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Case Studies

Benzene Exposure and Leukemia

Dawn Tharr, Column Editor

Reported by Leonard D. Pagnotto

Background

A technician who had used benzene for 5 years to calibrate laboratory instruments developed leukemia 15 years later and died. This article deals with an investigation of the technician's workplace and work practices. The workplace was a laboratory with no windows or ventilation fans. The benzene was poured from a pint bottle into a small cuvette and used to calibrate spectrophotometers. The pouring procedure was awkward and usually resulted in some skin contact with liquid and vaporized benzene. The pouring procedure was replicated three times in a well-ventilated laboratory and the breathing zone air of the pourer was monitored to determine benzene exposure during this procedure. Even under these well-ventilated conditions, benzene vapor exposure was as high as 17 ppm during the first 3 minutes of the procedure. Calculations were also made to estimate benzene skin absorption that may have occurred from benzene spilled on the technician's hands. In addition to the benzene liquid and vapor exposure from the pouring process, the technician reported that several major benzene spills had occurred in the laboratory. On one occasion, he spilled one-third of a pint of benzene on the laboratory floor. He mopped the floor with paper towels and discarded them in an uncovered trash can. It was concluded that the technician's dermal benzene absorption and benzene vapor exposure during his employment put him at risk of developing leukemia.

Introduction

Benzene is a colorless, highly flammable, nonpolar liquid with an odor characteristic of aromatic hydrocarbons. Most benzene is consumed in the chemical industry as a raw material for numerous organic chemicals. It is also used as a reagent in chemical laboratories and, as in this case, as a reference for calibrating spectrophotometers.

Benzene produces narcotic effects. However, the effects of chronic exposure to this compound are by far the most important. Benzene is capable of producing leukemia and other diseases of the blood and blood-forming organisms. Some effects such as leukemia may develop several years after cessation of exposure to benzene. The technician in this case was never informed about these effects.

The technician was exposed to benzene for 5 years (1971–1975), and developed leukemia 15 years later. He died the following year at the age of 42. A year before his death he complained of headache, excessive fatigue, flu-like symptoms, and excruciating pain in his legs below the knees. His physician found that he had developed leukemia.

Details of his work practices and benzene handling procedures were described by the technician in a deposition taken from him in 1990, a year before he died. Some of the information found in this report was taken from this deposition. The rest of the report deals with an investigation of the technician's workplace.

The technician repaired, calibrated, and installed laboratory equipment in laboratories. He spent 90 percent of this time on field assignments during the early part of his employment. Later his work was done largely in his company's service department.

The service department where he worked was a relatively small room that measured 15 × 45 ft with a ceiling height of nearly 10 ft. It was essentially a passageway between a warehouse and a large office. Two vents that were part of the heating system were located in the ceiling, but there were no windows or ventilation fans. Thermostats controlling the service department environment were located in the main office. Any ventilation provided to the service department was limited to fugitive cross-drafts between the main office on one side and the warehouse on the other. The door to the office was usually kept open except when office personnel detected chemical odors; this occurred, according to office workers, two to three times a week. It was reported that 6 to 8 pints of benzene were used over a period of 5 years. In addition to benzene, trichlorethylene and alcohols were also used in the service department.

The technician used benzene to calibrate spectrophotometers. He explained in his deposition that he would pour two or three drops of benzene from a pint bottle with a mouth opening of approximately 1 inch directly into a small glass cuvette with a 0.5-inch^2 opening. He wiped the excess benzene from the outside of the cuvette, capped it, and placed it in the sample holder of the spectrophotometer. The pouring took only a few seconds, but the calibration procedure took a minimum of 20 minutes if significant adjustments were not required. Calibrations with benzene over a 5-year period were performed as often as four or five times a day. After each calibration, the benzene remaining in a cuvette was dumped into a laboratory sink. The technician mentioned in his deposition that when pouring the benzene in the manner described earlier, some of it would spill on his hands. Sometimes the benzene would run down his hands and the skin would turn white. It would remain so until he wiped it off or washed his hands. He wore no protective garments or respirator.

The technician also recalled four or five sizable spills that occurred. On one occasion, he reported that he was interrupted while trying to pour a few drops of benzene into a cuvette and spilled one-third of a pint of the solvent. He said the benzene ran down his left arm and fell to the floor. He mopped up the benzene from the floor with paper towels and discarded the towels in an uncovered trash can. He also said that empty benzene bottles were always discarded in the trash.

Exposure Estimates

No air tests were ever performed during the technician's 5-year benzene exposure period. In the absence of such exposure information, replicates were performed of the pouring operation as described by the technician to determine the extent of his benzene exposure. The procedure was performed three times in a well-ventilated laboratory (10 to 12 air

TABLE 1. Benzene Pouring Experiment

Time interval	Trial 1	Trial 2	Trial 3
0–3 minutes	17	6	13
0–5 minutes	9	5	8
0–10 minutes	6	2	5
15–35 minutes	—	—	0.8

changes per hour). Benzene (0.5 ml) was allowed to spill on the outside of the cuvette. Some spillage was expected because of the awkward pouring procedure used by the technician.

For these experiments, a respirator with a charcoal filter was worn. Air samples on charcoal tubes positioned in the breathing zone were collected and analyzed for benzene by gas chromatography. The results are reported in Table 1. Even under well-ventilated conditions, benzene vapor averaged as high as 17 ppm during the first 3 minutes after the benzene was poured and the cuvette was capped. The average benzene exposure over a period of 15 to 35 minutes after the pouring was still significant. The technician sometimes performed five calibrations a day in a poorly ventilated room.

In addition to his airborne benzene exposure, it was quite likely that the technician also absorbed significant amounts of benzene through his skin. The technician in his deposition mentioned that some benzene would spill on his hands when he poured it. Calculations were made to estimate how much skin absorption would occur from a spill of as little as 1 ml of benzene on the palm of his hand.

Several studies have evaluated dermal absorption of benzene to human skin. Maibach, exhibits 231–6 and 231–7 in the 1987 OSHA Benzene Standard, reported that 0.065 percent absorption occurred from a single application of undiluted benzene to the intact skin on the forearm of human volunteers. A twofold increase in benzene absorption (0.128%) was noted when the palm of the hand was exposed. Franz, exhibit 159–30 in the 1987 OSHA Benzene Standard, found that 0.05 percent of the benzene applied to the forearm of volunteers was absorbed. No tests on the palm of the hand were performed.

Based on this information, the technician may have absorbed 5 to 6 mg of benzene through the palm of his hand on days he performed five calibrations. If the technician's skin was damaged from repeated exposures to benzene, the absorbed dose would be much higher. According to National Institute for Occupational Safety and Health investigators as reported in the 1987 OSHA Benzene Standard, 6 mg of benzene absorbed through the skin may be compared to an estimated 14 mg of benzene that would result from the inhalation of 1 ppm over an 8-hour day.

Conclusion

It is concluded from the information provided in this report that the technician's benzene exposure was high and he was at considerable risk of developing leukemia.

Acknowledgment

The air samples were analyzed by Robert Kenrick, Chief of Laboratory, Massachusetts Division of Occupational Hygiene.

EDITORIAL NOTE: Leonard D. Pagnotto is with LDP Associates, Inc., 12 Johns Avenue, Medfield, Massachusetts 02052; telephone: (508) 359-5696.

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