HETA 93-0974-2353
OCTOBER 1993
DEPARTMENT OF HEALTH SERVICES
FRANKFORT, KENTUCKY

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SUMMARY

In June 1993, the National Institute for Occupational Safety and Health (NIOSH) received an employer request for a Health Hazard Evaluation (HHE) from the Health Commissioner for the Commonwealth of Kentucky. The HHE request concerned an outbreak of skin disorders among laboratory workers in the basement of the Health Services Building in Frankfort, Kentucky.

NIOSH investigators visited the facility on June 18 and July 2, 1993. During the initial visit, all ten workers in the radioimmunoassay (RIA) lab, the phenylketonuria (PKU) lab, the clinical chemistry lab, and the sickle cell anemia lab, along with six other workers from other laboratories or offices in the basement, were interviewed. A walk-through survey was also conducted during this visit. During the second visit, the air handling units (AHUs) in the three mechanical rooms located in the basement were inspected. Air and surface sampling for fibrous glass, and measurements of temperature, relative humidity (RH), and carbon dioxide (CO_2) concentrations were conducted in the RIA lab, the PKU lab, the clinical chemistry lab, and the sickle cell anemia lab.

The most consistent finding on medical interview was a prickling sensation on exposed surfaces of the skin, such as the forearms and face, and areas where rubbing with clothes may occur, such as the neck. Workers commonly reported an associated itch in these areas with a rash characterized by small, red, punctate lesions. Two employees also reported the presence of hives, usually after scratching the affected areas. The skin symptoms began in early to mid May, soon after the start of fibrous glass insulation installation in the mechanical rooms which housed the AHUs. Symptoms were reported more often in the early part of the week, were less severe in the later part of the week and usually resolved on weekends. They tended to recur upon returning to work the following week.

Inspection of the AHUs revealed several deficiencies in the cleaning and circulation of air to the laboratories by these units. These included a metal blank blocking the return of air to the AHU in mechanical room six, dirty cooling coils and condensate pans, organic matter including dead birds in the ductwork, the mixture of returning and outside air bypassing the roll filter, and microbial growth in the sound liner. Scraps of cut fibrous glass insulation material were present in all three mechanical rooms. Analysis of the four air samples by phase contrast microscopy revealed fiber loading between the limit of detection (0.002 fibers per milliliter) and the limit of quantitation (0.03 fibers per mililiter). The air concentrations were well below any current exposure criteria. Fibers in surface and vacuum samples were found to be cellulose with traces of synthetic and glass fibers. Temperature, RH and CO_2 measurements were all within the range of acceptable values recommended by ASHRAE.

The most likely cause of the skin symptoms among laboratory employees was an irritant dermatitis due to contact with glass fibers during the time of fibrous glass insulation installation in the three nearby mechanical rooms in the basement of the Health Services building. The nature of the reported skin symptoms was consistent with this type of exposure and the onset of symptoms was soon after the start of fibrous glass installation.

The fact that air and surface sampling for fibrous glass in the laboratories revealed only trace amounts of fibers indicate that little fibrous glass was distributed by the air handling unit located in mechanical room 6. This suggests that the main contact with fibers for employees in rooms G-5, G-14, G-16 and G-18 resulted from exposure to contaminated air in the corridors adjacent to the mechanical rooms where the fibrous glass insulation was being cut. The poorly maintained AHUs in the mechanical rooms probably contributed to the severity of this outbreak by inefficient filtering of the circulating air.

KEYWORDS: SIC 8071 (medical laboratories), fibrous glass, contact dermatitis

INTRODUCTION

In June 1993, the National Institute for Occupational Safety and Health (NIOSH) received an employer request for a health Hazard Evaluation (HHE) from the Health Commissioner for the Commonwealth of Kentucky. The HHE request concerned an outbreak of skin disorders among workers in the neonatal screening laboratories in the basement of the Health Services Building in Frankfort, Kentucky. Employees were concerned that their symptoms were caused by contact with carbonless copy paper forms which accompany the biological specimens analyzed in the laboratories.

To respond to this request, NIOSH representatives conducted site visits on June 18, and July 2, 1993. The site visits were conducted to determine the cause for the skin symptoms reported by employees. Medical interviews and an industrial hygiene assessment were conducted. An interim report was sent to the requestor and employee representative on July 12, 1993.

BACKGROUND

Health Services Building

The Health Services Building was built in 1960. The laboratory services section of the building is located in the basement. Neonatal screening is located in room G-5 (the PKU lab) and clinical chemistry is located in rooms G-14 (the RIA lab), G-16 (the clinical chemistry lab) and G-18 (the sickle cell anemia lab). Ten people work in these rooms. The basement also contains an animal house, toxicology laboratory and offices. Air- conditioning is provided by three AHUs located in three separate mechanical rooms in the basement.

Employee Health Concerns

In early May 1993, several employees in the laboratories began to notice itchy skin and rashes. Reports of these problems were made to the employee health nurse on several occasions during May. Four of the employees were assessed by their personal physicians and were removed from work in June because of recurrent skin disorders. One employee worked in the PKU lab, two in the RIA lab, and one in the sickle cell anemia lab. Following this occurrence, several other employees in other laboratories and offices in the basement began to report episodes of itchy skin and rashes.

Although the nature of the skin disorders and causative agent was unknown, the forms which accompanied blood specimens handled by laboratory workers were suspected because a new batch of forms had recently been received. The forms contain carbonless copy paper. It was later learned that fibrous glass insulation installation had recently commenced in the three mechanical rooms which housed the AHUs for the basement.

EVALUATION PROCEDURES

NIOSH investigators visited the site on two occasions. The first occasion was June 18, 1993, when two medical officers interviewed employees from the laboratories in the basement of the

Health Services Building. The second visit was on July 2, 1993, when a medical officer conducted a follow-up medical assessment of employees and an industrial hygienist conducted an industrial hygiene assessment of the site.

Medical Evaluation

The medical portion of the evaluation consisted of two parts. During the visit on June 18, interviews were conducted with all ten employees working in rooms G-5, G-14, G-16, and G-18. This included all four employees who, because of skin problems, had been removed from work, but had come in for the interviews. In addition, interviews were held with six other employees who work in offices and other laboratories in the basement at the other end of the building.

During the second visit, interviews were conducted with three of the four employees who were off work at the time of the first visit, but had since returned to work in another area of the building. The fourth employee was still off work at the time of the second visit and was not interviewed. In addition to the medical interviews, medical records held by the employee health nurse were examined.

Information on recent changes to the forms used in the laboratories was obtained from the manufacturer. The work schedules for the fibrous glass insulation installation were also reviewed.

Industrial Hygiene Evaluation

The industrial hygiene portion of the evaluation consisted of an inspection of the AHUs in mechanical rooms 6, 7, and 8, as well as the outside air (OA) intakes on the roof of the building; air and surface sampling for fibrous glass in the RIA lab, the PKU lab, the clinical chemistry lab, and the sickle cell anemia lab; and measurements of temperature, RH, and CO_2 concentrations in these rooms.

Four general area air samples for fibrous glass were collected, one in each of the four laboratories. Samples were collected on 25-millimeter (mm) diameter, 1.2-micron (µm) pore size mixed cellulose ester filters in three-piece cassettes with approximately 50-mm electrically-conductive extension cowls and backup pads attached via Tygon tubing to electrically-powered sampling pumps operating at a flow rate of 10 liters per minute. The cover of the cassette was removed from the cowl (open-faced sampling) to promote uniform distribution of the sample on the filter. Sampling pumps were calibrated before and after sampling using a rotameter. Air sample volumes ranged from 1150 to 1430 liters. Samples were submitted for analysis by phase contrast microscopy in accordance with NIOSH Method 7400.[1]

Surface samples were collected in the laboratories using two techniques. Surface wipe samples of settled dust were collected using Whatman Smear Tab mixed cellulose ester filters. Settled dust was also collected using the same type of sampling media used to collect air samples. In order to collect settled dust samples, the cassette was connected via Tygon tubing to a personal sampling pump operating at a flow rate of 4 liters per minute. Settled dust was then vacuumed on to the filter using the suction provided by the personal sampling pump. Surface and settled dust samples were immersed in Cargille liquids and examined by polarized light microscopy at a magnification of 100X.

CO_2 concentrations were measured using direct-reading colorimetric detector tubes and a bellows-type sampling pump. Air is drawn into the tube by squeezing the bellows. CO_2 in the air sample reacts with an indicating layer in the detector tube to produce a color change from white to blue violet. The length of the stain is dependent upon the concentration of CO_2 in the sampled air and the air sample volume, which is determined by the number of times the bellows are squeezed. The concentration of CO_2 can be read directly using gradations marked on the side of the tube.

Temperature and RH measurements were made 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°F and 0 to 100%, respectively. Instrument calibration is performed monthly using primary standards.

EVALUATION CRITERIA

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

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

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

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.[2-4] With few exceptions, pollutant concentrations observed in non-industrial indoor environments fall well below these published occupational standards or recommended exposure limits. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published recommended building ventilation design criteria and thermal comfort guidelines.[5,6]

Measurement of indoor environmental contaminants can be helpful in determining the cause of symptoms and complaints where there are strong or unusual sources, or a proven relationship between contaminants and specific building-related illnesses. Measuring ventilation and comfort indicators such as CO_2, temperature and relative humidity, can be useful in providing information relative to the proper functioning and control of Heating, Ventilation and Air Conditioning (HVAC) systems. The basis for measurements made during this evaluation are listed below.

Carbon Dioxide

CO_2 is a normal constituent of exhaled breath and, if monitored, may be useful as a screening technique to evaluate whether adequate quantities of fresh air are being introduced into an occupied space. The ASHRAE Standard 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 20 cubic feet per minute per person (cfm/person) for office spaces and conference rooms, and 15 cfm/person for reception areas, and provides estimated maximum occupancy figures for each area.[5]

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

Temperature and Relative Humidity

The perception of comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. ANSI/ASHRAE Standard 55-1981 specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable.[6]

Fibrous glass

Glass fibers of diameters greater than 3.5 micrometers (µm) are known to cause dermatitis through skin irritation.[7] The risk of fibrous glass dermatitis is increased in warm, humid climates or during the winter in temperate climates when the relative humidity is low. For most workers, symptoms disappear within a week or two of the cessation of exposure, but may persist for longer in some individuals. Allergic contact dermatitis has not been associated with glass fibers but may be caused by skin contact with the resins used in fibrous glass products. Fibrous glass can also cause eye and upper respiratory tract irritation.[7,8]

Several studies of skin irritation in office employees due to contact with glass fiber have been published.[9-13] In these studies, exposed employees reported a prickling sensation, and itching and rashes on exposed surfaces such as the forearms, neck and face. The rashes were most severe where there was rubbing against clothes such as around the collar. Symptoms were usually most severe following first exposure to the glass fibers.[14] Individuals who handle fibrous glass repeatedly may develop a tolerance to its irritant effects, while symptoms usually recur in employees who have intermittent exposure. Skin symptoms usually resolved following cessation of exposure. In these studies, employees have been exposed to glass fibers falling from ceiling spaces and through the air conditioning system.[9-11]

Based on experimental studies in animals and epidemiologic studies in humans, the International Agency for Research on Cancer (IARC) has concluded that certain man-made mineral fibers (MMMF), including glass wool and fibrous glass, are

possibly carcinogenic to humans.[15] Epidemiological studies of cancer risks in the MMMF manufacturing industry have shown a small excess of lung cancer in these workers, particularly in the mineral wool sector.[16]

In 1977, NIOSH proposed a recommended exposure limit (REL) of 5 mg/m^3 time-weighted average (TWA) for total fibrous glass dust and a 3 fiber/mL limit for fibers having a diameter equal to or less than 3.5 µm and a length equal to or greater than 10 µm, based on evidence that small diameter fibers produce fibrosis in animals and respiratory tract irritation in humans.[17] In 1988, as part of the proposed rules on air contaminants, OSHA proposed to adopt the NIOSH recommendation of 5 mg/m^3 for total fibrous glass dust as a permissable exposure limit (PEL), but not the 3 fiber/mL limit for small-diameter fibers.[18] In July 1992, an 11th circuit court ruled that the 1988 OSHA PELs for 212 air contaminants, including fibrous glass dust, were invalid. In many states, including Kentucky, PELs reverted to the less protective limits set in 1971.

RESULTS AND DISCUSSION

Medical

The most consistent finding on medical interview was a prickling sensation on exposed surfaces of the skin, such as the forearms and face, and areas where rubbing with clothes may occur, such as the neck. All employees reported an associated itch in these areas with, in half of the cases, a rash characterised by small itchy punctate lesions. Two employees reported the presence of hives, usually after scratching the affected areas.

In rooms G-5, G-14, G-16 and G-18, the skin symptoms began in early to mid-May. Among interviewed employees from the other end of the building, symptoms started in late May and early June. Symptoms were reported more often in the early part of the week and early in the day. Symptoms usually subsided later in the week and on weekends but tended to recur upon returning to work the following Monday.

Several other symptoms were also reported by some of the interviewed employees. Symptoms included breathing difficulties, headaches, sinus infections, irritated eyes, and a tingling sensation in the nose and lips. The temporal pattern with work for the latter symptoms was not as well defined as that for the skin symptoms.

Many of the employees in rooms G-5, G-14, G-16 and G-18 felt that the air in the rooms was often stuffy. They also reported that the indoor air temperature tended to fluctuate between hot and cold and that there were sometimes musty smells, particularly in the annex of room G-18.

The manufacturer of the forms that accompanied blood specimens indicated that no change to the paper used in these forms had recently occurred. A new printing of the form (with modified wording) occurred at the beginning of 1993, and these forms had been used since February. Three of the employees reporting skin symptoms did not handle these forms.

The fibrous glass insulation installation in the mechanical rooms of the basement was being installed to replace asbestos insulation, which had been removed during a recent asbestos

abatement project. Installation was carried out by an insulation contractor. The work commenced on April 5, 1993 but ceased on April 9 due to complaints from employees in the basement of an unpleasant odor. The odor was from a xylene-based adhesive used to install the fibrous glass. Work recommenced about three weeks later (at the start of May), initially on weekends only. Towards the end of May, week-day installation began and continued up until the dates of the NIOSH visits.

Many of the interviewed employees reported that the fibrous glass was often cut by the contractors in the corridor outside the mechanical rooms. Trash cans containing discarded pieces of cut fibrous glass were often left in the corridors during this time.

Environmental

In mechanical room 6, which contains the AHU supplying air to rooms G-5, G-14, G-16 and G-18, the return air duct for the AHU had been disconnected. Sheet metal blanks were in place to seal both ends of the disconnected duct. This was reportedly done to isolate this AHU from a previous asbestos abatement project, but the return air duct was not restored to its original condition following the completion of the project. A dead bird was found in the filter section of the AHU, upstream of the filter. The roll filter did not completely cover the air path; thus, air was bypassing the filter. The cooling coils and the condensate pan were dirty, and the sound liner in the section of the air handler downstream of the cooling coil showed evidence of microbial growth.

In mechanical room 7, the outside air (OA) plenum and the cooling coils were dirty, and the sound liner showed evidence of microbial growth. In addition, there was some standing water on the floor of the mechanical room.

In mechanical room 8, another dead bird was found in the filter section of the AHU, upstream of the filter. The fabric coupling between the OA plenum and the fan section of the AHU was largely missing, resulting in about a 3-inch gap between these sections. This allowed air from the mechanical room to be drawn into the recirculating air. The cooling coils, condensate pan, and sound liner were dirty. This unit was the dirtiest of the three AHUs.

None of the AHUs seemed to be designed or situated for easy access for inspection and maintenance. In mechanical rooms 7 and 8, there were scraps of fibrous glass insulation in the mechanical room, reportedly the debris of the recent insulation installation. In all of the AHUs, matted glass fibers and dirt, presumably from air filters, were found upstream of the cooling coils.

The bird screen section of the OA intake for mechanical room 6 was lying on the roof. On the roof, the OA intake for mechanical room 8 was found to be about 10 feet away from the exhaust outlet for a chemical fume hood, and about 12 feet away from the exhaust for a class 1 biological safety cabinet. Many of the exhaust outlets terminate below the parapet of the roof, and in most cases are oriented downward.

Temperatures in the four laboratories ranged from 71 to 75°F. Relative humidity ranged from 50% to 58%. One set of measurements was made in each laboratory, beginning at 2:13 p.m. Outside, the temperature was 86°F with a relative humidity of 69% at 3:20 p.m. The measurements inside the building fell within the range of acceptable values recommended by

ASHRAE. CO_2 measurements ranged from 400 ppm to 800 ppm. However, the limited number of occupants in these laboratories, as well as factors which are unique to the laboratory environment (e.g., requirements for local exhaust ventilation) limit the value of CO_2 measurements in this case.

Ceiling tiles in the evaluated space were made of plastic-coated fibrous glass. In many cases, the surface coating was gone, exposing the fibrous glass surface. Often, this surface was spotted with a moldy appearance. In many of the laboratories, notably the PKU lab, the ceiling around the supply air diffuser was streaked with black particles. In some cases, the diffuser was slightly rusty. In the annex of G-18, the return air duct was sealed off with plastic sheeting.

Analysis of air samples by phase contrast microscopy revealed that each of the samples had fiber loading between the limit of detection (0.002 fibers per milliliter) and the limit of quantitation (0.03 fibers per milliliter) for the analytical method. Values between the limit of detection and the limit of quantitation should be considered trace values, and are well below current exposure criteria. Fibers in surface and vacuum samples were found to be mostly cellulose with traces of synthetic and glass fibers.

CONCLUSIONS

The most likely cause of the skin symptoms among laboratory employees is an irritant effect due to contact with glass fibers during the time of fibrous glass installation in the three nearby mechanical rooms in the basement of the Health Services Building. The nature of the reported skin symptoms is consistent with this type of exposure and there is a plausible temporal relationship between the onset of symptoms and the fibrous glass insulation installation. Similar outbreaks of skin disorders related to this type of fibrous glass exposure have previously been reported in the scientific literature.

The poorly maintained AHUs in the mechanical rooms probably contributed to the severity of this outbreak by inefficient filtering of the circulating air. In mechanical room 8, air contaminated with glass fibers was able to enter the recirculating air through the gap between the OA plenum and the fan section of the AHU.

The fact that air and surface sampling for fibrous glass in the laboratories revealed only trace amounts of fibers indicates that little fibrous glass was distributed by the air handling system located in mechanical room 6. This suggests that the main contact with fibers for employees in rooms G-5, G-14, G-16 and G-18 resulted from exposure to contaminated air in the corridors adjacent to the mechanical rooms where the fibrous glass insulation was being cut.

The reporting of rashes on exposed surfaces apart from the hands, the finding of cases who did not handle the laboratory forms, and the time lag of several months since first use of the new batch of forms, make it unlikely that the skin disorders are related to handling the forms containing carbonless copy paper.

RECOMMENDATIONS

1. Remove the sheet metal blanks and reconnect the return air duct in mechanical room 6. This should improve air circulation in the rooms served by this air handler.

2. To prevent unfiltered outdoor air from reaching the AHU, ensure that roll filters fit securely in filter frames. Contact the manufacturer of the filters or the AHUs to determine why the filters are deteriorating, as evidenced by the accumulation of glass fibers upstream of the cooling coils. Generally, NIOSH investigators recommend installing the most efficient filters an AHU can handle without a decrement in performance. Due to access problems, installing more efficient filters, such as extended surface panel filters, would be problematic. Again, the filter or AHU manufacturer may be able to provide guidance in selecting a more efficient roll filter.

3. Clean the components of the AHUs. Coils and pans should generally be cleaned on an annual basis to prevent the growth of microorganisms. Clean coils also exchange heat more efficiently. The sound liners downstream of the cooling coils should be removed and replaced, preferably with a non-porous insulation. Porous materials that have become wet are difficult to clean and often support microbial growth long after they appear dry. Matter of microbial origin (spores, antigens, toxins, irritants) can remain in these materials for years.

4. Clean up the fibrous glass debris left in the mechanical rooms using suitable work practices when handling fibrous glass.[19]

5. Repair the gap between the OA plenum and the fan section of the AHU in mechanical room 8. Repair the bird screen on the OA intake serving mechanical room 6. Inspect the other OA intakes to determine whether they are in need of repair. Raise the exhaust stacks from chemical fume hoods and biological safety cabinets clear of the parapets. For chemical fume hoods, National Fire Protection Association standard 45 recommends that exhaust stacks should extend at least seven feet above the roof.[20] Ensure that these, and other contaminant sources, such as sanitary vents and bathroom exhausts, are separated from outdoor air intakes. Consult ASHRAE guidelines and applicable building codes for guidance.

6. Use commercial surface treatments to decontaminate ceiling tiles that show signs of water damage or microbial growth, but which reportedly cannot be removed and replaced because of asbestos contamination above the tile. Review the product information, and heed all directions, precautions and warnings to help ensure that the use of such treatments will not result in adverse health effects or interfere with the procedures carried out in the laboratories. Maintaining the relative humidity in the building between 40 and 60% should minimize the growth of pathogenic microorganisms.[5] The ceiling tiles should be removed and replaced as part of the scheduled renovation, using asbestos containment procedures. Black particulate on ceilings may be carbon particles from past cigarette smoke, dirt from poorly maintained AHUs, or microbial growth. This can be cleaned with a mild bleach solution.

7. Remove the plastic sheeting over the air return in the annex of G-18. Removal of the cardboard boxes from the high humidity environment in this room should reduce the musty smell.

8. Someone in the maintenance department should be thoroughly trained in the principles of the design, operation, and maintenance of the building's heating, ventilating, and air conditioning (HVAC) system. Space use and building occupancy often change from their original design. Also, as systems age, their performance may deteriorate. Therefore, throughout the useful life of the building, there will be a need to recommission systems periodically. ASHRAE has published a guideline for the commissioning of HVAC systems that may be useful in recommissioning this system.[21] Contact the architect, contractor, or consulting engineer to determine if any mechanical prints of this building are available to assist in the recommissioning of the HVAC system.

9. If further fibrous glass work is to be undertaken, this should be carried out using work practices to minimize the contamination of occupied areas with glass fibers. This type of work should be carried out at times when other people are not working in the building, such as during evenings or on the weekends.

10. Further reporting by laboratory workers of skin rashes consistent with fiber glass or other industrial dermatitis should be investigated to identify any source of contamination.

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