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Case Studies
An Industrial Hygiene Survey of an Office Building in the Vicinity of the World Trade Center: Assessment of Potential Hazards Following the Collapse of the World Trade Center Buildings

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INTRODUCTION AND BACKGROUND

Two months after the attack on the World Trade Center (WTC) in New York City, representatives of the U.S. Department of Health and Human Services (DHHS), who occupied the Federal Office Building (FOB) at 26 Federal Plaza, requested that the National Institute for Occupational Safety and Health (NIOSH) determine whether contaminants generated from the destruction of the WTC buildings were responsible for the chronic sinus infections, allergies, asthmatic bronchitis, and other health problems that they were experiencing.

This case study summarizes an industrial hygiene investigation conducted between November 12 and 15, 2001, that was designed to characterize the environment on the floors of the FOB where 400 DHHS employees worked at the time of the survey.(1) The FOB is 5 blocks northeast of the WTC site and consists of 3 interconnected structures that cover 2.8 million square feet of office space and is occupied by about 8000 workers.

METHODS

The investigation began with a preliminary survey of the complex's more than 100 air-handling units and fresh air intakes on the 15th and 44th floors that provided fresh air to the upper floors of the building. Fresh air intakes that provided ventilation to the lower floors and basement were not evaluated in this survey.

Sampling locations were selected based on: (1) areas where employees expressed concerns about environmental exposures; (2) heating, ventilation, and air conditioning (HVAC) areas of operational importance such as the air intakes on the 44th floor; and (3) unique areas including the cafeteria, parking garage, and lobby.

Area air samples were collected for analysis of a number of chemical elements as well as asbestos, carbon monoxide (CO), volatile organic chemicals (VOCs), total dust, polynuclear aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) to assess whether those substances had entered the complex as a result of the WTC collapse.(2,3)

Chemical Elements

Air, bulk dust, and surface wipe samples were collected for analysis of a number of chemical elements using a PerkinElmer Optima 3000 DV inductively-coupled plasma spectrometer as described in NIOSH Method 7300.(2)

Asbestos

Bulk samples of settled dust from the 44th floor air intakes were analyzed for asbestos, as were air samples, using NIOSH validated methods 7400, 7402, and 9002, as appropriate.[2]

Total Dust and Particle Size Analysis

Air samples from the selected locations were analyzed for total dust (NIOSH Method 0500).[2] Samples were also analyzed for particle concentration and size distribution using real-time light-scattering aerosol spectrometers. The Grimm Model 1105 was used for diameters between 0.5 and 15 μm, and the Model 1106 was used for diameters between 0.3 and 6.5 μm (Labortechnik GmbH & CoKG, Ainring, Germany).[3]

The calibration of these spectrometers varies with the properties of the aerosol being sampled and thus the output provides only the relative aerosol particle concentration. Therefore, samples for total particulate were collected near the aerosol spectrometer sampling probe to obtain data that could be used in conjunction with the aerosol spectrometer data to calibrate the instruments and to derive a conversion factor to adjust the real-time concentration. The conversion factor was obtained by dividing the total particulate sample result by the integrated particulate concentration obtained from the aerosol spectrometer.

Fine Particle Counts

A handheld condensation particle counter Model 3007 (TSI Inc., St. Paul, Minn.) was used to count particles having diameters between 0.01 and 1 μm with an upper concentration limit of 5×10^5 particles/cc at a flow rate of 100 cc/min.

VOCs

Samples for determination of VOCs were collected on both thermal desorption and charcoal tubes.

Thermal Desorption Tubes

Area air samples for VOC determination were collected on thermal desorption tubes having three sections: a front layer of Carbopack Y™, a middle layer of Carbopack B™, and a back layer of Carboxen 1003™. Analysis was performed by NIOSH (PerkinElmer ATD 400 automatic thermal desorption system and gas chromatograph with a mass selective detector). This procedure has not been validated by NIOSH for the compounds of interest, thus, the results are estimates of the true concentration.

Charcoal Tubes

Air samples collected on charcoal tubes were analyzed for benzene, toluene, xylenes, methyl-*t*-butyl ether (MTBE), 2-methoxy-1-propanol, methyl isobutyl ketone (MIBK), butyl cellosolve, and total "other" hydrocarbons by DataChem Laboratories, Inc. (Salt Lake City, Utah) using a Hewlett-Packard Model 5890A gas chromatograph equipped with a flame ionization detector.

PCBs

Air samples for PCB determination were collected on Tenax tubes. A stock solution of Arochlor 1254 in methylene chloride was used to "spike" blank tenax tubes over the range of 20–200 ng per tube to determine their collection and desorption efficiencies.

PAHs

Air samples for PAHs were collected on polytetrafluoroethylene filters followed by a washed XAD-2 sorbent tube using NIOSH Method 5506.[2]

CO

CO was determined using the direct reading ToxicUltra Atmospheric Monitors (Biometrics, Inc.) with an electrochemical CO sensor (nominal range: 0–999 ppm) calibrated before and after use according to the manufacturer's recommendations and operated in the passive diffusion mode, with a 30-sec sampling interval.

RESULTS

Elemental Analysis

Qualitative analysis of bulk and wipe samples revealed the presence of various chemical elements. While most air samples were below the limit of detection (LOD), a few were detectable but at concentrations well below those known to be related to adverse health effects among workers.[4]

Asbestos

One of two samples of settled dust analyzed by polarized light microscopy (NIOSH Method 9002) indicated the presence of chrysotile (1–<3%); the other contained <1% chrysotile.[2] Area air samples analyzed by phase contrast microscopy (NIOSH Method 7400) revealed fiber concentrations that were between the LOD and the limit of quantitation (LOQ) (0.004–0.025 fibers/cc). Subsequent analysis by transmission electron microscopy (NIOSH Method 7402) revealed that the fibers in the air samples were not asbestos.

VOCs

Thermal Desorption Tubes

The VOCs found in the FOB included: benzene, toluene, xylenes, MTBE, MIBK, butyl cellosolve, and total "other hydrocarbons." The greatest VOC concentrations (such as benzene, MTBE, and "other hydrocarbons") were found in the garage area near the loading dock under the building and were most likely the result of diesel engine combustion products generated by trucks that remained running while at the loading dock.[1]

Charcoal Tubes

Most of the samples were below the LOD, but for analytes that were detectable, their concentrations were well below those associated with adverse health effects. For example, benzene at 0.002 ppm and toluene at 0.01 ppm were found in the parking garage near the loading dock.

CO

Mean CO concentrations varied by location within the FOB (0.1–1.9 ppm); however, one sample taken at the loading dock while a diesel-powered truck was running indicated a peak concentration of 8.0 ppm.

PAHs

Traces of anthracene and fluoranthene were found in amounts above the LOD but below the LOQ.[2] The estimated concentration of anthracene was $<0.14\ \mu g/m^3$. The estimated fluoranthene concentration was $<1.2\ \mu g/m^3$(Occupational Safety and Health Administration permissible exposure limit = $0.2\ mg/m^3$). A trace of benzo(a)anthracene ($0.24\ \mu g/m^3$) was also found.

PCBs

No PCBs were detected on any of the thermal desorption tubes.[5]

Total Dust and Particle Size Analysis

Analysis of total and respirable dust samples indicated that concentrations were well below any established occupational exposure limits or guidelines and would probably be well below the Environmental Protection Agency ambient air standards for particulates having diameters of 10 μm or less (150 $\mu g/m^3$, 24 hour standard) and 2.5 μm or less (65 $\mu g/m^3$, 24 hour standard).[6]

Fine Particle Counts

The mean concentration of fine particles ($<1\ \mu$m) in office areas and hallways ranged from about 1661.0 ± 55 particles/cc in a corner office to 37,843.8 ± 268.5 particles/cc in a hallway on the fourth floor. Samples from elevators, the cafeteria grill, loading dock, basement garage, and a basement X-ray room in the FOB ranged from 7277.6 ± 207.6 particles/cc (basement hallway) to 335,923.5 ± 15,241.9 particles/cc (basement garage). Samples collected outside the FOB ranged from about 57,000 particles/cc on the roof to 63,000 particles/cc at ground level on the south side, and 80,000 particles/cc on the north side—indicating that a significant portion of the external dust particles were captured by the HVAC filters.

DISCUSSION

This investigation was designed to determine whether contaminants that resulted from the collapse of the WTC buildings had entered the FOB and adversely affected the health of DHHS workers.[7] The industrial hygiene investigation was performed in conjunction with medical/epidemiological investigation of the DHHS workers.[8] It is undisputed that a large dust cloud spread over lower Manhattan in the wake of the collapse of the WTC buildings and the fires that persisted for several days produced a variety of chemical contaminants. However, the composition and concentration of those contaminants at the time that the WTC buildings collapsed will never be known, as is the case for contaminants that existed in or around the FOB. Therefore, there is no way of knowing how the indoor air quality of the FOB and the current health of the workers in the building were affected at the time of the collapse of the WTC. That uncertainty is the basis for the most significant limitation of this investigation.

While there were similarities among the trace VOCs found in both the FOB and at the WTC site, the patterns of the major compounds found in the FOB did not match those found at the WTC site after September 12, 2001.[5,8] It is notable that many of the VOCs found in the FOB are typical of the substances that have been reported in other indoor air environments.[2,5,9,10]

An obvious concern was that the dust generated during the WTC collapse may have entered the FOB and resulted in higher than expected dust concentrations. However, the fine particle data presented in this report indicates that the building's HVAC system effectively removed a substantial percentage of those particles from the outside air. The higher fine particle concentrations found in the basement, garage areas, elevator, and kitchen grill likely resulted from diesel engine emissions and grease particles generated from the surface of the grill.

One reason for the higher particle concentrations in the basement parking garage area was the fact that the exhaust ventilation system in that location was not functioning properly. Furthermore, the exhaust system on the loading dock had been disconnected at the ceiling because it had been repeatedly damaged when vehicles struck the ductwork. Therefore, as the elevators located near the loading dock moved in their shafts, they had the potential for pulling engine exhaust into occupied areas of the building. The finding of benzene and toluene in the garage area was also not surprising since they are often present in gasoline, diesel fuel, and their combustion products.

HVAC Systems

Most of the FOB's air-handling units were variable air volume having variable frequency drive fans capable of flow rates ranging from 8000–80,000 cfm. The remaining air handlers were induction perimeter units that did not provide outside air.

In renovated portions of the FOB most of the exhausts were hard-ducted from each space. In the portion of the building that had not been renovated, the returns were designed to pull air from the corridors. All of the stairwells (except one that was located on the outside of the building) were enclosed but were not mechanically ventilated.

The FOB HVAC units were set to draw a minimum of 20% outside air but some areas, such as the garages and selected areas in the space occupied by two non-DHHS clients, were supplied with 100% outside air. The air that entered the building through the fresh air intakes was filtered through

2- or 4-inch prefilters (Precisionaire Economy) and 11.5-inch pleated filters (Pure Flo-cell). The manufacturer stated that the prefilter efficiency was 40% for particles at or about 1 μm and that the pleated filter efficiency was 80–85% for 1-μm particles.

Occupant Response

A number of the FOB occupants obtained portable air cleaners (PACs) for use in their workspaces. PACs are available in a wide variety of makes and models that use many different methods for cleaning the air including: HEPA filtration, carbon adsorption, ultraviolet irradiation, electrostatic precipitation, and negative ion generation.

There are several issues surrounding the use of PACs in office spaces. First, it is important to select a PAC that has an airflow capacity that is appropriate for the size of the room in which it will be used. Second, PACs require periodic maintenance. For example, HEPA filtration will capture 99.97% of particles having a diameter of 0.3 μm, and while the collection efficiency will increase with filter loading the airflow is reduced thus periodic filter replacement is required. Furthermore, carbon filters have been observed to degrade with loading. There is limited evidence that PAC use is associated with a reduction of asthma symptoms.[11]

CONCLUSIONS

NIOSH investigators conducted this evaluation to address DHHS employee concerns about ongoing building-related environmental exposures that may have been related to the WTC collapse. Some of their concerns were in response to symptoms reported among building occupants including headache and eye, nose, and throat irritation. The industrial hygiene survey described in this case study did not reveal any contaminant exposure that could explain the symptoms reported at the time of the survey. However, it is not possible to draw conclusions concerning exposure-related adverse health effects that may have resulted immediately following the WTC collapse. The results of VOC analysis from FOB air samples were similar to results obtained from other indoor environments.[9,10]

Recommendations

To prevent combustion products from entering the general ventilation system, all trucks should be turned off when parked in the building's garage or when they are on the loading dock. If that is not possible, a dedicated exhaust system should be installed to remove vehicle exhaust particles and gases. Further, the general ventilation in the garage should be improved to remove exhaust gases and particles generated by vehicles moving in and out of the garage and loading dock area. Similarly, particles generated in the cafeteria can be removed by local exhaust ventilation. These areas should also be kept under negative pressure relative to the rest of the building to avoid cross contamination.

Because asbestos was found in the settled dust in the air intakes prior to entering the HVAC system, those areas should be cleaned by licensed asbestos handlers as required by New York City law.[12] The feasibility of installing more efficient filters in the HVAC system and ensuring that their use does not result in increased static pressure that exceeds the system's limits should be explored.

If PACs are used in individual offices, they must be properly maintained and should be of the type that uses HEPA filtration. PACs that contain charcoal filtering media will help remove VOCs. Ozone-generating air cleaners are not recommended. Frequent vacuuming should minimize dust inside the building. Carpets and other upholstered surfaces should be vacuumed frequently with vacuums that contain HEPA filters. Nonporous surfaces should be cleaned with damp methods to prevent resuspension of settled dust.

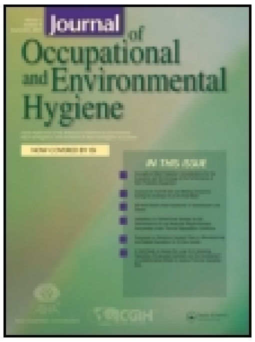
As is the case in any occupational environment, building employees who have work-related health concerns should report those concerns to their health clinic or other appropriate personnel. The staff of the health clinic should maintain a log of those concerns that includes a listing of symptoms and the work location of the employee. Periodically, clinic staff should provide building management with a summary of that information.

Managers and supervisors should receive training to ensure that they respond appropriately to employee health and safety concerns and steps should be taken to increase communication between management and employees. A health and safety committee consisting of workers and managers could be used to communicate these results and solve problems raised by employees.

REFERENCES

1. **National Institute of Occupational Safety and Health (NIOSH):** *Health Hazard Evaluation Report: 26 Federal Plaza, New York, NY* (2002-0038-2870). Cincinnati, Ohio: NIOSH (DHHS), 2002.
2. **National Institute of Occupational Safety and Health (NIOSH):** *NIOSH Manual of Analytical Methods 4th rev. ed*., Vol. 2. P.M. Eller, (ed.). Cincinnati, Ohio: DHHS (NIOSH), 1994.
3. **Grimm:** *Dust Monitor Instruction Manual* (Series 1.100 v.5.10 E). Ainring, Germany: Grimm Labortechnik GmbH & Co. KG.
4. **National Institute of Occupational Safety and Health (NIOSH):** *Recommendations for Occupational Safety and Health: Compendium of Policy Documents and Statements*. Cincinnati, Ohio: DHHS (NIOSH), 1992.
5. **National Institute of Occupational Safety and Health (NIOSH):** *CEMB Analytical Laboratory Report, Qualitative Analysis of Thermal Desorption Tubes* by A. Grote (Sequence Number 9801-AA, AB). Cincinnati, Ohio: HETA (NIOSH), 2001.
6. "National Ambient Air Quality Standards for Particulate Matter: Final Rule," *Federal Register 62*:138 (18 July 1997). pp. 38652.
7. **Trout, D., A. Nimgade, C. Mueller, R. Hall, and G.S. Earnest:** Health effects and occupational exposures among office workers near the World Trade Center disaster site. *J. Occ. Env. Med. 44*:601–605 (2002).
8. **National Institute of Occupational Safety and Health (NIOSH):** *New York City Department of Health (World Trade Center) Summary Report to the New York City Department of Health: NIOSH Air Sample Results for the World Trade Center Disaster Response* (HETA 2001-0554). Cincinnati, Ohio: NIOSH, 2002.

9. **National Institute of Occupational Safety and Health (NIOSH):** *Hazard Evaluation and Technical Assistance Report: Library of Congress, Washington, D.C.* (HHE 88-364-2104). Cincinnati, Ohio: NIOSH, 1991.
10. **Etkins, D.S.:** VOC measurements. In *Volatile Organic Compounds in Indoor Environments*. Arlington, Mass.: Cutter Information Corp., 1996. pp. 165–176.
11. **Institute of Medicine:** Indoor biologic exposures. In *Clearing the Air; Asthma and Indoor Air Exposure*. Washington, D.C.: National Academy Press, 2002. pp. 105–222.
12. **New York Committee for Occupational Safety and Health (NYCOSH):** "NYCOSH Factsheet 4. Cleaning Up Indoor Dust and Debris in the World Trade Center Area." [Online] http://www.nycosh.org/wtc-dust-factsheet.html. (2001).



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