Mercury Assessment
130 Liberty Street Property

Expert Report
Mercury

Report Date: May 2004

Prepared by:

RJ Lee*Group*, Inc.

350 Hochberg Road
Monroeville, PA
15146

Prepared for:
Deutsche Bank

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EXPERT REPORT OF Dr. Bobby Gunter and Dr. Richard J. Lee
SUBMITTED ON BEHALF OF DEUTSCHE BANK AG

1.0 Area of Expertise and Summary of Qualifications

Dr. Bobby J. Gunter was a Commissioned Officer in the United States Public Health service for 23 years where he worked for the National Institute for Occupational Safety and Health (NIOSH). Dr. Gunter published over 375 Health Hazard Evaluations, as well as articles in peer-reviewed journals. He is the author of the original NIOSH Asbestos Criteria Document and the Carbon Monoxide Criteria Document. He is the primary author of thirteen "Health and Safety Guides" that focus on health and safety hazards in specific industries and is co-author of chapters in several books. Dr. Gunter has presented scientific papers throughout the United States at numerous scientific meetings. Dr. Gunter served as the Course Director for Occupational Health and Industrial Hygiene at the Rollins School of Public Health at Emory University in Atlanta, Georgia from 1989 to 1998. He also directed graduate research for a number of students. In addition, he taught Occupational Health and Industrial Hygiene internationally for the World Health Organization (WHO) and the Pan American Health Organization (PAHO). He is an Adjunct Faculty member at Colorado State University and Oklahoma University School of Public Health. He is Board Certified in the Comprehensive Practice of Industrial Hygiene and is a Fellow of the American Board of Industrial Hygiene.

Dr. Richard J. Lee has spent 30 years developing techniques for characterizing respirable particles. Dr. Lee has used these techniques to investigate dust and debris in buildings throughout the United States. He has studied respirable asbestos, mineral wool, lead, fly ash, and other particle types and is widely regarded as a pioneer in this area. Dr. Lee developed the first computer-controlled electron microscope methods for determining the size and composition of airborne particles in an automated fashion. As early as 1980, he was retained by U.S. Environmental Protection Agency (EPA) to design a state-of-the-art particle characterization laboratory. His laboratory, RJ Lee Group, Inc., is the largest commercial electron microscope laboratory in the world. His company employs over 200 people, including personnel with advanced and specialized degrees in the areas of biology, chemistry, mineralogy, physics, geology, chemical engineering, electrical engineering, computer science, materials science, environmental science/engineering, civil engineering, mechanical engineering and industrial hygiene. Dr. Lee has published more than 100 papers in peer-reviewed journals, and has presented invited papers both nationally and internationally.

2.0 Expert Qualifications

Dr. Bobby J. Gunter has been qualified as an expert for the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), on lead and ammonia. He has been qualified as a mercury expert for the U.S. Department of Justice on a case involving the largest Superfund site in the United States. Dr. Gunter has also been qualified as an expert witness on carbon monoxide and hydrogen sulfide.

Dr. Lee has been qualified as a witness in State and Federal Courts as an expert in theoretical physics, materials science, exposure assessment, history of asbestos analysis and standards, particle characterization, aerosol physics, particle physics, particle transport, failure analysis, concrete analysis, cement chemistry, scanning electron microscopy, optical microcopy, transmission electron microscopy, chemical analysis, gas chromatography, physical testing, and product identification. Dr. Lee has testified on behalf of plaintiffs and defendants. He has not been precluded from testifying as an expert in any court.

3.0 Curriculum Vitae

The CV of Dr. Gunter is attached as Appendix A.

The CV of Dr. Lee is attached as Appendix B.

4.0 Purpose and Subject of the Report

In April of 2002, RJ Lee Group was retained by the law firm of Pitney Hardin LLP, on behalf of the Bank, to oversee and investigate the presence, type, amount, and extent of environmental contaminants in the Building. As a result of the WTC Event, a substantial amount of mercury was released.[1] This report summarizes the presence of mercury contamination within the Building and its systems and addresses the potentially adverse effects to human health resulting from the mercury contamination. The findings set forth in this report are based upon Dr. Bobby Gunter's and Dr. Richard Lee's review of the results of real-time mercury readings, extensive sets of analyses, their background, experience, and education, as well as their study of recognized scientific literature. The findings of prior Contamination Reports and the references cited therein; the underlying analytical data that have been previously published; and the Technical Memoranda produced in conjunction with this report are incorporated by reference.

[1] Nordgrén, Megan D., et.al., "The Environmental Impacts of the World Trade Center Attacks - A Preliminary Assessment," National Resources Defense Council. February 2002.

4.1 Background Information on Mercury

Mercury is the only metal that is liquid at room temperature. It is a heavy silvery white metal. It is a fairly good conductor of electricity but unlike most metals is a rather poor conductor of heat. It has a significant vapor pressure; at 20˚C a drop of liquid mercury vaporizes at a rate of 5.8 $mg/h \bullet cm^2$ and at its saturation point the surrounding air contains 13 mg/m^3, a level that far exceeds the human health risk levels (e.g., the OSHA PEL ceiling is 0.1 mg/m^3). The most important ore of mercury is cinnabar (HgS) (obtained by heating). Mercury is rarely found as a pure metal in nature. It easily forms alloys with many metals such as gold and silver which are called amalgams. Mercury in its elemental form is widely used in thermometers, barometers, thermostats, silent wall switches and fluorescent bulbs. Mercury can exist in both inorganic and organic forms.

"Mercury is a hazardous substance with unique qualities. Because of its high density, it tends to settle in cracks and crevices of interior spaces. It vaporizes at what is essentially room temperature and re-condenses to the liquid phase at cooler temperatures, adhering to surfaces. Its vapors are invisible and heavy, tending to settle in the breathing zone of children. The targets of exposure to mercury are believed to be the central nervous system and kidneys. Some of the effects of exposure to elemental mercury include tremors, depression, irritability, insomnia, emotional instability, and, at high doses, death."[2]

5.0 Opinions

Mercury is not present in normal Class A office buildings except at trace levels.[3]

The Building is contaminated with mercury above trace levels as a result of the WTC Event.

It was necessary to assess the extent and source of mercury contamination within the Building due to the toxic nature of mercury and its health risk.

Methyl mercury, a highly toxic form of mercury, is created by microbial action on metallic mercury and was found in trace amounts in the Building. Levels of methyl mercury will likely increase unless the source of mercury and bacteria are effectively remediated.

Mercury contamination within the Building is pervasive,[4] resulting in surface concentrations of mercury greater than Appropriate Levels[5] and elevated

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[2] U.S. Environmental Protection Agency (EPA), "EPA Superfund Record of Decision: Grand Street Mercury," EPA/ROD/R02-97/166. 1997.

[3] RJ Lee Group, "Contamination Report Pursuant to *Background Levels in Buildings* Summary Report," December 2003.

[4] RJ Lee Group, All Contamination Reports, December 2003.

airborne concentrations[6] of mercury exceeding warning and unsafe levels set by EPA, U.S. Agency for Toxic Substances and Disease Registry (ATSDR), and Occupational Safety and Health Administration (OSHA) (Appendix C).

The complex mixture of mercury species present in the fireproofing and oxide layer on the structural steel of the Building is statistically the same as the mercury species found in WTC Dust, demonstrating that the mercury is from a common origin, the WTC Event.

Certain remediation and demolition activities will increase the levels of mercury within the Building which at times are likely to exceed worker exposure limits.[6]

Mercury volatilizes into the air at room temperature and thus poses a unique health risk to any Building occupant.[7]

Returning the Building to normal operations would increase the temperature in the Building from current levels and result in elevated air levels of mercury in the Building.[6]

If the Building were reoccupied and returned to normal use without removing the mercury contamination, air levels of mercury in occupied spaces will likely increase to levels that exceed the health screening risk standards established for the Building.[7]

Based upon existing information, we cannot conclude that it is feasible to remediate the mercury from the Building.

I, Dr. Bobby Gunter, hold these opinions to a reasonable degree of scientific certainty. I, Dr. Richard J. Lee, hold these opinions to a reasonable degree of scientific certainty.

6.0 Basic Facts/Methodology

Additional Testing and Results Reported Herein:

H1: Mercury Speciation

H2: Mercury Air Monitoring

H3: Remediation of Steel

H4: Evaluation of Background Steel

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[5] Center for Toxicology and Environmental Health," Determination of Appropriate Levels for Surfaces in the Building," December, 2003.
[6] RJ Lee Group, "Technical Memorandum *H2: Mercury Air Monitoring*," May, 2004.
[7] Goad, Phillip T. et al., "Risk Assessment and Public Health Implications of WTC Dust Contamination of the Deutsche Bank 130 Liberty Street Property," May, 2004.

7.0 Summary of Specific Grounds for Each Opinion

Sources and Characteristics of Mercury[8,9,10,11,12,13]

Mercury's unique physical and chemical properties allow it to exist in many forms. It is the only metal that is liquid at room temperature and is different from other heavy metals in that it forms a metal vapor even at ambient temperatures (i.e., it is volatile).[14]

Elemental mercury has a high surface tension and it can dissolve other metals such as gold, silver, tin and aluminum to form alloys known as amalgams.[15,16,17] Mercury can exist in both inorganic and organic forms. Inorganic salts of mercury have been used as germicides and fungicides. Metallic and many organic species of mercury are volatile and can transfer through the vapor state and redeposit, as the vapor condenses, onto other surfaces. Airborne mercury concentrations are affected by temperature, airflow, moisture, activity levels, and the material on which it is condensed or deposited.[18]

A large amount of mercury was released during the collapse of the WTC towers and surrounding buildings due to the abundance of items containing mercury (such as fluorescent lamps, thermostats and other electrical components which were destroyed).[1] For example, mercury is a component of fluorescent lamps and is released into the air in a vaporized form if a lamp is broken. The mercury emissions from the disposal of fluorescent lamps are viewed with concern by regulators and the EPA has established proper disposal methods for waste lamps.[19] It was calculated that if one average-

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[8] Stwertka, Albert, "A Guide to the Elements," 2nd Edition, pp 181-183. 2002.

[9] Lide, David R., ed., "CRC Handbook of Chemistry and Physics," 75th Edition. Boca Raton, FL. CRC Press, p 4-18. 1995.

[10] Brady, J.E. and Holum, J. R., "Chemistry: The Study of Matter and Its Changes," pp 932, 965. 1992.

[11] Cotton, F. Albert and Wilkinson, Geoffrey, "Advanced Inorganic Chemistry," 5th Edition, pp 597-622. 1988.

[12] Greenwood, N.N. and Earnshaw, A., "Chemistry of the Elements," pp 1395-1422. 1984.

[13] Housecroft, Catherine E. and Sharpe, Alan G., "Inorganic Chemistry," p 537. 2001.

[14] Howard Hughes Medical Institute (HHMI), "Laboratory Chemical Safety Summaries: Mercury," http://www.hhmi.org/research/labsafe/lcss/lcss57.html, 1995; accessed March 31, 2004.

[15] Hatch, John, E. editor, "Aluminum: Properties & Physical Metallurgy," Published Metals Park, OH: American Society for Metals, Corrosion Behavior, p. 259, 1984.

[16] Abbott, Jim and Openshaw, Paul, "Mercury removal technology and its application". Synetix, Belasis Av., Billingham, Cleveland, TS23 1LB, UK, presented at GPA November Conference 2001. http://www.gasprocessors.com/GlobalDocuments/E01Nov_02.pdf; accessed March 31, 2004.

[17] Aluminum Association Technical Information Service, "Guidelines for the Use of Aluminum with Food and Chemicals," Aluminum Consultants Group, Inc., p. 7 and p. 40. 1994.

[18] U.S. Environmental Agency (EPA), "Mercury Study Report to Congress: Overview," http://www.epa.gov/oar/mercover.html, August 19, 2003; accessed March, 2004.

[19] U.S. Environmental Protection Agency (EPA), "Mercury Emissions From the Disposal of Fluorescent Lamps, Final Report," http://www.epa.gov/epaoswer/hazwaste/id/merc-emi/merc-pgs/merc-rpt.pdf, pp 2-4, June, 1997; accessed March, 2004.

sized fluorescent lamp is broken inside an 8′ x 12′ x 18′ room, the airborne mercury concentration would be about 0.5 mg/m^3. This level of exposure far exceeds all health-based risk criteria (Appendix C).

7.1. Mercury is not present in normal Class A office buildings except at trace levels. [3,5,6]

There are no published values for levels of mercury on surfaces in commercial Class A buildings. Mercury was infrequently detected at trace levels in the Background Building surface evaluations[3]. The probable pre-WTC Event surface concentrations for this metal in the Building were at or below those identified in either the Background Buildings or cold spot analysis[5].

- The Background Building mercury levels measured for similar Class A offices were all lower than the levels in the Building. [3]
- When compared to other buildings[20] and to outdoor measurements,[6] the ambient air mercury levels inside the Building were elevated.[6]

7.2. The Building is contaminated with mercury above trace levels as a result of the WTC Event.

(a) The WTC Event released a substantial amount of mercury from fluorescent lamps, thermostats and other electrical components in the WTC towers.[1]

According to the LMDC,[21] the office space lost by the collapse of the WTC (all 6 buildings) is *13,420,045 ft^2(9,522,832 ft^2 for WTC 1 and 2).*

According to the EPA,[19] the fluorescent lamp density for a large commercial building is *0.038 lamps/ft^2.*

By multiplying the above values, we have *509,962 lamps for all 6 buildings and 361,868 lamps for WTC 1 and 2.*

Again, according to the EPA report[19] each lamp has between 10-41 mg of mercury. For all 6 buildings there is *5.1 Kg Hg to 20.9 Kg Hg and for WTC 1 and 2* there is *3.6 Kg Hg* to *14.8 Kg Hg.*[22]

- Other scientific studies indicate that mercury levels in the surrounding areas were elevated after the WTC Event.[23,24,25,26] IH

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[20] The background buildings used for the study include some of those studied in RJ Lee Group, "Contamination Report Pursuant to Testing Protocol *Background Levels in Buildings* Summary Report," December, 2003, along with other additional buildings.

[21] Lower Manhattan Development Corporation (LMDC), "World Trade Center Memorial and Redevelopment Plan, Draft Generic Environmental Impact Statement, Volume 1," p 9-32, January, 2004; accessed April, 2004.

[22] The above values assume that all the areas have the same density of lamps and do not take into account mercury present in other devices such as switches, thermostats and computers.

Consultants (IHC) conducted a mercury pilot study in Lower Manhattan in the spring of 2002 at several different locations (residential units and roadways). Their results show the presence of mercury both in air and on surfaces.

- The EPA later retested the same residential spaces in the summer of 2002 and found mercury in air at lower concentrations[23,25] than originally observed by IHC.

(b) The Building's location (280 feet[27] south of WTC-2) resulted in maximum impact from the WTC Event.[28]

- More specifically, the Building was at the edge of the collapse envelope (debris zone) for the South Tower (WTC-2).[28]
- The collapse of WTC-2 caused the breakage of the majority of the north face windows of the Building below the 23rd floor and produced a *gash* in the north face between the 9th and 22nd floors due to one column tree from the WTC-2 that penetrated into the north face. This allowed a significant amount of dust and other contaminants to enter the Building.
- The collapse of the WTC towers spread dust and other contaminants in all directions for many blocks in Manhattan.**[29]** The analytical results[4,**30**] of samples collected during the study of the Building demonstrate the presence and persistence of mercury in the Building two years after the WTC Event. Mercury was found in all Building systems tested, such as mill scale and rust on the surface of structural steel, fireproofing, inside cell systems, interior ductwork, curtain wall cavities, and interior wall cavities. Furthermore, multiple sample types such as air[6], dust and bulk samples tested positive for mercury.

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[23] Johnson, Clyde, "Mercury Vapor Levels In Dwellings In Close Proximity To The WTC Site", http://www.tera.org/peer/WTC/Johnson 2002.pdf, June 2002; accessed March 2004.
[24] I.H. Consultants, Inc., "Mercury Contamination after September 11 2001-A Potential Public Health Risk in Lower Manhattan;" accessed March, 2004.
[25] U.S. Environmental Protection Agency (EPA), "Interim Final WTC Residential Confimation Cleaning Study, Volume 1," http://www.epa.gov/wtc/confirmation_clean_study.htm, May, 2003; accessed March, 2004.
[26] U.S. Environmental Protection Agency (EPA), "Attachment K, Summary of Mercury Vapor Results Using the Lumex Vapor Analyzer," http://www.epa.gov/wtc/confirmation_attachment_k.pdf; accessed March, 2004.
[27] Fisher Brothers, "Bankers Trust Plaza - Zoning Diagrams & Computations Number Z1," Greenwich and Liberty Streets, New York, N.Y., Project Number 7101, as modified by Deloitte & Touche. May 07, 2003.
[28] Milke, James A., "Bankers Trust Building Airflow Analysis," April, 2004.
[29] U.S. Federal Emergency Management Agency (FEMA), "World Trade Center Building Performance Study," FEMA 403, Chapter 1. May, 2002.
[30] RJ Lee Group, All Technical Memoranda. May, 2004.

7.3. It was necessary to assess the extent and source of mercury contamination within the Building due to the toxic nature of mercury and its health risk.

(a) The evaluation criteria for permissible exposure limits regarding mercury toxicity varies by regulatory agency. Table 1 presents the variety of established evaluation criteria that currently exist.

Table 1. Agency risk and threshold for toxicity levels.

Agency	Level
OSHA's Permissible Exposure Limit (PEL)[46] ceiling for mercury vapor	100,000 ng/m^3 (0.1 mg/m^3)
NIOSH Recommended Exposure Limit (REL)[31]	50,000 ng/m^3 (0.05 mg/m^3)
American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)[32] for elemental mercury	25,000 ng/m^3 (0.025 mg/m^3)
Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) has an Inhalation Reference Concentration (RfC) [33]	300 ng/m^3
ATSDR Minimum Risk Level (MRL)[34]	200 ng/m^3
California's Recommended Exposure Limit (REL)[35,36]	90 ng/m^3

The OSHA PEL is a ceiling limit. The NIOSH REL and ACGIH TLV limits are time-weighted averages (TWA). The EPA RfC, ATSDR MRL and CA REL are based on assumed continuous (i.e., 24/7, 365 days per year) exposure.

(b) The above criteria are described in Appendix C. These criteria were developed over a period of years and if these criteria continue to follow the current trend, it is expected that the criteria will be reduced in the

[31] National Institute of Occupational Safety (NIOSH), "Pocket Guide to Chemical Hazards: Mercury compounds [except (organo) alkyls] (as Hg)," http://www.cdc.gov/niosh/npg/npgd0383.html; accessed March 24, 2004.

[32] American Conference of Governmental Industrial Hygienists (ACGIH), "2003 TLVs and BEIs," based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, Cincinnati, OH. p 38. 2003.

[33] U.S. Environmental Protection Agency (EPA), "Inhalation RfC Assessment (I.B.)" for elemental mercury, http://www.epa.gov/iris/subst/0370.htm#refinhal, June 1995; accessed March 2, 2004.

[34] Agency for Toxic Substances and Disease Registry (ATSDR), "Minimal Risk Levels (MRLs) for Hazardous Substances" for mercury, http://www.atsdr.cdc.gov/mrls.html, January, 2004; accessed March, 2004.

[35] California Air Resources Board, "Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values," December 19, 2003; accessed March 31, 2004.

[36] California Office of Environmental Health Hazard Assessment (OEHHA), "All Chronic Reference Exposure LevelsAdopted by OEHHA as of August 2003,"
http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html; accessed March, 2004.

future. For example, the ACGIH TLV was recently lowered from 50,000 ng/m^3 (0.05 mg/m^3) to 25,000 ng/m^3 (0.025 mg/m^3).

(c) Based on the current mercury levels in the Building, employee education and training would be required if the Building were reoccupied.[37]

- All personnel whose employment may potentially involve exposure to mercury must be trained in the potential hazards associated with it. This allows the employees to make informed decisions as to whether or not they choose to work in that environment.

7.4. Methyl mercury, a highly toxic form of mercury, is created by microbial action on metallic mercury and was found in trace amounts in the Building. Levels of methyl mercury will likely increase unless the source of mercury and bacteria are effectively remediated.[47]

Organo (alkyl) mercury compounds including methyl mercury are more toxic and have lower risk levels than non-methyl mercury: the NIOSH REL[38] for organo (alkyl) mercury compounds, 0.01 mg/m^3, is five times lower than the corresponding value for metallic mercury (0.05 mg/m^3).[31] Methyl mercury was detected in mill scale of the structural steel and fireproofing. In addition, methyl mercury and dimethyl mercury were both detected in WTC Dust samples. These organo-mercury species are the products of microbial action on elemental mercury and are not expected to be found in a normal office building. The interior surfaces and air of the Building are contaminated with fungi and spores.[39, 40] The biological contamination is due to the moisture that intruded into the Building. This provided conditions conducive to fungal growth and the metabolism of mercury to organo-mercury. Under these circumstances, metallic mercury in the Building is likely to be converted into more toxic forms of mercury by the interaction of mercury with microbial contamination in the Building.

7.5. Mercury contamination within the Building is pervasive,[4] resulting in surface concentrations of mercury greater than Appropriate Levels[5] and elevated airborne concentrations[6] of mercury exceeding warning and unsafe levels set by EPA, U.S. Agency for Toxic Substances and Disease Registry (ATSDR), and Occupational Safety and Health Administration (OSHA) (Appendix C).

(a) Mercury is found throughout the Building.[4]

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[37] New York State Toxic Substances "Right to Know" Laws, N.Y. Lab. Law § 875 (McKinney 2002), N.Y. Pub. Health Law § 4800 (McKinney 2002).

[38] National Institute of Occupational Safety (NIOSH), "Pocket Guide to Chemical Hazards: Mercury (organo) alkyl compounds (as Hg)," http://www.cdc.gov/niosh/npg/npgd0384.html; accessed March 25, 2004.

[39] RJ Lee Group, "Contamination Report Pursuant to Testing Protocol-02 *Preliminary Biological Contamination* Summary Report," December, 2003.

[40] Shelton, Brian G., "Report on Microorganisms at 130 Liberty Street," May, 2004.

- Mercury levels in the Building consistently exceeded the Background Building levels measured for similar Class A office buildings. [3,6]
- Surface concentrations of mercury reported in CR-01[41] averaged 1.32 μg/ft^2 or 120 times the Appropriate Level.
- The maximum surface mercury concentration reported in CR-01 was 58.7 μg/ft^2 or over 875 times above the Maximum Appropriate Level.
- The highest mercury levels are found on the surface (mill scale and rust) of the structural steel (Figure 1).[42]

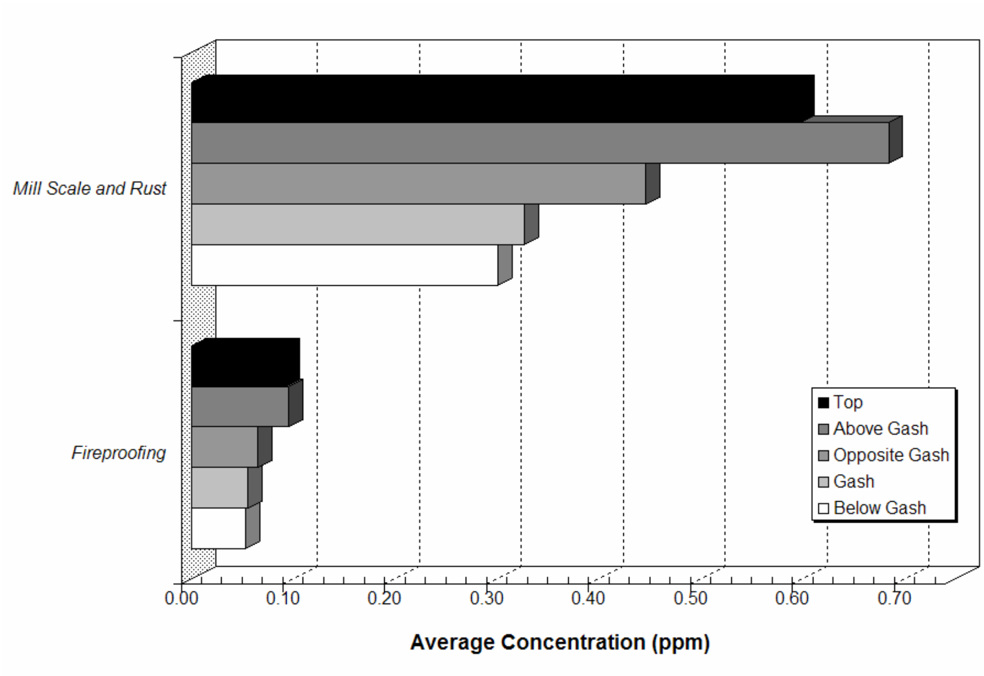

Figure 1. Average Mercury Concentrations on Steel and in Fireproofing in Building 5-Sector[41] Divisions.

- Concentrations of mercury in mill scale averaged 0.53 ppm, with a maximum concentration of 1.5 ppm.[42]
- The concentrations of mercury in mill scale exceed the 0.1 ppm soil clean-up objective for New York State.[43]

[41] RJ Lee Group, "Contamination Report Pursuant to Testing Protocol-01 *Interior Spaces* Summary Report," December, 2003.
[42] RJ Lee Group, "Contamination Report Pursuant to Testing Protocol-25 *Structural Steel* Summary Report," December, 2003.
[43] New York State Department of Environmental Conservation, "Heavy Metals Soil Cleanup Criteria Table," http://www.dec.state.ny.us/website/der/tagms/prtg4046.pdf; accessed March 2004.

- Mercury is found in the fireproofing.[44] The average mercury concentration in the fireproofing is 0.074 ppm while the maximum mercury concentration is 0.603 ppm.

(b) Mercury is detected in the Building air.[6]

- Ambient air mercury levels inside the Building (~90 ng/m^3) were elevated when compared to other buildings[20] (5-20 ng/m^3) and to outdoor[6] measurements (<5 ng/m^3).
- Real-time mercury ambient air levels in the Building vary greatly over time and monitoring location, often spiking above the various minimum risk levels (Figure 2). Although these risk levels are based on twenty-four hour a day and 365 days per year exposure, it was necessary to investigate the spikes to be certain there were no continuous mercury levels above these thresholds.

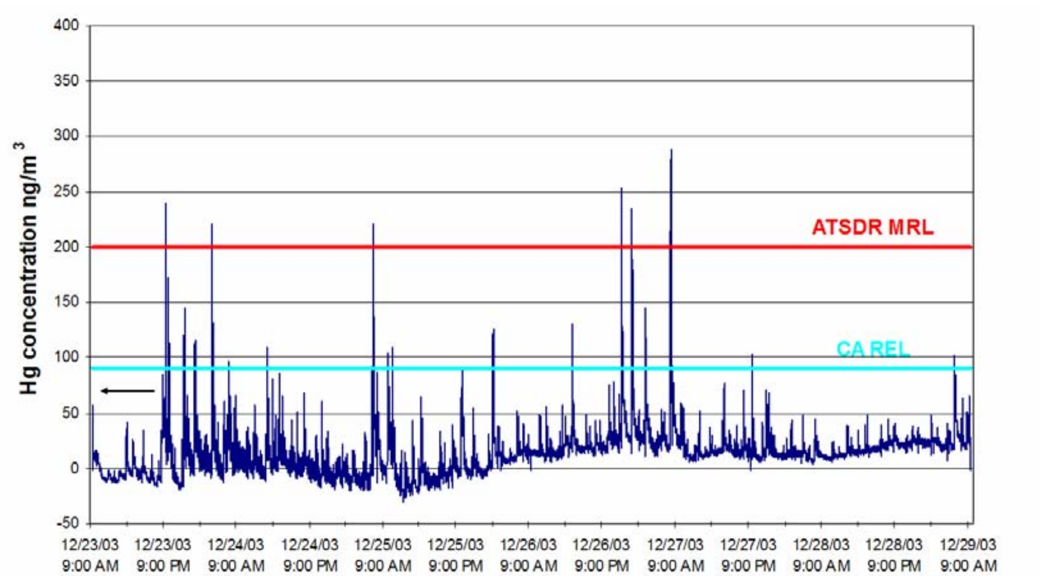

Figure 2. Variability of mercury vapors in air over time recorded by the Lumex Analyzer. Risk levels are also shown.

[44] RJ Lee Group, "Contamination Report Pursuant to Testing Protocol-04 *Spray-On Fireproofing* Summary Report," December, 2003.

- Mercury measurements taken during torch cutting of steel within the Building (*gash* area) exceeded 0.1 mg/m^3, the OSHA PEL[45,46] ceiling level (a worker's exposure to mercury vapor shall at no time exceed this ceiling level).

7.6. The complex mixture of mercury species present in the fireproofing and oxide layer on the structural steel of the Building is statistically the same as the mercury species found in WTC Dust, demonstrating that the mercury is from a common origin, the WTC Event.

(a) Mercury found in the Building's mill scale and rust on structural steel and fireproofing has the same chemical species as the mercury found in the WTC Dust. [47]

- Under normal circumstances, structural steel, including the mill scale and rust layer, does not contain mercury as a component.[48,49,50]
- The complex mixture of mercury compounds that was found in the fireproofing and in the mill scale and rust on the structural steel of the Building is statistically the same as the mixture of mercury compounds found in WTC Dust.[47] This speciation result demonstrates that the mercury in the mill scale and rust on the structural steel and in the fireproofing have the same origin as the mercury in WTC Dust, the WTC Event.
- The speciation study[47] provides independent support for the premise that mercury in the fireproofing and structural steel is a result of the WTC Event.

7.7. Certain remediation and demolition activities will increase the levels of mercury within the Building which at times are likely to exceed worker exposure limits.

(a) Mercury levels (air and surfaces) were monitored during a variety of remediation, sampling and construction activities.

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[45] U.S. Occupational Safety and Health Administration (OSHA), "Exposure Limits," http://www.osha.gov/SLTC/mercury/exosure_limits.html; July 23, 2003; accessed March, 2004.
[46] U.S. Occupational Safety and Health Administration (OSHA), "Occupational Safety and Health Guideline for Mercury Vapor," http://www.osha.gov/SLTC/healthguidelines/mercuryvapor/recognition.html; accessed March, 24, 2004.
[47] RJ Lee Group, "Technical Memorandum *H1: Mercury Speciation*," May, 2004.
[48] Nucor, "Material Safety Data Sheet," December 09, 2002.
[49] United States Steel Corporation, "Material Safety Data Sheet: Slabs, Blooms, Ingots, Tube Rounds - HSLA Steel," USS Code Number: 1H001, Revised May 01, 2002.
[50] RJ Lee Group, "Technical Memorandum *H4: Evaluation of Background Steel*," May, 2004.

(b) Certain remediation and demolition activities will result in the release of mercury in the Building.

- Mercury was liberated from surfaces as a result of the heat generated from power tools, torches, welders, and other equipment (Table 2).[6]
- During the cutting of the steel in the *gash* area after it had been abated, mercury levels exceeding the OSHA PEL level were recorded.[6]

Table 2. Average mercury levels during drilling of steel beams compared to corresponding non-drilling averages.

		Mercury concentration (ng/m^3)	
Date	Floor	Drilling (average)	Non drilling§ (average)
11/22/2003	34	204	11
11/24/2003	34	177	12
11/24/2003	29	275	13
12/03/2003	19	107	17

Measurements were performed in the vicinity of the drill bit and the workers/samplers.
§These measurements were taken when the drilling was paused.

7.8. Mercury volatilizes into the air at room temperature and thus poses a unique health risk to any Building occupant.

Mercury is an extremely toxic metal.

Mercury volitization in the air at normal building temperatures and conditions poses a risk to occupants in the Building.

Mercury is readily absorbed by all routes of entry including inhalation, ingestion, and cutaneous (skin).[51]

Mercury crosses the placenta and concentrates in the fetus, sometimes exceeding 10 times the mother's blood level.[52]

WTC Dust and WTC Hazardous Substances include a complex mixture of metals. Cadmium, lead, and beryllium were also found in samples collected and analyzed from the Building[41]. Cadmium and beryllium are known lung

[51] Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profile for Mercury," p 11. March, 1999.

[52] Agency for Toxic Substances and Disease Registry (ATSDR), "Toxicological Profile for Mercury," pp 220-221. March, 1999.

carcinogens; lead[53] and cadmium[54] are central nervous system and kidney toxins. Exposure to lead can have detrimental effects on reproduction for both males and females. Due to the potential for a synergistic effect, the above risks posed by the metals should be considered when discussing mercury toxicity in the Building.

7.9. Returning the Building to normal operations would increase the temperature in the Building from current levels and result in elevated air levels of mercury in the Building.6

Temperature has an effect on the ambient mercury levels in the Building. On average, the levels of mercury observed in the air inside the Building were higher as the temperature increased inside the Building. Figure 3 shows a plot of the average temperature and average airborne mercury readings taken in one location on the 39th Floor of the Building. Average mercury readings tended to increase and decrease with temperature. Ambient mercury levels in a closed office space on the 39th Floor under heated and unheated conditions are shown in Figure 4 and Table 3. The air mercury readings were higher at the higher temperatures. Reestablishing normal temperature within the Building above ambient winter conditions will increase the vapor pressure of liquid mercury, thus increasing the concentration of mercury vapor in the Building air.

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[53] Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Lead," July, 1999.
[54] Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Cadmium," July, 1999.

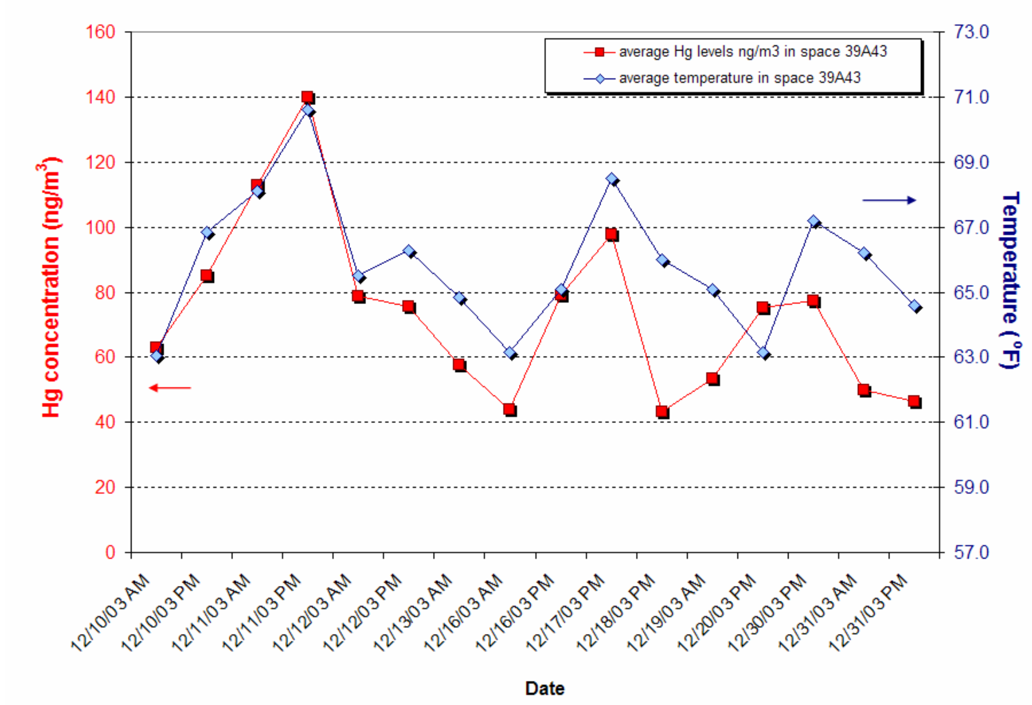

Figure 3. Average air mercury levels and temperatures in one location on the 39th floor from 12/10 to 12/31/2003.

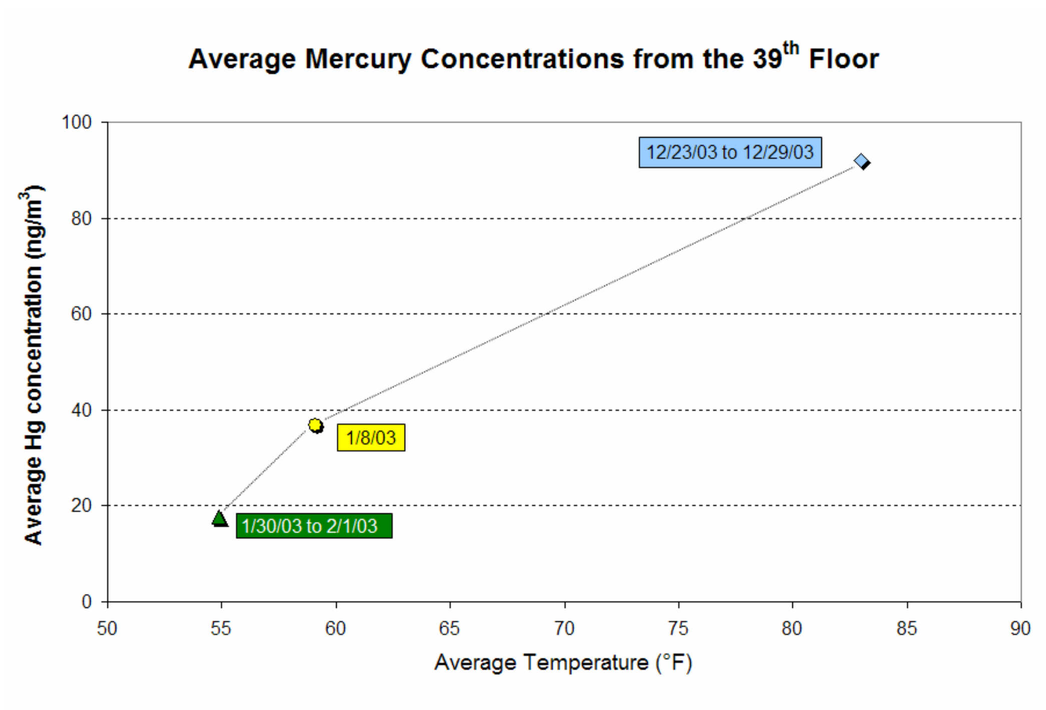

Figure 4. Average mercury concentrations in a closed office space on the 39th floor as a function of the average temperature inside the room.

Table 3. Average temperatures and average mercury concentrations in a closed office space on the 39th floor.

Date	Duration	Average Temperature (°F)	Average mercury concentration (ng/m^3)	Room condition
12/23/2003-12/29/2003	~6 days	83	92	Heated
01/08/2004	~1.5 h	59.1	36.7	Not heated
01/31/2004-02/01/2004	~2 days	54.9	17.6	Not heated

7.10. If the Building were reoccupied and returned to normal use without removing the mercury contamination, air levels of mercury in occupied spaces will likely increase to levels that exceed the health screening risk standards established for the Building.7

The reduction in airflow that results from repairing the open Building for return to service as an office building will increase the mercury vapor concentration. Reestablishing normal temperature within the Building above ambient winter conditions will increase the vapor pressure of liquid mercury, thus increasing the concentration of mercury vapor in the Building air. Recirculation of air during regular HVAC functioning would cause mercury concentration buildup. For example, in most HVAC systems, during extreme hot and cold periods, a significant portion of the air is recirculated, resulting in a closed system with little or no exchange of air from the outside.[55] Furthermore, mercury is released[6] by the application of heat or mechanical processes, (i.e., drilling, welding, cutting and remediation activities), and the mercury released will recontaminate the Building.

7.11. Based upon existing information, we cannot conclude that it is feasible to remediate the mercury from the Building.

Mercury can dissolve other metals to form alloys known as amalgams.[8,9,10,11,13] As a result, mercury would amalgamate on all metals such as aluminum, tin, silver and gold, making its removal almost impossible without destructive damage of the substrate. Such surfaces and other similar sources will slowly release mercury and since mercury is volatile it will redistribute throughout the Building. Mercury was found in all Building systems[4] tested such as mill scale of structural steel, fireproofing, inside cell systems, interior ductwork, curtain wall cavities, and interior wall cavities. Multiple sample types such as air,[6] dust, and bulk samples tested positive for mercury.

Mercury contamination is especially difficult to remediate from porous surfaces.[56] Surfaces that have cracks, crevices and other similar features will retain mercury.

The oxide of the structural steel (the mill scale and rust) has the highest concentration of mercury. Remediation of mercury from the oxice of

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[55] Grimm, Nils R. and Rosaler, Robert C. eds., "HVAC Systems and Components Handbook," 2nd Edition, McGraw-Hill, pp 7.7.18-7.7.19. 1998.

[56] National Institute of Occupational Safety (NIOSH), "Criteria for a Recommended Standard: Occupational Exposure to Inorganic Mercury," NIOSH HSM 73-11024. 1973.

structural steel would require complete removal of mill scale and rust.[57] It is not possible to predict whether the mercury can be contained during the removal of the mill scale and rust. Given the nature of mercury, it is likely to migrate to other parts of the Building where it could recontaminate metal surfaces that had already been remediated.

[57] RJ Lee Group, "Technical Memorandum *H3: Remediation of Steel*," May, 2004.

Appendix A

CV of Dr. Bobby Gunter

Bobby J. Gunter, Ph.D., CIH
18 Berkeley Court
Doylestown, Pennsylvania 18901
(215) 489-9391

EDUCATION:

Ph.D. Preventive Medicine and Public Health, 1967 University of Oklahoma, Oklahoma City, Oklahoma

Master of Science in Sanitary Science, Public Health, 1964 University of Oklahoma, Norman, Oklahoma

B.S. Natural Science, 1963 Southeastern State University, Durant, Oklahoma

CERTIFICATIONS

Board Certified in Industrial Hygiene (#1083)
Fellow AIHA

EMPLOYMENT

- Private Consultant, Occupational and Environmental Health, 1991 -Present
- Regional Director for Occupational Health, The Hartford Steamboiler Insurance Company, Atlanta, Georgia 1991
- Consultant, Environmental and Occupational Health Westinghouse Environmental and Geotechnical, Inc., 1989-1990
- Scientist, Commissioned Corps U.S. Public Health Service, Commissioned Officer, Captain (06), Ret., Denver, Colorado, Atlanta, Georgia, and Cincinnati, Ohio, 1967-1989
- Supervisory Occupational Health Consultant, National Institute for Occupational Safety and Health (NIOSH), USPHS, Denver, Colorado 1987-1989
- Regional Industrial Hygienist, NIOSH, USPHS, Denver, Colorado 1971 -1987
- Assistant Director for Research and Requirement Analysis, Bureau of Occupational Safety and Health (BOSH), Cincinnati, Ohio 1969 -1970
- Occupational Health Consultant, DHEW/Region II- New York, NY 1968-1970
- Special Assistant to Chief, BOSH/HSMHA/DHEW, Cincinnati, Ohio 1968 - 1969
- Occupational Health Consultant, DHEW/Region III, Charlottesville, Virginia 1967 - 1968

- Industrial Hygienist, Division of Technical Services, BOSH/HSMHA/DHEW, Cincinnati, Ohio 1967 - 1968

- Research Assistant, Veterans Administration Hospital and University of Oklahoma Medical Center, Oklahoma City, Oklahoma 1965 - 1967

- Chief Chemist, City of Norman, Oklahoma 1964-1967

PROFESSIONAL TESTIMONY:

- Professional Witness for OSHA Helena, Montana - Lead Toxicology and Lead Plant Evaluations

- Denver, Colorado - Ammonia Toxicology and Hazards of Ammonia Explosions

- Professional witness - U.S. Department of Justice– U.S. Largest mercury hazardous waste site--1999.

- Denver, Colorado - Metal and Solvent Hazards in the manufacturing of Steel.

- Testified before the U.S. Senate on Health and Safety Problems in Small Industry (1977-1978)

- Professional witness for other clients and will provide additional information upon request.

TEACHING (LECTURES)

40-hour Hazardous Waste Operations OSHA 1910.120
8-hour update for OSHA 1910.120 For EPA and Many other clients
OSHA 1910.1200 Hazard Communication Training
OSHA 1910.1450 Laboratory Health and Safety
Toxicology for Scientist and Engineers EPA
Presented over 200 Professional Papers concerning Occupational Health, Environmental Health and Industrial Hygiene.
Arson Investigators for States of Tennessee, Michigan, and Georgia

CLIENTS (TAUGHT)

U.S. Environmental Protection Agency
United States Public Health Service (USPHS)
Agency For Toxic Substance Disease Registry (ATSDR)
Clayton Environmental
Wilmer Engineering
Tony Williams Trucking
Delta Environmental
A.T. Kearney
U.S. Department of Transportation

GSA
SONOCO Engraph
Georgia Environmental Protection Division
United states Department of Parks NPS
Wrigleys Company
INS Investigations
Unified Investigations
R.J. Lee Group
Ambient

FACULTY APPOINTMENTS

Emory University
Rollins School of Public Health
Adjunct Professor 1989-Present
Course Director for Industrial Hygiene 1989-1998
Colorado State University, Fort Collins, Colorado 1973-Present
Oklahoma University Health Science Center, Oklahoma City, Oklahoma

CURRENT PROJECTS

Development of Site Specific Health and Safety Plans for OSHA 1910.120 activities.

- Health and Safety Officer for class A to D sites OSHA 1910.120
- Factory OSHA audits and compliance monitoring with reports.
- Professional witness for a. variety of legal cases.
- Training of all OSHA 1910.120 activities.

PUBLICATIONS:

Gunter, B.J. Solomon, L.A., Hinshaw, L.B. and Nau, CA. *The Effect of Endotoxin Shock on Plasma Zinc Concentrations, The Physiologist*, 9:195 (August 1966)

Hinshaw, L.B., Solomon, L.A., Gunter B.J., *Mechanisms of Endotoxin Shock*, Western Society for Clinical Research, Carmel College, Monterey, Ca. (January 1967)

Hinshaw, L.B., Solomon, L.A., Erdos, E.G. Rains, D.A. and Gunter, B .J., *Effects of Acetylsalicylic Acid on the Canine Response to Endotoxin*, The Journal of Pharmacology and Experimental Therapeutics, 3:157, (Sept. 1967)

Stumpf, J., Blehm, K., Buchan, R., and Gunter B.J., *Characterization of Particulate Aerosol-Size Distribution and Formaldehyde Content*, AIHA Journal 47:725-730, 1986.

Downey, E., Buchan, R., Blehm, K., and Gunter B.J., *A comparison of Two Ozone Sampling Methods*, AIHA Journal, *44333-335,* 1983

Campbell, D., Lockey, J., Petajan, J., Gunter, B., and Rom, W., *Health Effects Among Refrigeration Repair Workers Exposed to Fluorocarbons*, British Journal of Industrial Medicine 43:107-Ill, 1986.

Wingfield, W., Ruby, D., Buchan, R., and Gunter, B., *Waste Anesthetic Gas Exposures to Veterinarians and Animal Technicians*, JAVMA, 178:399-402, 1981.

Occupational Disease (*The Silent Enemy*), Government Publication 1968

Criteria and Recommended Standard for Occupational Exposures to Asbestos, 1971

Criteria and Recommended Standard for Occupational Exposures to Carbon Monoxide, 1971

Primary Author on 14 Health and Safety Guides, these books are about 100 pages in length.

Published *375* Health Hazard Evaluations which included Industrial Hygiene, engineering, medical and biological monitoring of a large variety of industrial work environments. A list of individual copies can be supplied upon request.

CHAPTERS IN BOOKS

ACGIH Occupational Hazards to Health Care Workers, (Gunter, B J. pp 187-191, 1986.

BIOLOGICAL MONITORING OF EXPOSURE TO CHEMICAL ORGANIC COMPOUNDS
Xylene Exposure in a Histology Laboratory Investigated by Environmental and Biological Monitoring, Lowery, L, Thoburn, T.W,, Phipps, F.C., Gunter, B.J., and Sollenberg, J., pp 143-153, John Wiley and Sons, Inc. 1987.

Appendix B

CV of Dr. Richard J. Lee

Richard J. Lee

Affiliation: RJ Lee Group, Inc.
350 Hochberg Road
Monroeville, PA 15146

Education:
Ph.D., Theoretical Solid State Physics, 1970, Colorado State University
B.S., Physics, 1966, University of N. Dakota

Career/Employment:
- RJ Lee Group, Inc., President, 1986 - Present
- U. S. Steel Technical Center, Head - Physics, Electron Microscopy and Surface Analysis Section, 1973 - 1985
- Purdue University, Associate Professor, 1971
- Purdue University, Assistant Professor, 1970
- Lake Region Junior College, Instructor, 1966

Summary:
- Pioneered the use of quantitative electron diffraction techniques for the identification of asbestos
- Development of automated techniques for combined x-ray microanalysis and electron microscopy
- Developed and manufactured first PC-based Scanning Electron Microscope
- Developed and manufactured Forensic product for GSR
- Developed and manufactured Forensic LIMS software

Honors, Awards, Fellowships & Memberships:
- Microbeam Analysis Society
- ASM International
- ASTM Committee
- American Concrete Institute
- American Ceramic Society
- National Stone, Sand and Gravel Association
- International Standards Organization
- Health Effects Institute - Asbestos Research Literature Review Panel
- EPA Scientific Review Panel on Air Chemistry and Physics (1989)
- EPA Select Panel for Development of Methodology for Asbestos Analysis by Transmission Electron Microscopy (1987-Present)
- Advisor on asbestos analysis to the Environmental Protection Agency
- External Advisory Committee for the College of Natural Sciences, Colorado State University
- National Defense Education Act Fellowship - 4 years
- Honorary Doctor of Science – University of North Dakota, 1996
- Entrepreneur of the Year – Mid-Atlantic States, 1991
- Innovator of the Year – North Dakota, 1998

Publications & Presentations: 177
Patents: 3

Richard J. Lee, PhD
Publications & Presentations

Pattanaik, S., G. P. Huffman, S. Sahu, R. J. Lee, "X-ray absorption fine structure spectroscopy and X-ray diffraction study of cementitious materials derived from coal combustion by-products," Accepted for publication in Cement and Concrete Research, December 15, 2003.

Bailey, Kelly F., J. Kelse, A. G. Wylie, R. J. Lee, "The Asbestiform and Nonasbestiform Mineral Growth Habit and Their Relationship to Cancer Studies", A Pictorial Presentation, (2003).

Lee, R. J.; S. R. Badger; K. P. Rickabaugh; C. C. Bunker, "Mercury Contamination at Ground Zero", Presented at the Air Quality Symposium, September 23, 2003.

Sahu, S., S. R. Badger, R. J. Lee, N. Thaulow, "Determination of Water-to-Cement Ratio of Hardened Concrete by Scanning Electron Microscopy," to be Published in Cement and Concrete Composites (2003).

Lange, J.H.; Thomulka, K.W.; Lee, R. J.; Van Orden, D.R.; "Surface and Passive Monitoring for Asbestos in an Industrial Facility", Envirosafe Training and Consultants, Inc., Pittsburgh, PA, July 2, 2002.

Marchand, J., E. Samson, Y. Maltais, R. J. Lee, "Predicting the Performance of Concrete Structures Exposed to Chemically Aggressive Environments - Field Validation", Published in the Annual Conference of the Canadian Society for Civil Engineering, June 2002.

Lee, R. J., H.P. Lentz, D.G. Kritikos, A.M. Toms, "One-Button Wear Debris Analysis", Published by Microscopy Society of America, Microsc. Microanal. 8 (Suppl. 2) (2002).

Sahu, S., S. A. Brown, R. J. Lee, "Thaumasite Formation in Stabilized Coal Combustion By-Products", Cement & Concrete Composites 24, pp 385-391 (2002).

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Lee, R. J., D. Van Orden, W. H. Powers, K. A. Allison, "Implications of Analytical Techniques for Asbestos Identification", Presented at the National Stone, Sand & Gravel Association's Environment, Safety, and Health Forum, September 2001.

Lee, R. J., G. S. Casuccio, S. F. Schlaegle, T. L. Lersch, "The Characterization and Speciation of Particulate Matter", Presented at the Air & Waste Management Association Annual Conference and Exhibition; Orange County Convention Center, Orlando, Florida, June 2001.

Sahu, S., A. E. Snyder, S. R. Badger, R. J. Lee, "Depth Profiling and Phase Discrimination in Deteriorated Concrete Utilizing Scanning Electron Microscopy with Automated Point Count Analysis", Published in the Proceedings of the Twenty-Third International Conference on Cement Microscopy, Albuquerque, New Mexico, USA, pp 383-390 (2001).

Badger, S. R., S. Sahu, R. J. Lee, "Use of Water to Cement Ratio and Point Count Analyses to Determine Mix Designs of Hardened Concrete", Published in the Proceedings of the Twenty-Third International Conference on Cement Microscopy, Albuquerque, New Mexico, pp 391-402 (2001).

Badger, S. R., B. A. Clark, S. Sahu, N. Thaulow, R. J. Lee, "Determination of the Water to Cement Ratio of Hardened Concrete Utilizing Backscattered Electron Imaging", Presented at the Transportation Research Board Conference, Washington DC, January 2001.

Badger, S. R., B. A. Clark, S. Sahu, N. Thaulow, R. J. Lee, "Backscattered Electron Imaging to Determine Water-to-

Cement Ratio of Hardened Concrete", Published in the Transportation Research Record, No. 1775, Concrete, Materials and Construction, pp. 17-20 (2001).

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Cassucio, G. S., B. G. Osgood, S. R. Badger, R. J. Lee, "Investigation of Nuisance Dust Near A Cement Plant", Presented at the Air & Waste Management Association's 93rd Annual Conference & Exhibition, Salt Lake City, UT, June 2000.

Sahu, S., B. A. Clark, R. J. Lee, "Delayed Ettringite Formation and the Mode of Concrete Failure", Published in Materials Science of Concrete - The Sidney Diamond Symposium, pp 379-394 (1998).

Badger, S. R., N. Ritchie, R. J. Lee, N. Barbi, "New Technology to Measure Steel Cleanliness Using Computer Controlled Scanning Electron Microscopy", Published in the AISE Conference Proceedings (1998).

Badger, S. R., R. J. Lee, "Innovative Microscopic Investigations in Cement and Concrete", Engineering Foundation Conference (1998).

Badger, S. R., R. J. Lee, L. Zhu, "Using Computer Controlled Scanning Electron Microscopy (CCSEM) to Measure Steel Cleanliness", Published in the Electric Arc Furnace Conference Proceedings (1998).

Lee, R. J., D. Van Orden, I. M. Stewart, "Dust and Airborne Concentrations - Is there a Correlation?", Published in the Advances in Environmental Measurement Methods for Asbestos, ASTM STP 1342, M.E. Beard, H.L. Rook, Eds., American Society for Testing Materials (1998).

Lee, R. J., A. J. Schwoeble, H. P. Lentz, "Application of SEM in Forensic Science", Presented at the Scanning Microscopy International Meeting, May 1993, Published in the Scanning Microscopy Journal, Presented to the Southern Association of Forensic Scientists, Auburn, AL, April 1996.

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Lange, J. H., K. W. Thomulka, R. J. Lee, G. R. Dunmyre, "Evaluation of Lift and Passive Sampling Methods During Asbestos Abatement Activities", Published in the Bulletin of Environmental Contamination and Toxicololgy, Vol. 55, No. 3, pp 325-331, September 1995.

Lee, R. J., R. G. Florida, I. M. Stewart, "Asbestos Contamination in Paraffin Tissue Blocks", Published in the Archives of Pathology & Laboratory Medicine, Vol. 119, June 1995.

Clark, B. A., P. W. Brown, A. J. Schwoeble, Y. Jie, R. J. Lee, "Comparison of Ettringite Morphologies Observed on Fracture Surfaces and in Thin Sections", Presented at The American Ceramic Society 97th Annual Meeting, Cincinnati, OH, April 1995.

Lee, R. J., T. V. Dagenhart, G. R. Dunmyre, I. M. Stewart, D. R. Van Orden, "Effect of Indirect Sample Preparation Procedures on the Apparent Concentration of Asbestos in Settled Dusts", Published in Environmental Science & Technology, Vol. 29, No. 7, pp 1728-1736 (1995).

Oehlert, G. W., R. J. Lee, D. R. Van Orden, "Statistical Analysis of Asbestos Fibre Counts", Published in Environmetrics, Vol. 6, pp 115-126 (1995).

Van Orden, D. R., R. J. Lee, K. M. Bishop, D. Kahane, R. Morse, "Evaluation of Ambient Asbestos Concentrations in Buildings Following the Loma Prieta Earthquake", Published in Regulatory Toxicology and Pharmacology, Vol. 21, pp 117-121, June 1994.

Lee, R. J., M. L. Demyanek, F. C. Schwerer, K. A. Allison, G. R. Dunmyre, "Air, Surface, and Passive Measurements in a Building During Spray- Buffing of Vinyl-Asbestos Floor Tile", Published in Applied Occupational Environmental Hygiene, 9(11):869-875 (1994).

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Kennedy, S. K., D. Gerber, M. Owen, R. J. Lee. "Computer Controlled SEM/EDS and Spectrographic Cathodoluminescense Analysis of Quartz Silt", Presented at the MAS-93 Meeting, July 1993.
Wylie, A.G., K. F. Bailey, J. W. Kelse, R. J. Lee, "The Importance of Width in Asbestos Fiber Carcinogenicity and its Implications for Public Policy", Published in the American Industrial Hygiene Association Journal, Vol. 54, Number 5, pp 239-252, May 1993.

Clark, B. A., R. J. Lee, "Energy Dispersive X-Ray Analysis of Cement Paste Features Resulting From Heat Treatment", Presented at the American Ceramic Society 95th Annual Meeting and Exposition, Cincinnati, OH, April 1993.

Wagner, K. E., R. J. Lee, "Microscopic Crack Pattern Evaluations on Hardened Concrete — Comparison Between Sound and Deteriorated Members", Presented to the American Ceramic Society 95th Annual Meeting and Exposition, Cincinnati, OH, April 1993.

Skalny, J. P., B. A. Clark, R. J. Lee, "Alkali-Silica Revised", Presented at the 15th International Conference on Cement Microscopy, Dallas, Texas, April 1993.

Lee, R. J., D. A. Warner, H. P. Lentz, "Use of the Personal SEM for Evaluation of Cementitious Products", Presented to the 15th International Cement Microscopy Association, Dallas, TX, March 1993.

Demyanek, M. L., G. R. Dunmyre, R. J. Lee, C. F. Richardson, X. Li, "Adhesive Lift and Passive Particulate Sampling Technology", Presented at the Industrial Hygiene Monitoring Symposium, March 1993.

Lange, J. H., J. W. Grad, P. A. Lange, K. W. Thomulka, G. R. Dunmyre, R. J. Lee, C. F. Richardson, and R. V. H. Blumershine, "Asbestos Abatement of Ceiling Panels and Mold Growth in a Public School Building After Water Damage: A Case Study of Contaminant Levels", Published in the Fresenius Environmental Bulletin, 2:13-18 (1993).

Clark, B. A., A. M. Dalley, Y. Jie, J. P. Skalny, R. J. Lee, "TEM and EDS Analysis of Cement Paste in Concrete and Experimental Mortars", Poster Session American Ceramic Society PAC RIM Meeting, Honolulu, Hawaii, November 1993.

Clark, B. A., A. J. Schwoeble, R. J. Lee, J. P. Skalny, "Detection of ASR in Opened Fractures of Damaged Concrete", Published in Cement and Concrete Research, Vol. 22, pp 1170-1178, November 1992.

Clark, B. A., E. A. Draper, R. J. Lee, J. Skalny, M. Ben-Bassat, A. Bentur, "Electron-Optical Evaluation of Concrete Cured at Elevated Temperatures", Published in the Proceedings of the American Concrete Institute Symposium on How to Produce Durable Concrete in Hot Climates, San Juan, Puerto Rico, October 1992.

Jie, Y., A. J. Schwoeble, R. J. Lee, "Influence of Ashing in Concrete Samples for Carbon Coating Removal", Electron Microscopy I, 5th Asia-Pacific Electron Microscopy Conference, Beijing, China, World Scientific, pp 450-451, August 1992.

Lange, J. H., R. J. Lee, G. R. Dunmyre, "Monitoring Asbestos in an Industrial Facility Using Surface Dust and Passive Air Samplers", Published in Emerging Technologies for Hazardous Waste Management, 1992 Book of Abstracts for the Special Symposium, Atlanta, GA, Industrial & Engineering Chemistry Division, American Chemical Society, September 1992

Lee, R. J., A. J. Schwoeble, Y. Jie, "Use of Backscattered Electron Image Intensity Signals to Calculate the Water/Cement Ratio of Concrete", Presented at the EMSA 50th Anniversary Meeting, Boston, MA, August 1992.

Lee, R. J., G. R. Dunmyre, "Surface and Passive Air Samplers", Presented at the ASTM Johnson Conference, Johnson, VT, July 1992.

Lee, R. J., G. R. Dunmyre, G. J. Kotyk, K. E. Scutt, "The Effects of Ultrasonic Resuspension During Dust Sample Preparation for Transmission Electron Microscopy Analysis on Asbestos Fiber Concentrations", Presented at the Environmental Management Ninth Annual Conference and Exposition of NAC, Pittsburgh, PA, April 1992.

Kennedy, S. K., G. A. Cooke, R. J. Lee, J. P. Skalny, "Mathematical Unmixing of Aggregate Types in Concrete Products Using Q-Mode Factor Analysis - Method and Case Study", Published in the Proceedings of the 14th International Conference on Cement Microscopy, pp 359-378, April 1992.

Lee, R. J., G. R. Dunmyre, "Direct Preparation: Innovative Sampling Technology, Applications for Other Indoor Air Contaminants", Presented at Settled Dust Sampling: Asbestos and Other Particulates, Georgia Tech Research Institute, Atlanta, GA, April 1992.

Skalny, J. P., B. A. Clark, R. J. Lee, "Alkali-Silica Reaction Revisited", Published in the Proceedings of the 14th International Conference on Cement Microscopy, pp 309-324, April 1992.

Lee, R. J., D. R. Van Orden, M. Corn, K. S. Crump, "Exposure to Airborne Asbestos in Buildings," Published in Regulatory Toxicology and Pharmacology, Vol. 16, pp 93-107, March 1992.

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Lee, R. J., E. A. Draper, J. P. Skalny, "Advanced Methods of Concrete Characterization", Published in the Proceedings of the Materials Research Society, Boston, MA, Vol. 245, pp 349-358 (1991).

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Lee, R. J., "The Impact of Computers on Modern Microscopy", Presented to the Metro Microbeam Group, Paramus, NJ, November 1990.

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Lee, R. J., "Testimony to the Occupational Safety and Health Administration on Notice of Proposed Rulemaking - Occupational Exposure to Asbestos: Tremolite, Anthophyllite and Actinolite, 29 CFR parts 1910 and 1926", Washington, DC, May 1990.

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Dagenhart, T. V., J. Fisher, K. Bishop, G. R. Dunmyre, R. J. Lee, "Fibrous Pyroxenes: Common Rock-Forming Minerals Which May Be Confused with the Amphiboles", Presented to the National Asbestos Council Seventh Annual Asbestos Abatement Conference and Exposition, San Antonio, TX, February 1990.

Lee, R.J, J. Millette, E. Chatfield; "Could You Identify This Material? (Fosterite)" (1990)

Schlaegle, J. R., G. S. Casuccio, R. J. Lee, G. R. Dunmyre, "Evaluation of Asbestos Content in Settled Dust Samples Using CCSEM and MicroImaging Techniques", Presented to National Asbestos Council, Inc., Indianapolis, IN, September 1989.

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Appendix C

Potentially Relevant Action Levels

0.09 µg/m³ - California Chronic Inhalation Reference Exposure Level (REL) – RELs are levels below which no adverse health effects are anticipated in the general human population. RELs are based on the most sensitive relevant adverse health effect reported in the medical and toxicological literature. RELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. A 24 hours per day, seven days per week exposure is assumed. *Using their methodology to adjust to exposures during a work week would result in a level of 0.25 ~ug/m^3.*

0.2 µg/m³ - ATSDR Chronic Minimal Risk Level (MRL) – defined as an estimate of daily human exposure to a substance that is likely to be without an appreciable risk of noncancer adverse health effects ("to any element of the human population") for exposures lasting one year or longer, up to an entire lifetime. This is not a level above which toxicity is likely to occur, nor does it represent a toxicity threshold. Regarding the MRL, the ATSDR also notes, "The MRL is *not* intended , nor should it be indiscriminately used, as a clean-up or remediation level, or as a predictor of adverse health effects it might be unnecessarily stringent for application to some exposure situations (i.e., higher air concentrations might afford a similar degree of protection in some exposure scenarios); thus its relevance in any specific environmental situation is intended to be determined by an experienced public health or medical official." (emphasis in original). It is also assumed that the exposure will be for 24 hours per day, *365* days per year, i.e., adjustments would have to be made to extrapolate the chronic MRL to exposures of lower duration or frequency.

0.3 µg/m³ - USEPA Chronic Reference Concentration (RfC) – the RfC is intended to protect against noncancer health effects for exposures of 7 years or longer, up to an entire lifetime. It is defined as follows:

> *An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer effects during a lifetime.*

As with the MRL, the RfC is also based on assumed continuous (i.e., 24/7, 365 days per year) exposure.

1 µg/m³ - ATSDR Residential Occupancy Level – level acceptable for occupancy of any structure after a spill. The ATSDR notes, "ATSDR would prefer no one ever be chronically exposed to concentrations above the MRLs; however, experience has shown cleanup operations in a response to concentrations below 1 µg/m³ can be extremely disruptive to individual and family quality of life. This level is still 25 times lower than the human LOAEL (lowest observable adverse effects level) on which the MRL is based. An air concentration of 1 µg/m³, as measured by the highest quality data (e.g., NIOSH 6009 or equivalent), is considered safe and acceptable by ATSDR, provided no visible metallic mercury is present."

3 µg/m³ - ATSDR re-occupancy after a spill of an occupational or commercial setting where mercury is not usually handled. Based on the residential occupancy level but adjusted for the shorter duration exposures typical of most workplaces. This concentration is approximately 10 times lower than levels of known human health effects, provided no visible metallic mercury is present to act as an attractive nuisance or a source for more vapors. "Those exposed in this instance would not expect hazards associated with mercury as part of their normal work and may include transient exposures by more sensitive individuals (e.g., retail facilities)."

10 µg/m³ - ATSDR level where isolation of residents from exposure following a metallic mercury spill in their homes. They note, "…this concentration approaches levels reported in the literature to cause subtle human health effects. Applied to acute exposure with good accuracy by real-time instruments, this value allows for interventions before health effects would be expected."

10 µg/m³ - ATSDR acceptable level in a modified test procedure to allow personal effects to remain in the owner's possession. For personal effects, such as clothing, warmed in a discrete plastic container much smaller than a typical room (e.g., a garbage bag), this concentration is considered safe by ATSDR based on a number of factors.

25 µg/m³ - ATSDR level for an occupational setting where mercury is handled. Based on the 1996 ACGIH TLV. Assumes hazard communication program as required by OSHA is in place; engineering controls as recommended by NIOSH; and medical monitoring programs as recommended by the ILO, NIOSH, ACGIH are in place. Above this level, the ATSDR recommends worker protective equipment upgrade.