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Case Studies

Survey of Lead Contamination in an Office Building

Dawn Tharr, Column Editor

Reported by Christopher F. Lovelace, Mary T. Giguere, John J. Curran, Peter D. Morris, Luanne K. Williams, and Paul A. Matson

Introduction

In response to employees' complaints concerning particulate fallout from heating, ventilation, and air conditioning (HVAC) ductwork, the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR) performed an evaluation of the North Carolina Department of Transportation's (NCDOT) office buildings in downtown Raleigh, North Carolina. The evaluation confirmed the presence of lead in dust in the office buildings. The investigation involved multiple sampling periods and was performed from January to August 1992. Wipe samples, settled dust samples, air samples, and employee blood lead levels (BLL) were measured. This project involved a variety of measurement techniques and resulted in findings that may be of interest to others investigating HVAC contamination.

Background

The central offices of the NCDOT in Raleigh, North Carolina, are housed in a complex of three connected buildings: the Highway Building, the Annex Building, and the Museum Building (Figure 1).

The Highway Building, constructed of native stone, was completed in 1953. It is six stories high (basement, ground, 1–5), and contains approximately 90,000 net usable square feet of floor space. Approximately 450 employees work in this building.

The Annex Building was completed in 1965 and is of similar construction. It is attached to the west arm of the Highway Building; walk-through hallways connect floors 1–5 of these two buildings. The Annex Building contains approximately 47,000 net square feet of floor space, and approximately 350 employees work in this building.

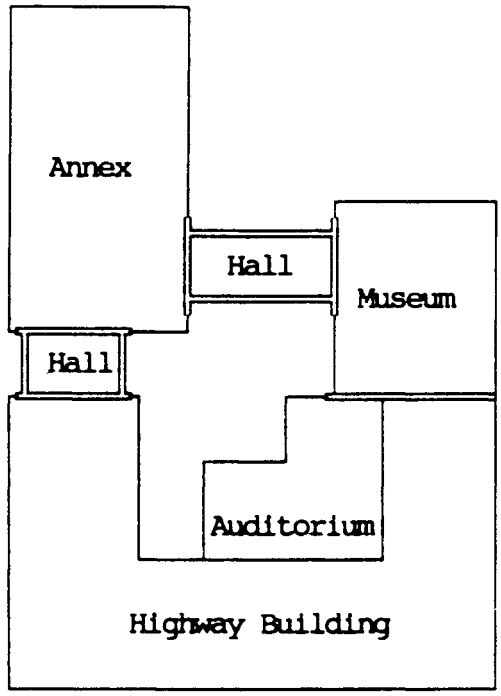

FIGURE 1. Schematic of project area (not to scale).

In both the Highway Building and the Annex Building, heat is supplied to HVAC units on each floor from a central steam station located off-site. Ductwork distributes forced air for heating and air conditioning. Air returns for recirculation are located at various locations on each floor of both buildings.

The Museum Building is three stories tall and of similar age to the Highway Building. It is attached by hallways to both the Highway Building and the Annex Building. This building has an HVAC system completely separate from the other two buildings. For this reason, the building was omitted from environmental evaluation.

Conversations with NCDOT officials determined that the HVAC ductwork in the buildings had never been cleaned, with the exception of one wing of the first floor of the Highway Building that was cleaned in 1990. The HVAC systems were turned off each evening and restarted each morning in an effort to increase energy efficiency.

Environmental Sample Collection Methods, Results, and Observations

January–April 1992

Lead in dust in the Highway Building was originally discovered in January 1992. In response to an employee's complaints about air quality and the presence of fallout from the ductwork, a bulk dust sample was analyzed. The analysis showed that this sample contained 1.17 percent lead by weight.

An initial building survey by the NCDEHNR was conducted in April 1992. Black particulate, ranging from

less than 1 mm to greater than 5 mm in diameter, was found in almost all areas of the Highway Building and, to a lesser extent, throughout the Annex Building. Employees indicated that the material often covered desks, filing cabinets, and computers and that this particulate was being released from the ductwork in large quantities. Visual inspection of the interior of ductwork revealed similar particulate material.

After the initial building survey, the NCDEHNR performed wipe and air sampling to establish if lead was present in the buildings. Wipe samples (n = 2) indicated the presence of lead on surfaces. Methods of wipe sample collection involved use of unscented, aloe-free, and alcohol-free store brand baby wipes (per conversation with John Neefus, Research Triangle Institute) according to U.S. Department of Housing and Urban Development (HUD) protocol.[9] Wipe samples were analyzed using National Institute of Occupational Safety and Health (NIOSH) Sampling and Analytical Method 7082 with a prior ashing step to remove the organic matrix; analysis was performed in the laboratory facilities of NCDEHNR. Of these samples, one collected from the window sill in a library storage room indicated that 7231 $\mu g/m^2$ of lead were present.

Air samples (n = 5) were collected to help determine if airborne lead was an occupational hazard to employees. Areas sampled in the Highway Building included the fifth floor library and other fifth floor rooms where employees were concerned about air quality. Air samples were collected and analyzed using NIOSH Method 7082, with analysis done in state laboratory facilities (NCDEHNR). Analyses showed that airborne lead concentrations were below the limit of detection (LOD = 4.2 $\mu g/m^3$). It was concluded that airborne lead was not a hazard for employees in the areas tested.

June 1992

One wipe sample, two bulk material samples, and two settled dust samples were collected in the Highway Building. All of these samples showed the presence of lead. The settled dust sample collection devices were of special construction and consisted of an open plastic box with an adhesive-coated 36 cm^2 surface (manufacturer, R.J. Lee Group). The settled dust samples indicated that fallout from the duct work was accumulating at a rate of 255 $\mu g/m^2/24$ hrs in the fifth floor library and 292 $\mu g/m^2/24$ hrs in an office on the first floor. These results prompted further investigation.

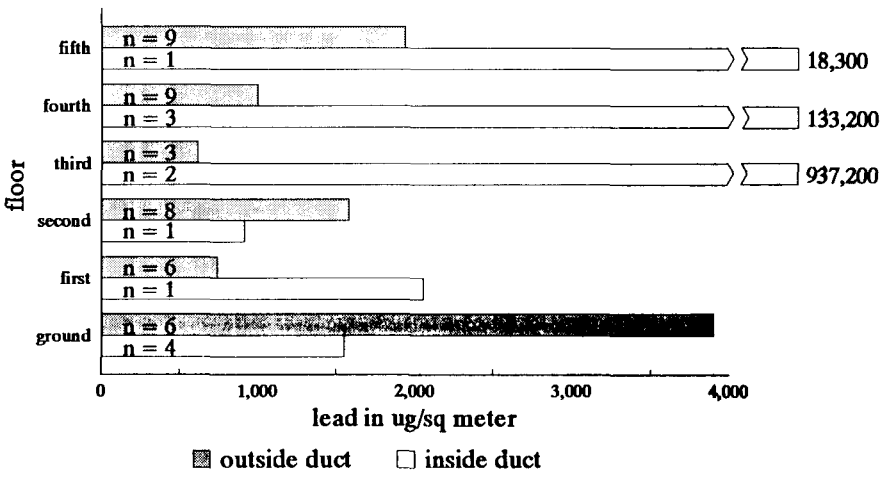

FIGURE 2. Wipe samples from highway building.

July 1992

Comprehensive sampling, including wipe and air samples, was conducted from July 20–23, 1992.

In the Highway Building, wipe samples were collected at multiple locations on all floors (n = 8 inside ductwork, n = 29 outside ductwork) and showed that lead in dust was present inside the ductwork and on various surfaces outside the ductwork (Figure 2). The amount of lead present inside the ductwork ranged from 764 to 1,653,812 $\mu g/m^2$. The amount of lead present on surfaces such as floors, file cabinets, and desk tops ranged from nondetectable to 6607 $\mu g/m^2$.

Air samples collected at multiple locations on floors 1–5 and at one location in the basement of the Highway Building (n = 15) indicated that airborne lead dust concentrations were below the LOD.

In the Annex Building, wipe samples collected at multiple locations on floors 2–6 (n = 3 inside ductwork, n = 12 outside ductwork) showed that lead in dust was present inside the ductwork and on various surfaces outside the ductwork (Figure 3). Lead inside the ductwork ranged from 7661 to 13,235 $\mu g/m^2$. Lead on surfaces such as floors, file cabinets, and desk tops

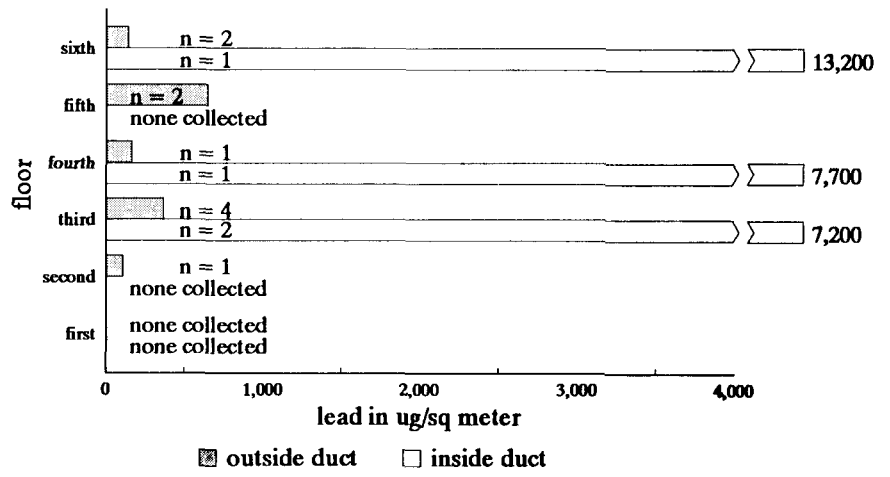

FIGURE 3. Wipe samples from annex building.

ranged from nondetectable to 1173 $\mu g/m^2$.

Air samples collected at multiple locations on floors 2–6 of the Annex Building (n = 10) indicated that airborne lead dust concentrations ranged from nondetectable to 5.3 $\mu g/m^3$.

At this time, it was discovered that partial cleaning of the ductwork had occurred and was to continue. We requested that this cleaning be discontinued until the sampling was completed and the findings could be used to guide a coordinated cleanup of both buildings.

After comprehensive sampling, the findings that lead dust was present throughout the Highway Building and Annex Building prompted us to make specific cleaning recommendations to NCDOT facilities management. The cleaning project, including generalized building cleaning and HVAC ductwork cleaning, was completed in early August 1992.

Biological Sampling, Methods, and Results

August 1992

After compilation of environmental data, meetings were conducted to determine a further course of action. At this time, there was particular concern among the NCDOT employees about their personal health risk from lead dust present in the building.

Because of the presence of lead-containing dust on work surfaces, there was the potential for the employees to ingest lead by hand-to-mouth activities, especially since large numbers of employees ate, drank, and smoked at their desks. A survey of employees found that 90 percent of the employees ate food, 100 percent drank beverages, and 10 percent smoked tobacco while in their offices. To estimate the risk of lead ingestion by hand-to-mouth activities, a health-protective surface level was calculated by assuming that employees' hands would have contamination equal to the contamination on indoor surfaces, that dust would be ingested from a 10 cm^2 area of skin while eating or smoking, and that 0.5 μg/day would be an acceptable intake for lead.[2,3] As a result of these considerations, 500 $\mu g/m^2$ was calculated to be a level of concern and was used to determine potential health risks to building occupants. This level is less than one-fourth the most stringent HUD clearance level of 200 $\mu g/ft^2$ (approx. 2160 $\mu g/m^2$). Thirteen, or approximately 25 percent, of the sampled areas outside the ductwork exceeded this level.

Since many areas outside the ductwork had lead levels greater than 500 $\mu g/m^2$, the decision was made to conduct BLL monitoring. Fifty-six randomly selected Highway Building employees had their BLLs measured. Questionnaires were administered to collect information on potential sources of lead exposure. In addition to the randomly selected group, 32 Highway Building employees, 20 Annex Building employees, and 22 Museum Building employees requested BLL measurement.

The BLL samples were collected by an outside laboratory and analyzed in a graphite furnace by atomic absorption. A conservative approach to determining elevated BLLs was used. A BLL of >10 μg/dl was considered elevated; this is the level of concern for women of childbearing age.[4–7]

No employees had elevated BLLs. The mean BLL for the randomly selected individuals in the Highway Building was 1.5 μg/dl (range, 0–5 μg/dl). The mean BLL for the group of employees in the Highway Building who requested testing was 1.6 μg/dl (range, 0–4 μg/dl). The mean BLL in the Annex Building employees was 1.8 μg/dl; (range, 0–7 μg/dl), and the mean BLL in the Museum Building employees was 1.7 μg/dl (range, 0–4 μg/dl).

Environmental Sample Collection Results and Observations After Cleanup

August 1992

After the HVAC duct cleaning, further environmental sampling was con-

ducted to evaluate the cleaning operation and for use in conjunction with the biological monitoring.

Wipe samples were collected at multiple locations in the basement and on floors 1, 2, 4, and 5 of the Highway Building ($n = 5$ inside ductwork, $n = 10$ outside ductwork) and floors 2 and 3 of the Annex Building ($n = 1$ inside ductwork, $n = 3$ outside ductwork). Results ranged from 1560 $\mu g/m^2$ to 194,218 $\mu g/m^2$ inside ductwork and from nondetectable to 581 $\mu g/m^2$ on surfaces outside the ductwork.

Air samples were also collected on floors 1, 3, and 5 of the Highway Building ($n = 3$). Airborne lead dust concentrations were below the LOD.

Discussion of Possible Sources of Lead Contamination

Wipe samples from inside the duct work were later collected in various areas of the basement and on the fifth floor of the Highway Building and analyzed for other metals, including zinc. Zinc averaged 207,967 $\mu g/m^2$ ($n = 4$); lead in these same samples averaged 23,774 $\mu g/m^2$. These results indicate that one of the potential sources of the lead was the galvanized ductwork. The zinc/lead components of the galvanization process may have oxidized over the years and become a part of the overall dust component of the building.

A major offset printing operation was located on the first floor of the Highway Building for approximately 30 years. This operation was moved out of the building in 1990. A smaller reproduction area was located on the 5th floor during the same period. However, the use of lead-containing inks in these printing operations was never definitely established.

The lead in dust in the buildings was probably present from multiple external and internal sources. Potential external sources include leaded gasoline, paving operations, coal and oil combustion by-products, and deteriorated lead-based paint. Potential internal sources include renovations, printing media, solder, and the galvanized ductwork. Dust and debris inside the ductwork was dislodged by vibration during daily HVAC system start-up. Small amounts of lead were added to the total building dust over a long period of time and accumulated inside and outside of the ductwork. Because air returns were located inside the contaminated buildings, the lead-containing dust had the potential to recirculate many times through the ventilation system.

Conclusions

Our investigation found that NCDOT buildings were contaminated with lead-containing dust which was distributed throughout the buildings by the HVAC system. However, the amount of lead present on the working surfaces of the offices was not a good indicator of employee intake of lead, as measured by BLL. Building and ventilation system cleanup seemed to reduce the amount of lead-containing dust present, although there continued to be measurable amounts of lead present on most surfaces both inside and outside the ductwork.

The results of this investigation suggest there may be minimal risk of lead toxicity to employees working in buildings where similar lead concentrations exist. Our calculated level of concern for lead on surfaces (500 $\mu g/m^2$) may have been overly conservative for this group of adults. However, health risks may differ for children, whose behavior may put them at increased risk for lead ingestion. This investigation also demonstrates that it may be difficult to totally remove lead-containing dust from a building by conventional cleaning procedures. Knowledge of the sampling methods used and environmental and biological results obtained in this investigation may help other occupational health professionals determine a course of action when faced with a similar situation.

Acknowledgments

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