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HENRY FORD HIGH SCHOOL
DETROIT, MICHIGAN

NIOSH INVESTIGATOR:
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I. SUMMARY

On May 19, 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from teachers at the Henry Ford High School in Detroit, Michigan to determine whether malfunctioning PCB-containing fluorescent light ballasts were the cause of an increased incidence of respiratory symptoms, sore throats, and headaches. Electrical burnout of fluorescent lighting ballasts causes the heating and volatilization of an asphalt potting-compound inside the ballast, as well as the PCBs. Symptoms similar to those reported have been associated with these exposures during burnout situations.

On May 27-28, 1987 an environmental investigation was conducted. Air and surface wipe samples for polychlorinated biphenyls (PCBs) were collected in four index classrooms where teachers had complained of the symptoms, and in three reference rooms in an area of the school where symptoms had not been reported. PCB air concentrations did not exceed 0.1 ug/m^3 in any of the reference rooms. PCB concentrations were 0.2, 0.3, and 0.4 ug/m^3 in three of the four index rooms, indicating that ballast burnout had occurred recently. NIOSH has concluded that PCBs are potential human carcinogens and recommends that occupational exposures to PCBs be controlled to the lowest feasible level (LFL). Airborne occupational exposures should not exceed a time-weighted average during a full work-shift of 1 ug/m^3 (using recommended sampling and analytical methods). This "occupational" exposure criteria is not meant to be applicable for exposures to the general population, such as this case where large numbers of young people have potential exposures.

Surface PCB concentrations for wipe samples collected from high-contact surfaces, such as student and teacher desk tops, averaged 1.3 ug/m^2. The highest result was 2.4 ug/m^2. PCB concentrations on low-contact surfaces (horizontal surfaces above six feet in height) ranged from 1.6 to 9.2 ug/m^2 and averaged 5.8 ug/m^2. High-contact surface concentrations below 50 ug/m^2 can be considered to be within the "background" reference range.

Based upon the results of this evaluation, the NIOSH investigator concluded that the prudent course to protect the health of the faculty and students would be to systematically remove all PCB-containing ballasts and replace them with ballasts which do not contain PCBs. Interim recommendations are made.

KEYWORDS: SIC 8211 (Elementary and Secondary Schools), polychlorinated biphenyls (PCBs), fluorescent light ballast, irritation symptoms, indoor air

II. Introduction

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation in May 1987 from a representative of teachers at the Henry Ford High School in Detroit, Michigan. There was concern that increases in the incidence of acute and chronic illnesses among teachers and students were resulting from contaminants released by malfunctioning fluorescent light ballasts. Long lasting respiratory infections and congestion, sore throats and headaches were reported.

An environmental evaluation was conducted on May 27-28, 1987. Air and surface wipe samples were collected to determine the presence of polychlorinated biphenyls (PCBs), a volatile component of fluorescent light ballasts manufactured prior to 1978.

III. Background

Henry Ford High School is a public school in a northwestern area of the city of Detroit, Michigan. The school employs nearly 140 workers, of which 122 are teachers. There were 3200 students enrolled here during the 1986-87 school year. The school was opened in February, 1957. An addition was made in 1962.

All classrooms at Henry Ford are lighted with fluorescent lighting systems. The system in the new wing of the school operates on a 277 volt current, and the system in the original wing of the school operates on 110 volts. The reported health complaints were from teachers in the newer wing.

The transformer element (ballast) of most fluorescent lighting systems manufactured before 1978 contains a capacitor filled (approximately 20 milliliters) with 100% PCBs. The capacitor assembly is surrounded by a petroleum-based asphalt compound containing a high percentage of silica. This material can also contain percent levels of PCBs. Normal ballast operation is not believed to emit measurable amounts of PCBs. However, electrical burnout of these ballasts can result in the release of PCBs. The service life of these ballasts is estimated to average from 12 to 18 years. Electrical malfunction is not uncommon after ten years of operation.

Surface residues and air concentrations of PCBs indicate historical episodes of ballast malfunction. The overheating or burnout process is accompanied by an acrid smoke and a strong obnoxious odor, which is caused primarily by the heated asphalt. Symptoms including headache, eye irritation, sore throat, nasal congestion, and nausea have been reported to be associated with exposures to contaminants during electrical burnout of fluorescent light ballasts.[1] The incidence of ballast burnout at Henry Ford High School was reported to be frequent. The index rooms in this evaluation were reported to have had burnouts in recent months.

IV. Evaluation Design and Methods

To determine the potential for inhalation and dermal exposure to PCBs, general area air and surface wipe samples were collected in five classrooms, the library, and a room containing a number of counselor offices. Classrooms 223, 227, 237, and 210 were the index rooms in the evaluation. That is, teachers in these rooms experienced the reported symptoms. The library, and rooms 200, and 201 (counselor suite) were used as reference rooms, where teachers had not reported symptoms. Rooms 223, 227, and 237 are located in the newer wing of the school. The other rooms and the library are located in the original structure.

One air sample was collected in each of the rooms. Surface wipe samples were also collected in each of the rooms. Both high and low contact surfaces were sampled. Horizontal surfaces below six feet in height, such as desk tops, were considered to be high contact surfaces. Horizontal surfaces above six feet in height, such as the tops of storage cabinets, were considered to be low contact surfaces.

Surface wipe samples were collected by using 3" x 3" gauze swatches wetted with 8 milliliters (ml) of hexane, and wiping a 0.25, 0.50, or 1.0 m^2 area. General area air samples were collected by drawing air through 150 milligram (mg) florisil tubes attached to battery operated sampling pumps at a pre-calibrated flow rate of one liter per minute for about 16.5 hours.

For analysis, the florisil tubes were separated into their primary and backup sections. Each section was desorbed in one ml of hexane with sonication for 1/2 hour. The gas chromatographic analysis was performed on a Hewlett-Packard Model 5730A gas chromatograph equipped with an electron capture detector and accessories for capillary column capabilities. A 30m x 0.31mm fused silica WCOT capillary column coated internally with DB-5 was used with temperature programming from 210 °C (held for two minutes) to 310 °C at a rate of 8 °C/minute. Five percent methane in argon was used as the carrier gas. The injector was operated in the splitless mode. The presence of an Aroclor was determined by comparison with standard sample Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 obtained from the EPA. Quantitation was performed by summing the peak heights of the five major peaks of the standards and comparing those sums to the sums of the same peaks in the sample. The NIOSH calculated limit of detection (LOD) was 0.02 ug/sample for Aroclor 1242, and 0.05 ug/sample for Aroclor 1254. The calculated limit of quantitation (LOQ) was 0.09 ug/sample for Aroclor 1242 and was 0.20 ug/sample for Aroclor 1254.

The gauze samples were prepared for analysis by extraction in 40 ml of hexane with shaking for 30 minutes. The hexane was transferred to a concentrator tube and the gauze was rinsed twice with 10 ml of hexane. The concentrated hexane eluent was cleaned on a florisil column and the sample was brought to a final volume of three ml. GC analysis was the same as previously described for the florisil tube samples. The NIOSH calculated LOD was 0.08 ug/sample for Aroclor 1242, 0.16 ug/sample for Aroclor 1254, and 0.04 ug/sample for Aroclor 1260. The calculated LOQ was 0.26 ug/sample for Aroclor 1242, 0.59 ug/sample for Aroclor 1254, and 0.13 ug/sample for Aroclor 1260.

V. Evaluation Criteria

A. Toxicology

PCBs are chlorinated aromatic hydrocarbons that were manufactured in the United States from 1929 to 1977 and marketed under the trade name Aroclor.[2] PCBs found wide use because they are heat stable, resistant to chemical oxidation, acids, bases and other chemical agents, stable to oxidation and hydrolysis in industrial use, have low solubility in water, low flammability and favorable dielectric properties. Additionally, they have low vapor pressure at ambient temperatures and viscosity-temperature relationships which were suitable for a wide variety of industrial applications. PCBs have been used commercially for insulating fluids for electrical equipment, hydraulic fluids, heat transfer fluids, lubricants, plasticizers, and components of surface coatings and inks.[3] The PCB mixtures marketed under different trade names are often characterized by a four-digit number. The first two digits denote the type of compound, with "12" indicating biphenyl, and the latter two digits giving the weight percentage of chlorine.

The International Agency for Research on Cancer has concluded that the evidence for PCBs' carcinogenicity to animals and to humans is limited. "Certain polychlorinated biphenyls are carcinogenic to mice and rats after their oral administration, producing benign and malignant liver neoplasms. Oral administration of polychlorinated biphenyls increased the incidence of liver neoplasms in rats previously exposed to N-nitrosodiethylamine".[4]

B. Exposure Criteria

NIOSH recommends that exposures to PCB's be controlled to the lowest feasible level (LFL). Airborne exposure to PCBs in the workplace should be limited to not more than the minimum reliable detectable concentration of 1 microgram of PCB per cubic meter of air (ug/m^3) (using the recommended sampling methods) determined as a time-weighted average (TWA) for up to a 10-hr workday, 40-hr workweek. The NIOSH Recommended Exposure Limit (REL) was based upon the findings of adverse reproductive effects in experimental animals, on the conclusion that PCBs are carcinogenic in rats and mice and, therefore, potential human carcinogens in the workplace, and on the conclusion that human and animal studies have not demonstrated a level of exposure to PCBs that will not subject workers to possible liver injury.[5] The Occupational Safety and Health Administration (OSHA) promulgated its permissible exposure limit (PEL) of 1 mg/m^3 for airborne chlorodiphenyl products (PCBs) containing 42% chlorine and 0.5 mg/m^3 for chlorodiphenyl products containing 54% chlorine determined as 8-hr time-weighted average (TWA) concentrations based on the 1968 Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH).[6] The TLVs, which have remained unchanged at 1 mg/m^3 and 0.5 mg/m^3 through 1986, are based on the prevention of liver injury in exposed workers. The ACGIH Short Term Exposure Limits (STEL) for airborne chlorodiphenyls are 2 mg/m^3 and 1 mg/m^3 for 42% and 54% chlorine products, respectively. The OSHA PEL and the ACGIH TLV and STEL values include a "Skin" notation which refers to the potential contribution to overall exposure by the cutaneous route, including the mucous membranes and eyes, by either airborne or direct skin contact with PCBs.

There are no standard evaluation criteria (RELs, PELs, or TLVs) for industrial or office building surfaces contaminated with PCBs. In July of 1985, an advisory panel was convened to provide guideline recommendations for air and surface cleanup for PCBs, dioxins, and furans for the State Highway Department Building in Santa Fe, New Mexico.[7] Both NIOSH and the Environmental Protection Agency were represented on this panel. The guidelines established included specifications for PCB concentrations not to exceed 50 ug/m^2 on "working" surfaces. Examples of working surfaces included "high contact" areas such as desk tops and chairs.

VI. Results

Results for all samples are presented in Table 1. Those for air samples are under the column headed with the units ug/m^3 (micrograms per cubic meter). Those for surface wipe samples are under the column headed with ug/m^2 (micrograms per square meter).

A. Air Samples

The PCB air concentrations in the reference rooms, room 200, room 201, and the library office were (0.1), (0.1), and 0.1 ug/m^3 respectively. Values reported in parentheses are considered to be trace quantities (quantities above the analytical limit of detection, yet insufficient for accurate quantitation). Aroclor 1242 was detected in the library office and Aroclor 1254 in the other two rooms.
The PCB air concentrations were (0.1), 0.2, 0.3, and 0.4 ug/m^3 in the index rooms 223, 210, 227, and 237 respectively. Aroclor 1242 was detected in rooms 237 and 210. Aroclor 1254 was detected in rooms 223 and 227. Although these concentrations are below the occupational exposure criteria, they should be viewed with caution and regard since they are up to four times greater than those found in the reference areas of the building, and the exposure is not limited to working adults.

B. Surface Wipe Samples

Surface concentrations of PCBs found on high contact surfaces in all the sample locations ranged from (0.6) to 2.4 ug/m^2. Low contact surface contamination ranged from 1.6 to 9.2 ug/m^2. Aroclors 1242, 1254, and 1260 were detected. Only one of the Aroclors was seen on a particular sample. These concentrations are low when compared to surface concentrations of PCBs previously measured by NIOSH researchers in one study in commercial buildings, where high contact surfaces ranged from none detected (1 ug/m^3) to 45 ug/m^3 and low contact surfaces ranged from none detected (5 ug/m^3) to 72 ug/m^3.[8] In another study, the PCB concentrations on high skin contact surfaces ranged from none detected (1 ug/m^2) to 5.9 ug/m^3, and averaged 1.3 ug/m^3.[7] There does not appear to be any difference between the reference and index areas in the school with respect to contamination on high contact surfaces.

VII. Discussion

The PCB concentrations measured indicate that fluorescent light ballast burnout may have occurred recently in some

of the index rooms. Another NIOSH study has shown that electrical burnout of in-service fluorescent light ballasts manufactured prior to 1978 can result in airborne and surface concentrations of PCBs above comparative background levels, and that these concentrations can remain elevated for several weeks, before returning to approximately background levels in about 5 months under "normal ventilation" conditions.[8] PCB air concentrations can easily exceed 1 ug/m^3 following ballast burnout.

The PCB concentrations measured at Henry Ford High School were below occupational exposure criteria. While exposures to PCBs at these levels have not been found to be detrimental to the health of normal, healthy, working adults, there is a large population of adolescents attending this school whose exposure should be minimized to the extent feasible. The elevated PCB concentrations in the index rooms, when compared to the reference rooms, should be viewed as an unnecessary exposure. This reasoning should justify the removal of all PCB-containing ballasts in the school. Most are approaching the end of their expected service life and may be prone to failure. Additionally, these findings are only indicators of historical episodes that likely resulted in higher exposure to PCBs and the irritating fume from the asphalt potting-compound. The acute symptoms reported are consistent with this type of exposure.

Reoccupancy of classrooms after a burnout situation should be preceded by ventilation and cleanup of contaminated surfaces. Nonionic surfactant detergents have been recommended for general surface cleaning.[6] The index rooms as well as any others suspected of being the site of ballast burnouts should be cleaned before being returned to general use.

VIII. Conclusions

Based on the increased air concentrations of PCBs found in the index rooms evaluated, recent PCB-containing ballast burnouts had most likely occurred. Because of the low acute toxicity of PCBs, a significant adult human health risk is not likely to be associated with being in a room for a short period of time during electrical burnout of a pre-1978 fluorescent light ballast. However, because of the large number of students potentially exposed to the elevated PCB concentrations and to the highly irritating smoke and vapor associated with ballast burnout, the NIOSH investigator believes that the prudent course to protect the health of the faculty and students would be to systematically remove all PCB-containing ballasts and replace them with ballasts which do not contain PCBs.

IX. Recommendations

1. In a systematic fashion, remove all PCB-containing fluorescent light ballasts in the Henry Ford High School and replace them with ballasts which do not contain PCBs.

2. In the interim, when a PCB-containing ballast fails, proper procedures should be followed to minimize the potential exposure to PCBs via inhalation, dermal absorption, or ingestion. They are:

    a. turn off the light fixture and remove persons from the room as soon as possible;

    b. open the windows in the room and take any measures possible to vent room air directly to the outdoors and replace it with fresh air;

c. remove the failed ballast;

d. clean up any asphalt-residue that may have leaked from the ballast;

e. and wipe down the top surfaces of general contact items (such as desks, chairs, tables, etc.).

X. References

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XI. Authorship and Acknowledgements

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XII. Distribution and Availability of Report

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Henry Ford High School
2. OSHA, Region V
3. NIOSH Cincinnati Region

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 1
Air and Surface Wipe Sample PCB Results*
Henry Ford High School, Detroit, Michigan, May 27, 1987
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Location	Sample Information: Volume m^3	Sample Information: Area m^2	Concentration ug/m^3	Concentration ug/m^2
Room 227	0.99		0.3	
Teacher desk top		0.50		1.3
Student desk top (2)		1.00		0.7
Top of Storage Cabinet		0.50		8.6
Room 237	0.99		0.4	
Teacher desk Top		0.50		0.6
Student Desk Top (2)		1.00		1.7
Top of Storage Cabinet		0.50		2.0
Room 223	0.99		(0.1)**	
Teacher Desk Top		0.50		(0.9)
Student Desk Top (2)		1.00		0.8
Top of Storage Cabinet		0.50		2.8
Library Office	0.99		0.1	
Countertop Behind Desk		1.00		1.0
Countertop Right of Desk		0.50		2.0
Bookshelf Top		0.50		7.4
Room 200	0.98		(0.1)	
Teacher Desk Top		0.50		(1.0)
Student Desk Top		1.00		1.6
Room 201 (Counselor Suite)	0.99		(0.1)	
Counselor Desk Top		0.50		1.3
Table Top		0.50		2.4
Top of Storage Cabinet		0.50		4.7
Room 210	0.99		0.2	
Teacher Desk Top		0.50		1.9
Student Desk Top		0.50		(0.6)
Top of Storage Cabinet		0.25		9.2

* Air sample results are reported in micrograms per cubic meter (ug/m^3) of air, and surface wipe samples are reported in micrograms per square meter (ug/m^2) of surface area.

** Values in parentheses are between the analytical LOD and LOQ. These are given in Section IV., Evaluation Design and Methods.