal desorption tube for qualitative screening of VOCs and one charcoal tube for quantitative analysis of VOCs. Additionally, an HNu® Photoionization Analyzer was used to locate the source of the odor.

Thermal desorption tubes containing three beds of sorbent materials, Carbotrap C/Carbotrap/Carbosieve S-III, were connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.05 liters per minute (ℓpm). Quantitative samples for VOCs were collected on solid sorbent charcoal tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.2 ℓpm. These samples were then analyzed for specific compounds as indicated by the results of the qualitative analyses. Thermal desorption tube and charcoal tube samples were analyzed via gas chromatography/mass spectrometry (GC/MS).

The HNu® Photoionization Analyzer (Model PI 101) was used to locate sources of VOCs within the office and hallway areas of the building. The HNu® employs the principle of photoionization for measurement of trace concentrations of gases.[1] The instrument is designed to detect trace gases over a concentration range from less than 1 part of contaminant parts per million (ppm) of air to 2000 ppm.[1] The instrument was calibrated using 58 ppm isobutyl ether, so the concentrations indicated on the instrument would be considered relative concentrations as compared to the calibration gas.

On April 9, 1992, NIOSH investigators returned to conduct employee interviews and further air sampling. The seven employees present, who spent a significant portion of their work week in the office, were interviewed. Further sampling was conducted using the HNu® photoionization analyzer.

V. EVALUATION CRITERIA

A number of published studies have reported high prevalences of symptoms among occupants of office buildings.[2-6] NIOSH investigators have completed over 700 investigations of the indoor environment in a wide variety of settings. The majority of these investigations have been conducted since 1979.

The symptoms and health complaints reported 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 workplace environment has been implicated because workers report that their symptoms lessen or resolve when they leave the building.

Scientists investigating indoor environmental problems believe that there are multiple factors contributing to building-related occupant complaints.[7,8] 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.[9-14] Reports are not conclusive as to whether increases of outdoor air above currently recommended amounts ($\geq$15 cubic feet per minute per person) are beneficial.[15,16] However, rates lower than these amounts appear to be associated with an increase in the rates of complaints and symptoms in some studies.[17,18] Design, maintenance, and operation of HVAC systems are critical to their proper functioning and provision of healthy and thermally comfortable indoor environments. Indoor environmental pollutants can arise from either outdoor sources or indoor sources.[19]

There are also reports which show that occupant perceptions of the indoor environment are more closely associated with the occurrence of symptoms than the measurement of any indoor contaminant or condition.[20-22] Some studies have shown relationships between psychological, social, and organizational factors in the workplace and the occurrence of symptoms and comfort complaints.[22-25]

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; VOCs 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, no cause of the reported health effects could be determined.

Exposure standards tailored to 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.[26-28] 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.[29-30] 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.[31]

Measurement of indoor environmental contaminants has rarely proven to be helpful, in the general case, 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.

VI. RESULTS AND DISCUSSION

A. Industrial Hygiene Sample Results

1. Air Sample Results

Total ion chromatograms of qualitative air samples collected inside the State Auditors Office did not identify any particular petroleum-based product; however, all were very similar and showed a distinctly different pattern from the chromatograms of samples collected in other office suites of the building. For comparison purposes, the analytical laboratory collected air samples over the headspace of bulk kerosene and bulk diesel fuel samples. Based on the resulting chromatograms, the field samples appeared to contain some type of petroleum distillate that was similar the bulk diesel fuel sample. However, the absence of distinct peaks for aromatics (benzene, toluene, and xylenes) in all of the field samples differentiate these samples from the kerosene and diesel fuel headspace samples.

The results of quantitative sampling for hydrocarbons are presented in Table I, as total airborne hydrocarbons, which are a specific class of VOCs. Quantitative sample results indicated that the air contained a complex mixture of hydrocarbons ranging from C_4 to C_{12}. These sample results were reported as C_4 to C_6 (concentrations were quantified using *n*-hexane as the standard), and C_7 to C_{12} (concentrations were quantified using *n*-octane as the standard). The results were compared to the NIOSH standard for stoddard solvent (350 mg/m^3) because the majority of hydrocarbons detected were in the C_7 to C_{12} range, and stoddard solvent consists of hydrocarbons in this range. These results show that total airborne hydrocarbon concentrations within the State Auditors Office on

March 26 and March 30, 1992, were more than 20 times higher than total airborne hydrocarbon concentrations in the adjacent ground floor office and in one office suite on the second floor of the building. On March 26, a total airborne hydrocarbon concentration of 7.5 mg/m^3 was found in the conference room, and on March 30, a higher total airborne hydrocarbon concentration of 17.5 mg/m^3 was found in the conference room. On March 26th the outside temperature was mild, about 70°F, with clear skies. On March 30th, the outside temperature was about 65°F and a steady rain had been falling for several hours prior to sampling.

2. HNu® Photoionization Analyzer Results

The results of instantaneous measurements using the HNu® Photoionization Analyzer are presented in Table II. These measurements showed detectable airborne VOC concentrations measurement within the State Auditors Office; whereas, airborne VOC concentrations outdoors or in other office suites in the building were not detected using this instrument. These results also indicate that the vapors appear to be emanating from below the concrete slab flooring, since concentrations (120 ppm - 160 ppm) detected at the gap between the sewer drain pipe and at the concrete floor and the gap between the east wall and the floor in the conference room were a minimum of 2 to 3 times greater than anywhere else inside the State Auditors Office suite, including inside the sewer drain pipe. The HNu® results, in conjunction with the long-term air sampling results, suggest that the odor is emanating from the ground beneath the building slab. Identifying the source of the contamination is beyond the scope of this evaluation and further soil studies may be necessary to determine this. However, historical information verbally reported by the Sharonville Health Commissioner, to the NIOSH investigators, indicates that a truck stop was formerly located across the road from this office site.

3. Ventilation Evaluation

An inspection of the heat pump showed little accumulated debris on the coil in the condensate pan and some debris in the interior of the sump pump, but not enough to be a serious problem. On the morning of March 30, 1992, an open container with a pine-odor cleaning compound had been placed inside the AHU apparently to mask the odor in the suite. The NIOSH investigators removed the cleaning compound at least 30-minutes prior to the start of air sampling to allow the odor to dissipate. This may have affected the sample results for this day.

The outside-air supply duct was inserted through a rough-cut hole in the wall of the AHU plenum, and an existing gap between the outside-air supply duct and the wall of the AHU plenum was not properly sealed. Smoke tubes used to visualize airflow patterns showed that air from the closet was pulled into the AHU plenum. The outside air supply to the State Auditors Office was pulled into the suite using the AHU fan connected by over 30 feet of ducting to a dryer-vent type cap. The distance of the outside-air supply opening to the AHU fan and the several air duct elbows present could seriously impede the supply of outside-air to the State Auditors Office suite.

Smoke tubes used to visualize air flow patterns also showed that the State Auditors Office suite was under negative pressure when the exhaust fan was operating and even when the exhaust fan had been turned off. Therefore, contaminants from below the concrete flooring could be entering the suite even under normal HVAC operating conditions, and the amount of contaminants entering the State Auditors Office suite would be expected to increase when the exhaust fan was operating.

B. Medical interviews

On April 9th, the seven employees present who spent a significant portion of their work week in the office were interviewed. Several employees reported that they had occasionally noted the petroleum-like odor when they first moved to the office in August 1991, but most first noticed the odor in the late fall. They reported that the odor had become stronger and more frequent during January and February of this year and was usually most noticeable when the office opened at 8:00 a.m. Most felt that the intensity of the odor varied from day to day, but was most intense in the conference room. Several of the employees expressed concern about the possible health effects of exposure to the chemical mixture responsible for the odor. When questioned regarding specific symptoms experienced while at work during the preceding month, 5 employees reported frequent headaches, 2 frequent nasal congestion, 4 occasional eye irritation, 2 occasional throat irritation, 3 frequent severe fatigue, 1 frequent and 1 occasional nausea, and 2 reported occasional bouts of dizziness. In general, the symptomatic respondents felt that symptoms were more severe on days when the odor was stronger and that symptoms were more likely to occur after spending several consecutive days in the office. Most felt that the odor had been less noticeable, and their symptoms less severe, during the week of the medical survey.

VII. CONCLUSIONS

The air sampling data collected during this investigation suggests that the subsurface of this property may be contaminated with a complex mixture of hydrocarbons and indicates that the mixture is volatilizing and is most likely entering the building through cracks and gaps in the concrete flooring and foundation. The data showed that instantaneous measurements of VOC concentrations in Auditors Office suite ranged up to 160 ppm with time-weighted average (TWA) concentrations of total airborne hydrocarbons ranging from 5.9 to 17.5 mg/m^3. The TWA concentrations of total airborne hydrocarbons found in the Auditors Office are far less than the relevant standards for industrial exposures; however, the concentrations detected are more than 20 times greater than airborne concentrations detected in two other office suites located in the building. While there is inconclusive evidence that the employee symptoms are due to the total airborne hydrocarbon and VOC concentrations found it is of interest that research, by Molhove in Denmark, has found that test subjects exposed to solvents in chamber studies at concentrations comparable to those found in the State Auditors Office have experienced symptoms similar to those reported by the employees in this evaluation.[11] Therefore, it is recommended further soil studies be conducted to determine the source of the contamination and that efforts be initiated to lower the concentration of total airborne hydrocarbons and VOCs in the office space.

Subsequent to the NIOSH investigation, the building management retained the services of an environmental consulting firm to conduct a subsurface investigation of the property. The firm concluded that the "soils beneath the site appear to be contaminated with petroleum hydrocarbons." The vertical depth of contamination was identified as approximately 8 to 26 feet below grade at the front of the facility and 4 to 14 feet below grade at the rear of the facility; total petroleum hydrocarbons (TPH) and benzene, toluene, ethyl benzene, and xylenes (BTEX) were found. The firm also concluded that further investigations of the subsurface should be conducted to identify the exact source of the petroleum.

VIII. RECOMMENDATIONS

The following recommendations were offered to representatives of the building management and the State Auditors Office during the NIOSH visit on April 7, 1992.

1. Even though the TWA concentrations of total airborne hydrocarbons measured do not represent a health hazard when compared to the existing industrial exposure criteria, the levels found have been associated with symptoms similar to those reported by the employees at this work site. Therefore, for the comfort and overall well being of employees the source of the chemical contamination should be determined and the contamination should be prevented from entering the office space.

2. Further soil studies and other appropriate investigations should be conducted to locate and characterize the source of underground contamination. The Ohio Bureau of Underground Storage Tank Regulations (BUSTR) should be contacted for assistance with this problem.

3. A booster fan should be added to the outside-air supply system to place the office space under positive pressure and to assure adequate amounts of outside air enter the AHU. The gap at the point where the outside-air duct enters the AHU should be properly sealed to prevent air, from inside the AHU closet, from entering the AHU plenum. The American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) recommends that 20 cubic feet per minute per person of fresh outside air be supplied to office spaces.

4. The exhaust fan which was installed to remove the vapors from the State Auditors Office suite should be disconnected, or the fan should be reversed to provide more outside air. The use of the exhaust fan tends to place the office space under negative pressure in relation to the surrounding spaces. This complicates the situation by drawing the vapors out of the ground and into the office space.

5. After further soil sampling and determination of the contaminant source have been completed, methods similar to those used to mitigate excessive radon gas in buildings may be necessary. The object of this project should be to place the subslab of the building under negative pressure to remove the vapors before they enter the office spaces to decrease the concentrations of total airborne hydrocarbons to levels found in other areas of the building. Additionally, all cracks in the floor, the foundation, wall/floor gaps and sewer drain pipe gaps should be sealed to prevent vapors from entering the office area.

6. The practice of using pine-odor cleaning chemicals to mask odors should not be repeated. The source of odors should always be located and eliminated.

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Copies of this report have been sent to:

1. State Auditors Office, Sharonville, Ohio
2. Deputy Auditor of Administration, Columbus, Ohio
3. Health Department, Sharonville, Ohio
4. Health Department, Cincinnati, Ohio
5. OSHA, Region V

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.

Table I

TOTAL AIRBORNE HYDROCARBONS

State Auditors Office
Sharonville, Ohio
HETA 92-180

SAMPLE DATE	SAMPLE LOCATION	TOTAL HYDROCARBONS (mg/m^3)
March 26, 1992	Office entry way	5.9
	Conference room	7.5
	2nd Floor office	0.29
March 30, 1992	Furnace room	25.9
	Conference room	17.5
	Suite 103	0.27*
EVALUATION CRITERIA[a]	NIOSH REL OSHA PEL ACGIH TLV	350 525 525

mg/m^3 - milligrams of contaminant per cubic meter of air.

* - values with an asterisk lie between the analytical limit of detection (LOD) and the analytical limit of quantitation (LOQ), and should be considered semi-quantitative.

[a] - the criteria for stoddard solvent is used for comparison purposes only, the exact identification of the odor is not known.

Table II

HNU® PHOTOIONIZATION DETECTOR METER READINGS

State Auditors Office
Sharonville, Ohio
HETA 92-180

SAMPLE DATE	SAMPLE LOCATION	VOLATILE ORGANIC CHEMICALS (VOCs) (ppm)
March 30, 1992	General office workroom.	2 - 5
"	Conference room.	5 - 7
"	Furnace room.	5 - 10
"	Furnace room at sewer drain pipe gap.	50 - 60
"	Furnace room at sewer drain pipe gap with plumbers putty removed.	140 - 160
"	Inside sewer drain pipe.	0 - 2
April 9, 1992	General office workroom.	1 - 2
"	Conference room.	2 - 3
"	Conference room at floor/wall gap on the east side of the room.	120 - 160
"	Furnace room at breathing-zone height.	5 - 7
"	Furnace room at sewer drain gap at floor level.	50 - 60
"	Wall/floor gaps in other areas of the office.	1 - 2
"	Outside - at foundation/pavement gap, at south end of the building.	0
"	Outside - inside the sewer lid.	0
"	Outside - at breathing-zone height.	0

(ppm) = parts per million