NIOSH HEALTH HAZARD EVALUATION REPORT

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Research Triangle Park
Durham, North Carolina

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PREFACE

The Respiratory Disease Hazard Evaluations and Technical Assistance Program (RDHETAP) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSH) Act of 1970, 29 U.S.C. 669(a)(6), or Section 501(a)(11) of the Federal Mine Safety and Health Act of 1977, 30 U.S.C. 951(a)(11), which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

RDHETAP also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Richard Kanwal, M.D, M.P.H. and Jean Cox-Ganser, Ph.D. of the RDHETAP, Division of Respiratory Disease Studies (DRDS). Field assistance was provided by Fred McKnight (Turner Building Science), Terri Pearce, Ph.D., and Stephen Martin, M.S. Desktop publishing was performed by Amber Harton.

Copies of this report have been sent to employee and management representatives at United States Environmental Protection Agency, Research Triangle Park and to the OSHA Regional Office. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION AT UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NORTH CAROLINA, MARCH 2006

From September 6 through September 9, 2005, investigators from the National Institute for Occupational Safety and Health (NIOSH) performed a site visit at the Environmental Protection Agency facility at Research Triangle Park. This evaluation was conducted in response to a request from EPA management for a NIOSH health hazard evaluation regarding a history of particulate exposure and staff health effects in the laboratory areas of this facility. This report contains NIOSH's findings and recommendations and serves to close out this evaluation.

What NIOSH Did

- Reviewed reports of past environmental evaluations.
- Held meetings with employee and management representatives.
- Entered ventilation units and laboratories, performed limited air sampling for particulate counts, and made observations during changes to ventilation airflows.
- Held voluntary confidential interviews with 17 employees who requested interviews.
- Reviewed medical records at the onsite Federal Occupational Health (FOH) Clinic.
- Met with Dr. Goodno of the FOH Clinic.

What NIOSH Found

- Results of limited air sampling and staff observations suggest that particulate accumulation in the ventilation system air handling units, coupled with periodic loss of control of laboratory airflows by the system, is a likely source of excess particulate in laboratory areas. Other sources of laboratory particulate may include ceiling tiles, floor cleaning activities, and soil and construction activities outside the facility.
- Employees reported health effects they experienced in, or attributed to, the EPA/RTP facility. The most common reports were of upper and lower respiratory symptoms and eye irritation. These symptoms may represent primarily irritant responses. Whether or not particulate exposures in the laboratories caused or exacerbated asthma in some employees could not be determined from the information available.

What Managers Can Do

- Establish an indoor air quality committee and include employee representatives from all areas of the EPA/RTP facility.
- Continue with ongoing work to minimize particulate from the ventilation system. Address other potential sources of laboratory particulate.
- Continue to encourage laboratory employees to report symptoms that could be related to laboratory exposures; respond by following the steps outlined in recommendation #5.

What Employees Can Do

- Continue to report to EPA/RTP health and safety staff any respiratory or other irritant symptoms that occur in laboratory areas.
- Follow the recommendations for exposure avoidance and, if necessary, for medical evaluation outlined in this report.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report ##2005-0290-2992

Health Hazard Evaluation Report #2005-0290-2992
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SUMMARY

From September 6 through September 9, 2005, investigators from the National Institute for Occupational Safety and Health (NIOSH), Division of Respiratory Disease Studies, performed a site visit at the Environmental Protection Agency facility at Research Triangle Park in Durham, North Carolina. This evaluation was conducted in response to a request from EPA management for a NIOSH health hazard evaluation regarding a history of particulate exposure and staff health effects in the laboratory areas of the facility. Laboratory staff became aware of excessive indoor particulate levels starting in 2003. Some EPA researchers measured $PM_{2.5}$ (particulate smaller than 2.5 microns) levels and noted instances where indoor concentrations were higher than outdoor concentrations. Staff in many laboratories started to note a rapid buildup of white dust on surfaces which would quickly recur after cleaning. High efficiency particulate filters in bio-safety cabinets in many laboratories had to be changed out after several months use when normally they would be expected to last several years. Electrical components of several laboratory devices were found to be damaged and to have evidence of corrosion and accumulated particulate. Investigations by EPA/RTP facilities staff revealed that the humidification system in the heating, ventilation, and air conditioning (HVAC) units was causing a buildup of sodium and chloride deposits on the cooling coils and was a potential source of the laboratory particulate. An additional issue contributing to the particulate problem was periodic malfunctioning of ventilation-system controls which would cause transient increased airflows in laboratory areas. Such malfunctions were associated with increased deposition of visible particulate matter on surfaces. These events were referred to as “dumps” by EPA staff. In 2004, a number of laboratory staff in Buildings A and B developed acute health symptoms in laboratories where a dump had just occurred. The symptoms reported by these individuals included cough, shortness of breath, chest pain with inhalation, chest tightness, sore throat, and eye irritation. Some individuals had persistent symptoms for many days prior to eventual resolution, and some had symptoms recur when they tried to return to their usual laboratories. One individual reported receiving a diagnosis of asthma due to the particulate exposure. Despite attempts by EPA/RTP facilities staff to address the particulate problem, employees continued to detect excess particulate in laboratory areas and to experience respiratory symptoms. Results of limited air sampling and observations by NIOSH staff during the site visit suggest that particulate accumulation in the ventilation system air handling units, coupled with periodic loss of control of laboratory airflows by the system, is a likely source of excess particulate in laboratory areas. Other sources of laboratory particulate may include ceiling tiles, floor cleaning activities, and soil and construction activities outside the facility. The ongoing replacement of the cooling coils in the HVAC units, along with utilization of reverse osmosis and a water softener to treat the water for the humidification system, may correct the ventilation system particulate problem. However, the fact that the humidifier atomizer heads will still be relatively close to the cooling coils may cause particulate buildup on the coils to recur. In confidential interviews with 17 employees who requested interviews with NIOSH staff, employees reported health effects they experienced in, or attributed to, the EPA/RTP facility (mostly laboratory areas). The most common reports were of upper and lower respiratory symptoms and eye irritation. These symptoms may represent primarily irritant responses. Whether or not particulate exposures in the laboratories caused or exacerbated asthma in some employees could not be determined from the information available.

Particulate accumulation on, and corrosion of, the cooling coils in the HVAC units has likely led to increased amount of visible particulate and $PM_{2.5}$ in the laboratory areas of the EPA/RTP facility. The particulate may be responsible for the irritant-type symptoms that some employees have experienced while in their laboratories and/or adjacent offices. Symptoms were severe in instances where employees were exposed in relation to a particulate "dump" that resulted from a ventilation-system airflow malfunction. The ongoing replacement of the cooling coils reportedly will take several months to complete. This should decrease the amount of particulate that enters the laboratory areas from the ventilation system and may lead to resolution of employee symptoms. This report contains recommendations for steps that EPA/RTP facilities and health and safety staff should follow to prevent and minimize particulate from the ventilation system and other sources, and to protect employees that may continue to be adversely affected until the particulate problem is eliminated.

Keywords: NAICS Code 924110, indoor air, particulate, ventilation, respiratory, asthma

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INTRODUCTION

From September 6 through September 9, 2005, investigators from the National Institute for Occupational Safety and Health (NIOSH), Division of Respiratory Disease Studies, performed a site visit at the Environmental Protection Agency facility at Research Triangle Park in Durham, North Carolina. This evaluation was conducted in response to a request from EPA management for a NIOSH health hazard evaluation regarding a history of particulate exposure and staff health effects in the laboratory areas of this facility.

BACKGROUND

The Environmental Protection Agency facility at Research Triangle Park (EPA/RTP) is composed of several buildings with a total occupied space of approximately 1,000,000 square feet. Buildings A, B, C, D, and E are adjacent to each other in a row and are interconnected. Building H (High Bay) is connected to Building E by an enclosed walkway. Building C is a six-story office tower. Buildings A, B, D, and E each have a five-story section consisting of laboratories and adjacent office space. Buildings B, D, and E also have a three-story section consisting only of office space. An atrium connects each five-story and three-story section in Buildings B, D, and E. Each individual laboratory (and adjoining office space) is ventilated with 100% single pass outside air supplied by heating, ventilation, and air conditioning (HVAC) units located in the penthouse area of each five-story laboratory building. By design, air pressure in the laboratories and adjacent office space is slightly negative relative to hallways and corridors. The three-story office sections are supplied by HVAC systems that are separate from the laboratory sections and receive a mixture of re-circulated air and fresh air. These buildings were first occupied by EPA staff from November 2002 through March 2003. Occupancy occurred at different times in different areas of the buildings as construction work was completed. Approximately 1800 employees work at the facility. Of these 1800, approximately 525 work primarily in the laboratory areas.

According to chronological summaries compiled by EPA safety and facilities staff, laboratory staff became aware of excessive indoor particulate levels starting in 2003. Some EPA researchers measured $PM_{2.5}$ (particulate smaller than 2.5 microns) levels and noted instances where indoor concentrations were higher than outdoor concentrations. High efficiency particulate filters in bio-safety cabinets in many laboratories had to be changed out after several months use when normally they would be expected to last several years. Electrical components of several laboratory devices were found to be damaged and to have evidence of corrosion and accumulated particulate. Staff in many laboratories also started to note a rapid buildup of white dust on surfaces which would quickly recur after cleaning. Facilities and safety staff from the Office of Administration and Resources Management (OARM) and safety staff from the Office of Research and Development (ORD) at EPA/RTP began to investigate this problem in 2003. By February 2004, their investigations revealed that the humidification system in the HVAC units was a potential source of the particulate. Specifically, the water softener device used to remove minerals from Durham city water prior to use in the humidification system was causing a buildup of sodium and chloride deposits on the cooling coils in the HVAC units. Particulate from these deposits (and possibly from associated corrosion of the coils) could then be carried by the ventilation supply air into the laboratory areas.

An additional issue contributing to the particulate problem was periodic malfunctioning of ventilation-system controls which would cause transient increased airflows in laboratory areas. Such malfunctions were associated with increased deposition of visible particulate matter on surfaces. These events were referred to as “dumps” by EPA staff. In 2004, a number of laboratory staff in Buildings A and B developed acute health symptoms in laboratories where a dump had just occurred. Some staff developed symptoms after cleaning up the visible particulate on surfaces, while others said their symptoms started upon entering the laboratory. The symptoms reported by these individuals included cough, shortness of breath, chest pain with inhalation, chest tightness, sore throat, and eye irritation. Some individuals had persistent symptoms for many days prior to eventual resolution, and some had symptoms recur when they tried to return to their usual laboratories. One individual reported receiving a diagnosis of asthma due to the particulate exposure.

The steps taken by OARM to resolve the particulate problem included (1) discontinuing the use of the water softener for the humidification system in March 2004, (2) performing regularly scheduled pressure washing of the cooling coils in the HVAC units starting in August 2004, and (3) inspecting laboratory air supply ducts with replacement of any ducts found to have particulate accumulation. Despite these steps, reports of particulate deposition and dumps in the laboratories continued, and additional staff in 2005 reported respiratory, eye, and skin symptoms that they felt were due to exposure to particulate in their work areas. Due to the health concerns of a number of EPA employees, EPA management requested in July 2005 that NIOSH perform a health hazard evaluation to assess the ongoing particulate issue and related health effects and provide recommendations addressing both of these issues.

METHODS

Prior to the September 2005 site visit, we had several phone calls with EPA/RTP management. These calls, and documents provided by management on the history of the particulate problem and the findings from various evaluations undertaken since 2004, supplied the background information presented above. The documents provided included (1) ORD and OARM chronological summaries of events, findings from investigations, and interventions, (2) air sampling and wipe sample results, (3) results of scanning electron microscopy studies of particulate samples, and (4) copies of reports prepared by outside consultants.

The EPA/RTP site visit by NIOSH was conducted by a physician, an epidemiologist, an industrial hygienist, an engineer, and a senior indoor air specialist (the last under contract from Turner Building Sciences, Inc.). Our goal was to evaluate the ventilation system and other potential sources of laboratory particulate that might lead to health effects in laboratory staff. Activities conducted by the NIOSH team during the site visit included (1) meeting with representatives from management (including facilities and safety staff) and from the American Federation of Government Employees (AFGE), Local 3347, (2) a walkthrough of the facility, (3) visual observations in two laboratories during increases in ventilation supply and exhaust airflows induced by the facilities staff, (4) real-time air sampling for particle counts over several hours in two unoccupied laboratories on evenings when custodial staff performed burnishing (buffing) of hallway floors (See Appendix A, report prepared by Turner Building Sciences, Inc. for air sampling methods) and similar air sampling inside HVAC unit fan housings during unit startup, (5) voluntary, confidential interviews of EPA employees who requested to meet with NIOSH regarding their experiences at the facility, (6) review of medical records at the onsite Federal Occupational Health (FOH) Clinic, and (7) meeting with the FOH Clinic physician who evaluated some EPA employees who reported symptoms related to particulate in the laboratories.

RESULTS

Document Review

We compiled a detailed summary of the findings from investigations by EPA staff and by outside consultants (Appendix B). The main findings from these evaluations are briefly highlighted below:

Findings from evaluations by EPA staff:

- In April and June 2004, sampling for total particulate before, during, and after shutdowns of the ventilation system showed the highest levels to occur after restart of the ventilation system.

Sampling occurred in a laboratory in April 2004; the location of the June 2004 sampling was not reported.

- "Real-time particulate grab samples in July 2004 showed particulate air concentrations ranging from 45-58 ug/m^3 (micrograms per cubic meter) in laboratory areas in Buildings A, B, D, and E, with air concentrations of 191 and 212 ug/m^3 measured outdoors. Similar air sampling in April 2005 (on a day noted as having no humidification in building B) showed most indoor air concentrations to be the same or less than the outdoor concentration of 11 ug/m^3. Concentrations in Building A ranged from 41-286 ug/m^3, with seven of nine measurements greater than 190 ug/m^3. The air concentration was 82 ug/m^3 in Building A on a day noted to have "lower humidification" in Building A.
- Sampling for $PM_{2.5}$ in two laboratories in Building A in April 2005 showed air concentrations to vary over the course of the day. The highest levels were 242 ug/m^3 in one laboratory and 122 ug/m^3 in the other laboratory.
- Wipe samples obtained from surfaces in multiple laboratories and analyzed with scanning electron microscopy and energy-dispersive x-ray spectrometry (SEM/EDX) showed the predominant elements in the particles to be aluminum, silicon, sodium, chloride, oxygen, iron, calcium, and zinc.
- $PM_{2.5}$ was measured over time in Buildings A, B, D, E, and H and the dust was analyzed for elemental content. The highest measured air concentrations for sodium and chlorine were 69.5 ug/m^3 for sodium and 55.4 ug/m^3 for chlorine in a laboratory in Building A (A462A) on December 15 and 20, 2004, respectively. These were reported to be "exceptionally cold days" where humidification would have occurred. Sampling on January 4, 2005 showed $PM_{2.5}$ levels to be mostly below levels of detection in most laboratories except for the laboratory sampled in Building A. January 4, 2005 was reported to be "an exceptionally warm day" where humidification would not have occurred except in areas of Building A where animals are housed.

Findings reported by outside consultants:

- **Air Quality Sciences, Building Consulting, Inc. (AQS/BC)** performed an assessment at EPA/RTP in June 2004. As part of their assessment, they obtained wipe, settled dust, and air samples in laboratories and bulk samples from HVAC unit cooling coils. The bulk samples from the HVAC cooling coils "appeared to consist mainly of crystalline aluminum oxide or hydroxide particles derived from corrosion of aluminum metal (consistent with visual observations made on site)." AQS/BC reported that these corrosion products were also a major constituent (10% or greater by volume as a semi-quantitative estimate) in most of the dust and wipe samples and in one of two air samples. Soil minerals and construction debris, glass fibers, rust/metal flakes, cotton, and paint were also major constituents in many of the dust and wipe samples.
- **Gobbell Hays Partners, Inc.** (GHP) performed a visual assessment of the HVAC system in November 2004. GHP's findings included "…isolated areas containing a minor amount of particulate, rust/mineralization, and small amounts of construction debris. This particulate was generally in the main supply plenum in the Penthouse, lower portions of the medium pressure duct and at the metal pans of diffusers."
- Analyses performed by **Galson Laboratories** on bulk samples in July 2004 revealed fibrous glass content ranging from 65% to 100% in bulk samples from a reheat coil, HEPA filter, "ceiling cavity", and "ceiling tiles". Air samples from laboratories in Buildings A, B, D, and E analyzed for fibrous glass by **Galson Laboratories** in August 2004 showed all samples to have

less than 0.007 fibers per cubic centimeter of air.

- **Analytical Services, Inc**.'s x-ray diffraction analysis of a dust sample from laboratory A462A in July 2004 revealed the major components to be NaCl (sodium chloride) and SiO_2 (quartz). $NaSO_4$ (sodium sulfate) was reported to be a minor component.
- In June and July 2005, **Eastern Research Group, Inc.** performed wipe and tape lift sampling in several laboratories and HVAC units. Analysis "…using a Proton Induced X-ray Emission (PIXE) scan" indicated that, in the samples from the HVAC units, iron had the highest mean percentage of the total mass (45.7%), followed by aluminum (28.9%), silicon (6.6%), and zinc (6.4%). (Sodium and carbon were not included in the analysis.) In the samples from the laboratories, iron had the highest mean percentage of the total mass (24.9%) followed by calcium (14%), silicon (12.1%), aluminum (8.8%), zinc (8.6%), sulfur (7.6%), and potassium (6.7%). Analysis with polarized light microscopy (PLM) showed that 80-90% of the samples from the HVAC units and from a laboratory in Building E (which had recently experienced a "dump") were made up of "glass-like chips". In the samples from the other laboratories, glass-like chips made up 35-65% of the samples. Fibrous glass was present in the samples from two laboratories, making up 5% and 15% of the samples.
- In July 2005, **ESML Analytical, Inc**. performed light microscopy analyses of wipe samples from two laboratories in Buildings A and E. "Glass fragments" were reported to make up 25% of the sample from one laboratory and 35% of the sample from the other. The samples also contained 34-38% unidentified organics and inorganics, 15% gypsum/anhydrite, 5-10% cellulose, and 2-5% fibrous glass. By x-ray fluorescence spectrometry (XRF), the samples were reported to contain 50-70% carbon, 18.8% Al_2O_3, 4.4-5.4% SO_3, 2.1-2.4 % Fe_2O_3, 1.7-10.4% SiO_2, and 0.1-4.4% ZnO. Many other elements and oxides were present in smaller percentages. ESML Analytical, Inc., concluded that "The samples were found to contain primarily alumino-silicate glass fragments and organic dust."

Meetings with Facilities and Safety Staff

In discussions with EPA/RTP facilities and safety staff during our site visit, we obtained additional information on the operation of the ventilation and humidification systems. The humidification system contained within the HVAC units uses an atomizing nozzle system to generate a fine mist. Humidification to increase relative humidity on cold, dry days generally occurs during the months from September through April, with February and March being the months with the most days requiring humidification. Some humidification of animal areas in Building A occurs year-round. The humidification system was designed to use municipal water after processing through an onsite water softener device to remove dissolved minerals (accomplished through ion exchange with a cation resin). According to facilities staff, the humidification system was not fully operational until February 2003. The first laboratory device known to have failed due to the particulate problem was identified in April 2003, and the first report of particulate in a laboratory occurred in June 2003. OARM discontinued use of the water softener in March 2004 after recognizing that the water softener was causing sodium and chloride particulate deposition on the HVAC unit cooling coils. After this, the humidification system was supplied with municipal water without any additional treatment. Because the particulate problem persisted after the water softener was no longer being used, OARM investigated the possibility of residual particulate deposits within the ventilation ducts. Inspection of the ducts by an outside consultant firm (see Appendix B, Document Review) and by facilities staff did not reveal evidence suggesting the presence of substantial amounts of particulate within the ducts. However, facilities staff did discover collections of particulate in the drain pans below the cooling coils. These collections appear to result from condensate dripping off of the coils and carrying particulate with it. When an HVAC unit shuts off (e.g. when decreased building occupancy leads to a decreased need for ventilation) the condensate in the drain pan is able to dry, leaving accumulated particulate. To prevent the possibility of this particulate becoming airborne when the HVAC unit starts up again, facilities staff reported that they wet the particulate and/or clean out the drain pan before the unit restarts.

Pressure washing the cooling coils in the HVAC units was not effective at removing the accumulated particulate because the coils are arranged in rows and multiple layers such that the water from pressure washing is not able to reach the rows of coils beyond the first layer. Because of this, OARM has started to replace the cooling coils in the HVAC units and expects to have this project completed in 2006. (In a February 2006 communication, EPA RTP management reported that the replacement of cooling coils in all HVAC units in Buildings B and D had been completed and that the replacement of coils in Buildings E and H was in progress, with the replacement of coils in Building A to follow.) To prevent particulate accumulation on the new coils, OARM has installed a reverse osmosis system for use with the water softener to remove 98.5% of dissolved solids from the softened water prior to its use in the humidification system.

Facilities staff indicated that the ventilation system malfunction that leads to particulate dumps in the laboratories has been difficult to identify and correct. Apparently during a dump, a “controller fails”, causing variable air volume (VAV) boxes in several laboratories to “go wide open”. The HVAC units then increase air flow in order to maintain static pressure in the ducts. Over several minutes to an hour or longer, the computerized ventilation control system corrects the problem by restoring proper airflows into and out of the laboratory spaces. This type of malfunction has occurred at various times and locations with no apparent pattern. Facilities staff indicated that they are addressing power supply and computer control issues that may be responsible for the controller malfunctions.

Interviews with EPA/RTP Employees

Seventeen employees met with members of the NIOSH team to discuss health issues that they attributed to particulate exposures while working at EPA/RTP. Several other employees communicated their concerns in writing or by telephone. A small percentage of these employees reported developing acute respiratory symptoms when they entered their laboratories after a dump, or after they started to clean up the particulate. Their symptoms included cough, shortness of breath, chest tightness, chest pain with inhalation, throat irritation, and eye irritation. Their symptoms required one or more days to resolve. Two of these employees reported recurrences of their acute symptoms when they entered certain laboratory areas. One employee reported receiving a diagnosis of asthma. Most of the other employees reported gradual onsets of symptoms, the most common being eye irritation, throat and nasal irritation, coughing, chest tightness, and central chest pain with inhalation. Some of these employees noted marked improvement or resolution of symptoms when they were away from work for long weekends or on vacations. Two employees mentioned developing chronic headaches which persisted despite treatment but did resolve after several days away from work. Two employees reported skin irritation and one reported developing a chronic skin condition. Two employees reported developing cancer (in different organs) since starting work at the EPA/RTP facility.

Review of Medical Records

We reviewed the spirometry test results of two employees who reported recurrent lower respiratory symptoms when present in certain laboratory areas. In one worker the results of testing on one occasion were interpreted as showing possible mild airways obstruction; a later test was interpreted as showing mild restriction. Lung function after administration of a bronchodilator did not increase sufficiently to meet the American Thoracic Society criteria for reversibility of airways obstruction (an increase in the forced expiratory volume in the first second of exhalation (FEV_1) of 200 milliliters and 12% of baseline).[1] The other employee's spirometry tests were normal, and lung function after bronchodilator administration also did not increase sufficiently to meet the criteria for reversibility. Of note, the age data used to determine lung function predicted values was entered incorrectly at this employee's first test. When the correct (younger) age was used on later tests, the resulting predicted values were higher, making it appear that lung function as a percentage of predicted had declined. The actual measured values on the two tests were essentially unchanged.

Facility Walkthrough and Air Sampling

Walkthrough: The NIOSH team entered two HVAC units in the Penthouse area of Building B. One unit had its original cooling coils in place. On these coils, white crust-like material was evident on the part of copper pipe that was visible between the aluminum fins. In the other HVAC unit, the cooling coils had been recently replaced and appeared clean.

We entered several laboratories in buildings A, B, and D. In several of these laboratories, a light coating of coarse, whitish particulate could be seen on various surfaces such as laboratory benches and the metal framing around biosafety cabinets. This was most evident in laboratories that we were told had not been cleaned in many months (e.g. if the principal investigator and their staff had been assigned to other areas of the EPA/RTP facility).

Facilities staff showed us a section of cooling coil from a set of coils that had been removed from an HVAC unit. It consisted of copper pipe with attached circular aluminum fins. White crust was present on the exterior of the copper pipe where it was visible between the aluminum fins. When we allowed this section of cooling coil to fall approximately 12 inches onto a table top, a small amount of the white material came loose from the pipe and was visible on the table top as a coarse whitish dust. The material was similar in appearance to the particulate we noted on some laboratory surfaces.

Some laboratories had filters installed over the air diffusers in the ceiling. We were shown examples of used filters where the area of filter material that had covered the diffuser was noticeably darker than the rest of the filter material that had extended beyond the diffuser openings.

We lifted ceiling tiles in two laboratories and visualized the plenum space. In one such space, there was a small collection of brown, fibrous-appearing material lying on one ceiling tile. Otherwise the plenum space in these areas appeared generally clean. When we lightly tapped a ceiling tile on a bench top, a small amount of course material was released from the tile.

In two laboratories, facilities staff manually increased the supply and exhaust ventilation. We observed whitish dust to be discharged from the supply air diffuser in one of these laboratories when the ventilation was increased. When the supply air was shut off and the level of exhaust ventilation was maintained, we noted in the adjacent office of one laboratory that the ceiling tiles lifted up out of their frame when the door to the perimeter corridor was opened.

Air sampling: Particle count measurements in offices adjacent to laboratories in Building B were made on evenings when floor burnishing was to be performed in the corridor outside of the office. Particle counts in the office air increased at the time burnishing occurred. Particle counts in supply duct air at the time of burnishing did not increase. (See Appendix A, report prepared by Turner Building Science, Inc.)

Particle count measurements were made inside of the fan housings of two HVAC units in relation to start-up of the units. One unit had been shut off for several hours to allow the cooling coils and drain pan to dry. We noted that the drain pan of this unit contained discrete areas of white crust-like material. The other unit was only shut off for a few minutes. Particle counts after start up of the units were approximately 10 times higher in the unit that had been off for several hours compared to the unit that had been off for only a few minutes.

DISCUSSION

Past evaluations by EPA staff and outside consultants indicated that particulate deposition on the cooling coils in HVAC units was a potential source of the excess visible particulate and elevated $PM_{2.5}$ levels in laboratories in Buildings A, B, D, and E. Air sampling by EPA staff showed that total particulate in laboratories was greater on days when HVAC units were restarted compared to days prior to, and during, HVAC-unit shutdown. Air sampling also revealed higher $PM_{2.5}$ levels in certain areas (i.e., Building A laboratories) and on certain days (i.e., cold outdoor temperatures) when greater humidification by the HVAC units would have been expected. Some EPA consultants reported analytic findings indicating similar composition and appearance of the particulate in samples obtained from the HVAC units and in laboratories.

During our site visit we made observations and obtained particulate air sampling results that are consistent with the past findings of EPA staff and consultants. The discharge of whitish particulate from a supply air duct / diffuser after the facilities staff increased ventilation airflows, and the higher particle counts in the air outflow of an HVAC unit that had been turned off for several hours to allow drying of coils and drain pan compared to a unit that was shut off only briefly, suggest that the ventilation system is a likely source of particulate in the laboratory areas. The ongoing replacement of the cooling coils in the HVAC units, along with OARM's plan to utilize reverse osmosis and the water softener to treat the water for the humidification system, may eliminate this source of particulate in the future. However, as pointed out in the report by Turner Building Science, Inc. (Appendix A), the fact that the humidifier atomizer heads will still be relatively close to the cooling coils may cause particulate buildup on the coils to recur.

There are other potential sources of particulate that may contribute to the total particulate that impacts laboratory areas. One of these is airborne particulate resulting from floor burnishing. Another is outdoor dust particles made airborne by nearby traffic and construction activities and entrained into the facility by the ventilation system or through other openings in the building envelope. Dust from outside is also brought into the facility on occupants' shoes. Finally, ceiling tiles may release some particulate due to vibration or movement induced during normal as well as abnormal operation of the ventilation system. Whether or not these sources contribute substantially to the total particulate in laboratory areas is currently not known and may need further assessment in the future. (See. Appendix A, report by Turner Building Science, Inc.)

Although we (and several EPA staff also present) did not experience symptoms when the increase in ventilation air flow in a laboratory led to excess particulate, it is possible that EPA employees who have experienced symptoms after particulate dumps were exposed to higher particulate air concentrations. The excess visible particulate that we noted in a laboratory after ventilation was increased only covered a small area (approximately 2 square feet) of a laboratory bench beneath a diffuser, whereas descriptions by EPA employees of some past particulate dumps indicated that much larger surface areas were covered with visible particulate.

The symptoms reported by several laboratory employees may resolve as the planned replacement of the cooling coils in HVAC units eliminates this source of particulate. While none of the measured particulate air concentrations at EPA/RTP have exceeded the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for particulates not otherwise regulated of 15 milligrams per cubic meter (mg/m^3) of air (5 mg/m^3 respirable),[2] it is possible for some individuals to experience irritant-type symptoms (eye, nasal, and throat irritation) at lower air concentrations. It is possible that the lower respiratory symptoms (cough, chest pain with inhalation, chest tightness, wheezing) in some employees represent a similar irritant-type response. However, these lower respiratory symptoms can also be a manifestation of asthma. Asthma is a form of lung disease in which airways develop inflammation and bronchospasm (reversible airways obstruction) in response to a variety of specific and non-specific triggering agents.[3] Both irritant and allergic mechanisms have been shown to play a role in asthma development. Reactive airways dysfunction syndrome (RADS) is a known form of asthma caused by exposure to high concentrations of irritating substances. Individuals with RADS usually experience repeated episodes of bronchospasm in response to a variety of irritants (non-specific airways hyperreactivity). Individuals with asthma resulting from sensitization (allergic response) to an allergen also experience non-specific airways hyperreactivity.[3] None of the employees we spoke with reported recurrent lower respiratory symptoms when they were away from the EPA/RTP facility. Of the substances identified in the particulate in the laboratories and on the cooling coils, none are known sensitizers. While asthma has been diagnosed in workers involved in aluminum production, workers in that setting are exposed to multiple substances (including fluoride, hydrogen fluoride, sulfur dioxide, and coal tar pitch volatiles); it is still not clear what role, if any, aluminum plays in asthma development in these workers.[4]

A confirmed diagnosis of asthma requires an abnormal methacholine challenge test or, for individuals with airways obstruction on baseline spirometry, a 12% and 200 milliliter improvement in the forced expiratory volume in the first second of exhalation (FEV_1) after administration of a bronchodilator medication.[1,5] In an employee with confirmed asthma, establishing whether or not the asthma is related to workplace exposures requires serial monitoring of lung function at work and at home to see if a pattern consistent with occupational asthma is present.[6] The information available to us was insufficient to determine whether or not any EPA/RTP employees have developed new-onset asthma or exacerbation of pre-existing asthma as a result of any workplace exposures.

Two EPA employees expressed concern that they might have developed cancer due to exposures experienced in the current EPA/RTP facility. The period of time between exposure to a causative agent and the first manifestation of cancer (i.e. the latency period) ranges from 12 to 25 years for most cancers.[7] Since this facility has only been in use for the past three years, it is extremely unlikely that their cancers were in some way connected to the current EPA/RTP facility.

A number of employees we spoke with were concerned that episodes of water incursion (from burst pipes) and possible moisture damage to building materials at the EPA/RTP facility might have negatively affected indoor air quality. One water incursion event apparently required extensive remediation to Building C. While we did enter and walk through all buildings at the EPA/RTP facility, our examinations of these areas was limited to what is described in the results section of this report. We did not notice evidence of moisture-damaged building materials (except for a small number of stained ceiling tiles) in the areas we entered, but our walkthrough was limited in scope and did not involve any invasive examination of wall cavities.

CONCLUSIONS

Particulate accumulation on, and corrosion of, the HVAC-unit cooling coils due to the operation of the humidification system has likely led to increased amounts of visible particulate and $PM_{2.5}$ in the laboratory areas of the EPA/RTP facility. This particulate may be responsible for the irritant-type symptoms that some employees have experienced while in their laboratories and/or adjacent offices. Symptoms were severe in instances where employees were exposed in relation to a particulate "dump" that resulted from a ventilation-system airflow malfunction. The ongoing replacement of the cooling coils reportedly will take several months to complete. This should decrease the amount of particulate that enters the laboratory areas from the ventilation system and may lead to resolution of employee symptoms. The following recommendations address steps that EPA/RTP should take to prevent and minimize particulate from the ventilation system and other sources, and to protect employees that may continue to be adversely affected until the particulate problem is eliminated.

RECOMMENDATIONS

1. We suggest the formation of an indoor air quality committee which should include employee representatives from all areas of the facility. The status of any ongoing prevention and remediation activities should be regularly reviewed, and progress reports should be provided to all employees at the facility.

2. Recommendations from the NIOSH contractor for the site visit, Turner Building Science are summarized on page 1 of their report (Appendix A), and described in more detail in the body of the report. These recommendations largely pertain to understanding and decreasing particulate exposure in the facility, both from the HVAC system and other potential sources such as the tracking in of outdoor dusts, floor burnishing, and particulate from ceiling tiles. There is also a recommendation to increase cleaning activities in the laboratories.

3. We encourage facility managers to continue to implement the plans to mitigate the build-up of deposits on the HVAC cooling coils, to replace already damaged coils, and to stop the sudden, large pressure differentials that cause movement of ceiling tiles and particulate "dumps" in the laboratories.

4. After the planned remediation, environmental monitoring should be carried out to check the effectiveness of the interventions.

5. Both while the environmental remediations are being implemented and after their completion, laboratory employees should notify the health and safety department if they experience respiratory or other irritant symptoms. If these adverse health effects occur before the problem of particulate discharge from the HVAC system is resolved then the following steps should be taken:

   a. Inspect the duct work and diffusers in the employees work area(s) for residual particulate. Clean the diffusers and ducts (or replace the ducts) if particulate is present. This process should be accomplished in a way that minimizes staff exposures to particulate. Any individuals that have to be present during this process should wear appropriate respiratory and eye protection.
   b. Make N95 respirators (filtering facepieces) available to employees. Provide a selection of different models and sizes and assure a proper fit through fit testing. Offer eye protection (tight-fitting goggles) to employees who report eye irritation. Until the particulate problem is completely resolved, it may be necessary to relocate employees to unaffected areas if they continue to have symptoms despite the use of such personal protective equipment.
   c. Employees with lower respiratory symptoms (cough, chest tightness, wheezing, or shortness of breath) that persist despite duct cleaning (or replacement) and use of a N95 respirator should undergo further evaluation to establish whether or not they have asthma. A confirmed diagnosis of asthma requires an abnormal methacholine challenge test or, for individuals with airways obstruction on baseline spirometry, a 12% and 200 milliliter improvement in the forced expiratory volume in the first second of exhalation (FEV_1) after administration of a bronchodilator medication.[1,5] Employees should be referred by the FOH clinic to a pulmonary function laboratory for this evaluation. For employees with confirmed asthma, serial peak expiratory flow measurements may be helpful in demonstrating a work-

related pattern. Portable spirometers and peak flow meters that store results electronically are available. We recommend five measurements every day (upon waking, on arrival at work, at noon, at the end of the work day, and at bedtime) on workdays and days off for at least two weeks. Longer periods of serial monitoring are often needed. Serial peak flow results should be reviewed by a pulmonologist or occupational medical physician with expertise in their interpretation. Several patterns are consistent with work-related asthma (e.g., more variability on work days compared to off days; declines in daily averages over the work week or on workdays compared to off days; different diurnal variability patterns on workdays compared to off days). Employees with work-related asthma generally have a better prognosis if removed or protected from the causative exposures.

If these adverse health effects persist after the HVAC and cooling coil remediations have been completed and been shown to have been effective in lowering the type of particulate consistent with mineral build-up and corrosion of the cooling coils, then further investigation needs to be carried out by the health and safety department as to any other potential associated exposures.

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APPENDIX A

HVAC & IAQ EVALUATION

Preliminary Airborne Particulate Evaluation
US EPA Main Research Facility
Research Triangle Park, North Carolina

DECEMBER 2005

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December 21, 2005

Dr. Richard Kanwal
National Institute for Occupational Safety and Health
Dept. of Health & Human Services
1095 Willowdale Road, MS 2800
Morgantown, WV 26505

SUBJECT: Preliminary Airborne Particulate Evaluation
Main Research Building at US EPA
Research Triangle Park, North Carolina
TBS S0572-01 &-02

Dear Dr. Kanwal:

In accordance with our approved Scope of Work, we are pleased to offer this report on our observations and preliminary testing at the main lab building of the US EPA complex in Research Triangle Park, North Carolina. Our recommendations made herein are based primarily on our observations and limited monitoring collected while on-site. The enclosed report is of a technical nature; therefore, the reader will need to have some technical knowledge of the facility to properly evaluate the recommendations made herein. Turner Building Science, LLC (TBS) can perform all recommended additional services, if requested.

We are pleased to serve NIOSH as professional consultants. Please call me if there are any questions or subjects presented that need further clarification. You may reach me at our Vermont Office (802) 592-3097, or alternatively contact our president, Mr. William Turner, P.E., at our Harrison, Maine Office (207) 583-4571, ext. 11.

Very truly yours,

TURNER BUILDING SCIENCE, LLC

Frederick T. McKnight	William A. Turner, P.E.
Chief Indoor Air Quality Engineer	President

FTM/sai

BUILDING SCIENTISTS • IAQ CONSULTANTS

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Appendix B: Particle Monitoring Results and Pressure Differential Results

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

At the request of the National Institute for Occupational Safety and Health (NIOSH), Turner Building Science, LLC (TBS) conducted a preliminary walkthrough with limited monitoring of USEPA's main research building at Research Triangle Park, North Carolina. We present this Final Report with our observations and results of our monitoring. We have made some recommendations for improvement, as well as some for further testing and study. We are available to perform any or all of our recommended testing studies and engineering design. The completion of all the recommendations made herein could be expected to improve the indoor air quality of the facility. However, in the event that occupant symptoms do not subside, further evaluation may be required.

In essence, our observations lead us to believe that airborne particulate observed in many of the laboratories may have a number of sources, including the air handlers, ceiling tiles, and dust from spaces surrounding the labs, some of which may be distributed during maintenance operations. In addition, the operation of the air handler units and the terminal VAV boxes may at times confound the reported dust problem with possible loss of control, or other unknown control parameters that result in undesirable pressure differentials in various spaces. A management effort will be required in conjunction with active technical solutions to insure a reduction in particle production and distribution, as well as maintaining favorable pressure relationships.

We have summarized our recommendations in the listing below:

Recommendation #1:	Install walk-off mats at all normally used entry points.
Recommendation #2:	Complete testing of ceiling tile particle dispersion, and obtain additional material analysis.
Recommendation #3:	Perform adjustments and/or modifications to Automatic Temperature Controls.
Recommendation #4:	Perform additional sampling and analysis of dust from diffusers in laboratories.
Recommendation #5:	Relocate humidifiers to increase vapor absorption, or change the type of humidifiers used.
Recommendation #6:	Additional evaluation including pressure differential and air migration via tracer analysis.
Recommendation #7:	Replace floor-burnishing units with units that use powered vacuum recovery.
Recommendation #8:	Increase cleaning frequency of laboratories.
Recommendation #9:	Limit fiberglass exposure.
Recommendation #10:	Limit occupant exposure.

2.0 SCOPE OF WORK

The focus of this proposed work effort was to evaluate the conditions within the laboratory spaces with respect to the reported particulate material, provide recommendations to identify the likely source(s), and to make recommendations for corrective action and further testing, if warranted. The adequacy of the air quality was evaluated based on ASHRAE Standards and Guidelines for Acceptable Indoor Air Quality (ASHRAE 62-1999), Thermal Environmental Conditions for Human Occupancy (ASHRAE 55-1992), and OSHA Technical Manual (TED 1-0.15A).

The expected end results of these services were:

- A preliminary understanding of the current effectiveness and capability of the building's HVAC systems in providing sufficient quantities of suitable quality air (air free from contaminants at levels known to be detrimental to human health) as recommended in ASHRAE Std. 62-1999.

- A preliminary understanding of the ability of the building's HVAC system to provide recommended pressure differences between lab spaces and surrounding areas.

- An inventory of the particulate sources located within spaces being evaluated, or having a pathway to the spaces being evaluated that may diminish indoor air quality.

Specific Task Items

These tasks were verbally approved before the start of work, and are the framework for this report.

1. Observations and Review: We reviewed available information pertaining to the HVAC system design, as well as current operations of the building's HVAC systems for all areas of concern, including a review of mechanical plans, verbal reports summarizing historic maintenance, repair, and all follow-up testing of said systems conducted to date.

2. Effective Pressure Differentials: We performed on-site monitoring of the effectiveness of HVAC systems, as installed and operated, in providing the intended pressure differential between the laboratories and the surrounding ante-rooms (offices), service corridors, and perimeter corridors.

3. Contaminant Inventory: We conducted a visual inventory of existing sources of significant airborne particulate that may be responsible for the reported visual and non-visual airborne particulate loading. We completed limited airborne monitoring to determine if sources may have an impact on reported particulate problems.

4. Reporting: We reviewed the results of Tasks #1, #2 and #3 as they pertain to current ASHRAE Std. 62-1999, ACGIH, US EPA guidelines for characteristics of a comfortable, healthy, mixed-use office environment, and other guidelines for indoor air quality.

5. Recommendations: We have recommended herein corrective work as needed, to correct deficiencies, make improvements to provide adequate ventilation, building space pressure control, contaminant control, and occupant comfort during occupied periods. We have also recommended additional testing and evaluation procedures.

6. Guidance: We will assist either NIOSH officials, or US EPA officials through NIOSH by phone in dealing with occupant concerns related to recommendations, as needed.

2.1 Background

Facility

This facility is relatively new, and was designed and built specifically for the current Owner for the purpose of a research laboratory with support offices. The facility includes support services found in other large office complexes, including mail, food, health, and administration services, all of which are housed within the facility. The facility is divided into five (5) separate, but connected, buildings labeled A, B, C, D, & E, plus an additional building known as the "High Bay". A separate building (on campus) houses heating and cooling generators (boilers and chillers). The laboratory and associated spaces in each building are separated by atriums from the general administration office spaces, as well as other support services. The laboratory spaces and associated ante-room offices, as well as the perimeter and services corridors, are served by separate air handlers, which are not linked to the air handlers that serve the administrative and general offices, or the other support services.

HVAC Systems

The air handling units that serve the laboratories are manifolded together and feed a large supply duct. Individual laboratories and their connected ante-room offices (i.e. "ante-offices") receive air through a VAV (Variable Air Volume) box connected to the supply air duct. The space temperature within the ante-offices, laboratories, and the operation of any installed fume safety hoods are the factors that determine the amount of air delivered to the laboratory and ante-office. In addition, occupied and unoccupied conditions in the labs are determined by the on-off operation of the lighting. When the lights are turned on, the VAV box is placed in the occupied mode. When the lights are off, the VAV is placed in unoccupied mode. Occupied mode allows a variable quantity of air into the rooms to meet space demands for heating and cooling. In unoccupied mode, the quantity is fixed to a predetermined minimum amount that may vary from laboratory to laboratory based on the number of hoods.

The air handlers for the laboratories and associated spaces are once-through systems, i.e. 100% outdoor air is supplied to each space, and none of the air in the space is returned to the air handler. Each unit draws outdoor air in from a common louver. The air is filtered by a set of prefilters with a 30% dust spot efficiency rating, and then by cartridge filters with a reported 90% dust spot efficiency rating. Then, as required to maintain space conditions, the air is heated using hot water coils, humidified by atomizing-type water spray heads, cooled with chilled water using cooling coils, and delivered to the laboratory spaces via a VAV box. Laboratory general exhaust and fume hoods remove the air from the laboratories; none is returned to the air handlers.

Lab Arrangements for Pressure Control Zones

The laboratory wing of each building has a modular design. The perimeter of the wing is a corridor for normal personnel traffic between laboratories and other parts of the facility. Entry to each laboratory is via a small ante-room office, which separates the perimeter corridor from the laboratory space. Some laboratories may connect to neighboring laboratories via a door, but the only way to get from the perimeter corridor to the laboratories is via the ante-office, or the service corridor. The service corridor runs behind the laboratory spaces. Each laboratory has a service entry door that opens into the service corridor. Reportedly, there is a fair amount of foot traffic between laboratories via the service corridor. In addition, the service corridor is the means to move equipment in and out of the laboratory, as well as chemicals, special gases, samples, and other supplies.

To limit air movement out of the laboratories, and contain airborne contaminates within the laboratories, the air pressure within the laboratories is lower than any connected space, i.e. the ante-office and the service corridor. The perimeter corridors have the highest air pressure, and the ante-offices fall in between the laboratories and the corridors in terms of space pressure difference. Based on the pressure differences, air will move from the perimeter corridor into the ante-office, and then into the laboratories. Air also moves from the service corridor into the laboratories.

Air from the air handlers is supplied to all spaces in controlled amounts. The VAV box that supplies a laboratory also supplies the ante-office (there may be separate boxes, but they work in unison). There is an air-transfer grille between the ante-office and the laboratory, and doors between the perimeter corridor and the ante-office, and between the anteroom office and the laboratory are undercut. In addition, the door between the service corridor and the laboratory is undercut. The corridors have separate VAV boxes. These are the main pathways for air movement between the corridors and the laboratory.

Work Completed by Others

There are a number of completed evaluations and diagnostic work, including airborne and settled dust sampling. Reports of some of the sampling results and observations were made available to us before our walkthrough evaluation. For clarity, Table 1 summarizes the elemental analysis of a series of $PM_{2.5}$ measurements, and a recent settled dust analysis preformed by others are provided in Appendix A of this report.

All samples in Table 1 of Appendix A are assumed to be from occupied spaces, unless noted otherwise (i.e. outdoors and in duct). Another important parameter reported to us concerning the samples in Table 1 is that the humidifiers were on during the January 30th sample date. Additionally, the included settled dust report revealed that the dust sampled was primarily an alumino-silicate mineral that is very common in earth crustal materials (generally with a molecular formula of $Al_xSi_{2x}O_y(OH)_z$). Other materials reported include gypsum, fiberglass, and glass fragments, which are regularly found in new construction.

3.0 MEASUREMENTS CONDUCTED TO EVALUATE AIRBORNE PARTICULATE AND SPACE PRESSURE DIFFERENCES

Inhaleable Particle Concentrations in Buildings

Calibrated real-time particle counters, Climet Model CI-4100, Serial #903953 and #904187 were employed to collect particle size data for the period of our site work, September 7th, 8th, and 9th. The particle counters used in this sample series measured the opacity of the air, and converted that reading into counts of particles in the air stream passed through the counting chamber that are larger than 0.5µ and larger than 5.0µ. The particle counters were used to collect grab samples (random single count), or a short series of samples. The grab samples were intended to compare non-visible particulate quantities before some action occurred, and while the action was occurring. Additionally, the sampler was used to compare two spaces in real time. A multi-port device was employed to sample air in one location, and then in another, for a period of ten (10) minutes per space (port). This permitted sampling of both the air in the ante-

office space (B482), as well as the air entering the ante-office space from the air-supply duct.
If a building has a high level of air filtration, and the spaces are relatively free of dust reservoirs, the counter will indicate low counts of 5.0µ (micron) and larger particles. During occupied times, there may well be an increase in both size fractions (0.5µ and 5.0µ) due to human activity in the space.

The data collected by the particle counter is presented in two size fractions: particles larger than 0.5 microns (0.5µ) and larger than 5.0 microns (5.0µ). The inhaleable-size fraction is the 0.5µ count minus the 5.0µ count. These particles are small enough to move uninhibited past our respiratory system filters (mucus membranes and cilia), and are of sufficiently large enough size to settle in the lungs.

Particle counts of 0.5µ and larger are not affected as much as particle counts of 5.0µ and larger by the filtration of the air handlers. Generally, increases in 0.5µ (micron) and larger particle size during occupied times can be attributed to activities in the space that are disturbing any accumulated reservoirs of dust. Typical particle concentrations (larger than 0.5µ) in schools not found to have IAQ complaints associated with dusty conditions are in the range of 30,000 to 60,000 particles per cubic foot. It is important to note that the composition of recorded particle concentration is not known. We have found that in some cases, a small concentration of some known contaminant may result in reports of poor IAQ and occupant symptoms, or occupancy-related symptoms. The identification of these particles cannot be established by this device, and will need to be identified by other means, including observation, occupant interviews, microscopy, XRF, and SEM analysis. Further discussion pertaining to the particle data collected can be found below in the discussion section. Trend graphs of collected data can be reviewed in Appendix B.

Building Inter-Zonal Pressure Differences
When more air is mechanically blown into (supplied to) a room than removed (exhausted), the room will have a slightly positive air pressure. If more air is exhausted than supplied, the room pressure will be slightly negative. Air tends to flow from areas with positive pressure to areas with negative pressures. **Note**: One space can be positive to another, but negative to a third. Thus, the pressure relationships between rooms are important for air quality. Spaces containing contaminants, such as laboratories, should be under a negative pressure with respect to the surrounding areas to limit the flow of airborne contaminants from these spaces.

Building inter-zonal (room to room) pressure relationships were measured with an Energy Conservatory Model DG 2 Digital Micromanometers connected to a "Pocket Logger" 4 channel data logger. Spaces defined as being negative have air flowing into them from adjacent areas. Recorded building pressures and flow data has been provided in Appendix B.

4.0 DISCUSSION OF OBSERVATIONS, SAMPLING RESULTS AND RECOMMENDATIONS FOR IMPROVEMENT

Elemental Analysis

This facility is located in Research Triangle Park, which is a modern business park. Construction utilizing earth-moving equipment is ongoing at other building sites near this facility. Construction activities can raise large amounts of dust containing typical earth crustal materials, such as Al, Na, Mg, Si, S, K, Ca, P, Zn, and Fe. The elements usually are not pure species, but may be in the form of gibbsite ($Al(OH)_3$), kaolimite ($Al_2Si_2O_5(OH)_4$), calcite ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), dolomite ($CaMg(CO_3)_2$), magnetite (Fe_3O_4), pyrite (FeS_2), quartz (SiO_2) and other minerals. Most of these, but not all, are oxidized forms. Other forms are also likely to exist. The listed minerals are some of the most common to the eastern Appalachian chain and associated costal plain, but many different minerals and crustal materials can exist from these elements, and may be found in the area as well. Earth crustal materials in the form of dust and dirt can be found in many indoor environments. The dusts leak into buildings through cracks via pressure differences, are introduced by air handling units, and are carried in by occupants. Some materials such as gypsum, calcite (limestone), and silica (sand and glass) are used heavily in the construction of buildings. Most settled dust and PM elemental analysis will show quantities of each of the elements Al, Na, Mg, Si, S, K, Ca, P, and Fe in an indoor environment. Finding the elements listed in Table 1 and in the settled dust analysis in Appendix A are not unusual, particularly when the site was observed to be close to a construction site and to major highway traffic. Both traffic and construction can cause earth crustal materials to become airborne, therefore making their entry into the facility fairly easy.

Recommendation #1: Walk-off mats.

Walk-off mats located on the floors of all entry points that are used with any frequency are recommended to help minimize the amount of material tracked into the labs. Proper walk-off mats require a sufficient length of mat and a number of different mat surfaces to effectively remove tracked in materials.

Pressure Differential Full Exhaust

During interviews with occupants, we received reports of HVAC system operations that caused "wind tunnel" like noises, and lifting of some ceiling tiles. We were able to duplicate both of these effects by manipulating the VAV boxes and exhaust system. The operational event we simulated was one of turning on all of the exhaust hoods in a laboratory. The VAV box should, reportedly, automatically adjust to the increased exhaust condition. Whether actual flow rate of the VAV box under the full exhaust condition was within the initial design parameter is not known. However, under the actual operating condition, if a door were opened, the ceiling tiles would lift. Lifting of the tiles involves movement that releases small, but visible particles from the ceiling. In addition, as a separate test, we lightly tapped a ceiling tile in one lab and got a noticeable quantity of visible particles. (**Note**: Non-visible particulate may also have been released.) Some of the laboratories we observed had visible particles on lab benches that resembled the ceiling tile particles we had observed when we tapped the ceiling tile. In our opinion, it is likely that much smaller forces than those necessary to lift the ceiling tiles could produce sufficient movement (vibration) in the tile to result in a particle release event. The report of settled dust composition (completed by others) placed in Appendix A of this report indicates a high percent of glass fragments. The quantity of glass fragments identified (25% and 35%) are higher that expected from this type of sampling. Common sources of these fragments may include the ceiling tiles. Incidentally, as detailed below, the quantity of fiberglass fibers reported is also at the higher limit (5%) of what is expected from this type of sampling.

Recommendation #2: Additional testing of ceiling tile.
Sampling of ceiling tile debris should be completed. Analysis of the samples should include a microscopic exam, SEM with elemental analysis, and XRF analysis. These results should be compared to existing lab settled dust samples. Additional recommendations may be necessary based on the composition of the tiles.

Recommendation #3: Adjustment and/or modification to Automatic Temperature Controls.
The Automatic Temperature Controls (ATC) should be adjusted to limit high pressure differentials thoughout the complex, in order to limit the unintended raising of ceiling tiles. Additional engineering studies should be completed to determine acceptable flows, and how to adjust the controls system to maintain flows and pressure limits.

Visible Particles from Supply Air at Full Flow
During our interviews with occupants, we received reports that the supply air diffusers were observed to have spewed out particles from time to time, an event referred to as a "dump" by EPA staff. By manipulating the VAV box in one lab to the full open position to increase the supply airflow, we were able to observe a similar spewing of particles. It was unclear what may have been the source of the particles, the VAV box, or a source further upstream. Particle composition is also unknown.

Recommendation #4: Sampling to identify the source.
Additional samples of particulate from the supply air diffusers and ducts should be collected and analyzed via a microscopic exam, SEM with elemental analysis, and XRF analysis for comparison to existing lab settled dust samples. Additional recommendations may be necessary based on the composition of the particles from the air stream.

Air Handler Observations – Humidifiers
As part of the HVAC system evaluation, we observed the interior of a typical air handler. The units were arranged similar to that indicated in the drawings that were provided. The outside air inlet with dampers was at the upstream end of the unit. The next station in the unit was a 30% filter bank in front of a 90% filter bank. After the filters, there was a heating coil, and just downstream of this coil were the atomizer-type spray heads of the humidifier. Downstream of the humidifier heads were the cooling coils and the fan. In general, the units were well built and in good shape. However, the humidifiers heads are too close to the cooling coils. The location causes problems, as reported by the operators. The coils "catch" water droplets discharged by the humidifiers before they can completely evaporate. The result is a build-up of evaporates (nuclei and minerals) within the coils. The evaporate reportedly has prematurely restricted the coil airways. In addition, it appears that the cooling coils and the humidifiers can operate in unison, which allows the cooling coils to condense water vapor added to the air stream from the humidifiers, further exacerbating the evaporate build-up, and likely requiring additional run time of the humidifiers to maintain humidity levels in the laboratory spaces.

The cooling coils reportedly are being replaced because of a build-up of evaporates within the fins on the coil tubes in the interior rows of the coil, where it is difficult to clean. Reportedly, the water for humidification will be treated by a reverse osmosis device. The removal of particles from the water stream to the humidifier heads will reduce the potential for evaporates to accumulate at the current rate. However, the air filtration system is approximately 90% dust-spot efficiency, which will remove a large majority of particles down to about 1.0μm, leaving airborne colloidal silica, salts, carbon black, and other charged particles that can serve as nuclei for droplet formation, or to be collected by droplets. The current location of the humidifiers will exacerbate evaporate formation due to the head proximity to the condensing surfaces of the cooling coils.

Recommendation #5: Relocate humidifiers to a location where vapor absorption can be more complete, or change type of humidifiers used.
Additional engineering studies should be completed to determine if relocation of the humidifier heads, or providing a different type of humidification system, a clean steam system for example, may be more effective, and have less of an impact on air quality.

Air Handler Observations – Start-up
As part of our evaluation to identify particulate, sources we measured showed relative differences in particle counts between the start-up of a dry air handler and a wet air handler. A dry air handler was likely to have evaporates left in the drip pan and other surfaces where condensate from the coiling coils, or from the humidifiers, may have evaporated. A wet air handler was one with water in the drip pan. The sample tube of a particle counter was inserted into the fan housing of each air handler, and then the unit was started. The dry air handler had particle counts of at least an order of magnitude higher than the wet unit did.

Recommendation: See #5 Above.

Reentrainment Potential
We reviewed the arrangement of exhaust stacks with respect to air inlets, and found little physical evidence that reentrainment of exhaust fumes would be likely to occur. The observed separation between the discharges, inlets, and the reported air velocities, were sufficient to minimize any possibility of the discharge being entrained into the air intake.

There were occupant reports of odors from animal rooms (in Building A) migrating out of the room and into the lobby areas of Building A. We were not able to verify this condition due to time constraints.

Recommendation #6: Additional evaluation including pressure differential and air migration via tracer analysis.
Additional air movement analysis should be completed using ASTM tracer gas techniques. Tracer gas analysis will be key to finding the pathways that are involved with delivering odiferous air from its known sources to the lobby and other affected areas.

Maintenance Operations – Floor-Burnishing and Service Corridor
As part of our evaluation, we placed particle counters in the ante-office to count particles in the air within the office, and in the air being supplied to the office (i.e. from the air handlers), during and after the time in which the perimeter corridor floors were being burnished (polished). This was done in order to determine if the burnishing procedure of the perimeter corridor floors might be contributing to the non-visible particulate, and to the reported visible dust in the ante-offices and laboratories. The results of the particle monitoring can be viewed in Appendix B. The peaks from approximately 6:00 pm through 8:00 pm as shown on the graphed data of the ante-office suggest that burnishing the floors in the perimeter corridor has an impact on the inhaleable size fraction, and

larger size dust concentrations in the ante-office, and therefore in the laboratory, based on pressure differences and intended air flow between the two spaces. The monitoring run, where supply air was monitored (B367), showed no increase in the supply air counts as compared to the space counts, suggesting the increase of particles was not from the air handlers. Reducing the observed peaks will likely reduce the impact on the labs of visible particulate.

Recommendation #7: Replace floor-burnishing unit with a unit that uses powered vacuum recovery.
The existing floor-burnishing unit that was observed does not employ powered dust collection. As a means to reduce intermittent dust loading in the laboratories, we recommend that replacement burnishing units include a powered dust collector feature.

Maintenance Operations – Wax Stripping
As part of our observations of cleaning practices, we observed a maintenance crew stripping wax from the perimeter corridor of the High Bay building. The process was a wet process, and therefore did not likely create large quantities of airborne particulate.

Recommendation: None.

Maintenance Operations – Reported Laboratory Cleaning
There are many sources of particulate that could be responsible for the deposition of visible material on flat surfaces in the laboratories. Controlling all of them as outlined above in Recommendations #1, #3, #5, and #7 will likely reduce the accumulation. However, it is unlikely to completely prevent it. Nuisance dust (particulate not otherwise regulated) can cause respiratory, mucous membrane, and skin irritation even when exposure is less than the published OSHA time-weighted average (TWA) permissible exposure limit (PEL) of $5 mg/m^3$ (for respirable dust). Areas not regularly cleaned may produce peaks for short periods of time that are in excess of the published OSHA TWA PEL. Additionally, dusts may contain materials (such as pollen) that could trigger allergies or asthma in susceptible individuals. Keeping dust levels low is one of the parameters necessary to meet acceptable IAQ in occupied spaces.

The cleaning of laboratories and ante-room offices is currently divided between professional cleaning staff and the researchers assigned to each lab. The professional cleaners maintain the floors, which include vacuuming, waxing, burnishing, and stripping wax. All other cleaning operations are currently left to the researchers and their staff. It is prudent, in our opinion, to keep general particulate levels low in the occupied spaces by completing regular and frequent cleaning of exposed surfaces in each laboratory. In addition, efforts to minimize the release of ceiling tile material as recommended above (in Recommendations #2 and #3) are suggested before implementing the lab cleaning recommendation. Otherwise, based on results of current analysis, continued exposure to a source of contamination that is prominent, as reported by others in the "particulate problem", will likely continue after cleaning. Dusting and wiping down surfaces to control normal dust loading should be completed on a frequent (weekly) basis. High dust loading conditions may require a more frequent cycle of wiping.

Recommendation #8: Increase Cleaning Frequency

Since the deposition of airborne material will accumulate over time, we recommend cleaning laboratory surfaces on a weekly basis to control the build-up of accumulated material. High dust loading conditions may require a more frequent cycle of wiping. Nuisance dust may contain materials that could trigger allergies or asthma in susceptible individuals. Persons with allergies or asthma should not be in spaces while they are being cleaned, and personnel protection such as N-95 dust masks and covering of skin for people involved in cleaning may be prudent, especially during the first few cleaning cycles.

Airborne Fiberglass

Additionally, an employee reported a possible exposure to airborne fiberglass fibers. Fiberglass is a component of some materials used in modern construction. Therefore, the material is normally found in settled dust in indoor environments in the range of 3% to 5% of the material typically found in settled dust.

Recommendation #9: Limit Fiberglass Exposure.

Fiberglass is used in modern construction. Any clean-up or modification to the building system that contains fiberglass fibers, especially insulation products, should be completed while the work area is under condition of containment and isolation, as recommended by the Sheet Metal and Air conditioning Contractors' National Association Inc. (SMACNA) in their publication *Indoor Air Quality In Buildings Under Construction.*

Recommendation #10: Limit Occupant Exposures during Cleaning and Maintenance Work.

Persons with allergies or asthma should not occupy spaces that are being cleaned, and use of personnel protection such as N-95 dust masks and prevention of skin exposure (e.g. with long-sleeved shirts, etc.) may be prudent, especially during the first few cleaning cycles.

FOIA Request #05-1004 Stephens.doc
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TURNER GROUP TURNER BUILDING SCIENCE, LLC.

Appendix A

PM$_{2.5}$ Results and Settled Dust Report
Completed by Others

Table 1
$PM_{2.5}$ Airborne Particulate Elemental Analysis

DATE	SITE	UNITS	Na Conc.	Mg Conc.	Si Conc.	S Conc.	Cl Conc.	K Conc.	Ca Conc.	Fe Conc.	Zn Conc.	Br Conc.
1/30/2004	Field Blank	ng/cm2			0.1							
1/30/2004	Field Blank	ng/cm2			0.7		0.0					0.1
2/ 5/2004	Field Blank	ng/cm2										
1/ 4/2005	Field Blank	ng/cm2										
2/19/2003	Outside	UG/M3			0.5	2.3		0.2	0.3	0.3		
2/24/2003	Outside	UG/M3			0.3	1.8		0.1	0.1	0.1		
12/20/2004	Outside	UG/M3			1.7	0.3	0.1			0.1		
1/ 4/2005	Outside	UG/M3				0.9				0.1		
1/30/2004	A365A	UG/M3	39.5	1.3	40.5	2.3	32.1	6.1		0.2		8.1
2/ 5/2004	A366	UG/M3	34.7		5.2	2.8	23.5	0.1		0.1		
12/15/2004	A462A	UG/M3	69.8	5.9	13.8	2.8	52.9	3.3	9.5	0.1	0.3	0.6
12/20/2004	A462A	UG/M3	62.6	7.1	13.9	3.1	55.4	3.9	10.3	0.1	0.3	0.3
1/ 4/2005	A462A	UG/M3	19.1		2.5	1.2	15.9	1.0	2.6	0.3	0.1	
1/30/2004	B261	UG/M3	17.0		7.6	1.4	13.4	0.4	0.6	0.1		1.2
2/ 5/2004	B262	UG/M3	21.5	1.6	5.4	2.2	18.2	0.9	1.7	0.1		0.3
1/30/2004	B311C	UG/M3			27.9		0.5		0.1	0.1		1.5
12/15/2004	B467A	UG/M3	9.1	1.6	1.6	0.6	6.6	0.5	1.2	0.1		0.1
12/20/2004	B467A	UG/M3	2.3		0.6		1.1	0.1	0.2	0.1		
1/ 4/2005	B467A	UG/M3				0.3				0.1		
1/30/2004	D381	UG/M3	13.6		1.5	0.8	10.4	0.3	0.4			
2/ 5/2004	D381	UG/M3	20.6	1.5	4.0	2.0	17.3	0.8	1.6			
12/15/2004	D381	UG/M3	18.9	1.8	14.8	1.1	15.3	1.0	2.7	0.1	0.1	0.1
12/20/2004	D381	UG/M3	28.5	2.6	22.1	1.5	23.2	1.5	4.2	0.2	0.1	1.4
1/ 4/2005	D381	UG/M3			0.4	0.3	0.1					
1/29/2003	D453A	UG/M3			1.1	1.1	6.0	0.2	0.6			
2/ 3/2003	D453A	UG/M3			1.5	1.1	6.1	0.3	0.6	0.1		
2/ 6/2003	D453A	UG/M3			1.3	1.0	6.7	0.7	0.7			
2/13/2003	D453A	UG/M3			1.7	1.3	10.0	0.5	1.1	0.1		
2/28/2003	D453A air duct	UG/M3			2.0	2.0	11.4	0.5	1.5	0.1	0.1	
11/5/2004	D453A	UG/M3	2.5	0.2	0.4	0.3	2.4	0.2	0.5			
11/6/2004	D453A	UG/M3	2.5	0.2	0.4	0.3	2.4	0.2	0.5			
11/24/2004	D453A	UG/M3	3.3	0.3	0.6	0.3	4.5	0.3	0.9			
12/2/2004	D453A	UG/M3	2.1	0.3	0.4	0.4	2.8	0.2	0.5			
12/8/2004	D453A	UG/M3	3.3	0.4	0.5	0.5	2.8	0.2	0.5			
12/14/2004	D453A	UG/M3	7.8	1.0	1.2	0.5	7.3	0.5	1.4			
12/15/2004	D453A	UG/M3	11.9	1.4	2.1	0.8	13.1	0.8	2.5		0.1	
12/20/2004	D577A	UG/M3	15.1	2.3	2.3	0.8	12.1	0.7	2.2		0.1	
1/ 4/2005	D577A	UG/M3				0.3						
1/30/2004	E352	UG/M3	1.8		4.3	0.4	1.2		0.1	0.1		0.9
2/ 5/2004	E352	UG/M3			1.2	0.7						
12/15/2004	E352	UG/M3	27.8	2.9	3.8	1.4	23.0	1.5	4.1		0.1	
12/20/2004	E352	UG/M3	33.4	3.9	4.6	1.2	26.9	1.7	4.8	0.1	0.1	
1/ 4/2005	E352	UG/M3				0.3				0.1	1.4	
1/30/2004	H119-2	UG/M3			12.4		0.2					1.2
2/ 5/2004	H119-3	UG/M3	1.4			0.8	1.1	0.1	0.1			
2/ 4/2003	Atrium1	UG/M3			1.3	0.8	5.4	0.4	0.7	0.1		
2/ 7/2003	Atrium2	UG/M3			2.1	1.4	10.5	0.3	0.9			
2/13/2003	Atrium3	UG/M3			1.7	1.2	9.8	0.5	1.2	0.1		
2/28/2003	In XRF machine	UG/M3			2.0	1.7	10.1	0.5	1.4	0.1		
11/5/2004	In XRF machine	UG/M3										
11/6/2004	In XRF machine	UG/M3			0.1							
11/24/2004	In XRF machine	UG/M3										
12/14/2004	In XRF machine	UG/M3										
12/15/2004	In XRF machine	UG/M3										
12/17/2004	In XRF machine	UG/M3			0.3							
2/ 5/2003	Service Corridor	UG/M3			3.6	2.0	16.9	1.8	1.8	0.1		

Materials Science Division

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EMSL Case No.:	360500663
Sample(s) Received:	07/14/05
Date of Analysis:	07/14/05
Date Printed:	07/14/05
Reported By:	J.Newton

- Laboratory Report -

Full Particle Identification ™

For

Project: U.S. EPA

Analyzed by: [signature] *John Newton* *Laboratory Manager* 14 July, 2005 *Date*

QA/QC : [signature] *Eugenia Mirica, Ph.D.* *Materials Scientist* 14 July, 2005 *Date*

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Conclusions:

- The samples were found to contain primarily alumino-silicate glass fragments and organic dust.

Procurement of Samples and Analytical Overview:

The samples for analysis arrived at EMSL Analytical's corporate laboratory in Westmont, NJ. on 7/14/05. The package arrived in satisfactory condition with no evidence of damage to the contents. The samples were submitted for the purpose of determining the identification of the individual components. The samples reported herein have been analyzed per the following equipment and methodologies.

Methods & Equipment:

Polarized Light Microscopy (PLM)
epi-Reflected Light Microscopy (RLM)
Scanning Electron Microscopy (SEM)
Energy-dispersive X-Ray Spectrometry (EDX)
X-Ray Diffraction (XRD)
X-Ray Fluorescence Spectrometry (XRF)

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Results and Discussion:

Sample #: **Sample 0542 - E352A Lab**

Nuisance Particulate:		(%)	**Biological Particulate:**		(%)
Asbestos:	(T)	ND	Mold:	(Total)	ND
			Pollen:	(Total)	<1
MMVF's:	Fibrous Glass	2	Diatoms:	(Total)	ND
	Mineral Wool	ND	Insect Fragments:	(Total)	ND
	Glass Fragments	25		Spider silk	ND

Common Particulate:		(%)		(%)
Cellulose:	Processed	5	Rust (Iron Oxides)	2
	Natural	<1	Aluminum Oxide	<1
	Wood	ND	Zinc Oxide	ND
	Paper Pulp	5	Paint Fragments	<1
	Starch	ND	Quartz	2
Synthetics:	Nylon	ND	Calcite/ Dolomite	ND
	Polyester	ND	Gypsum/ Anhydrite	15
Hair:	Human	ND	Clay	ND
	Animal	ND	Plaster	ND
	Skin Fragments	<1	Cement	<1
Unidentified:	Inert Organics	25	Unidentified: Inorganics	13

Additional Particulate:				
	Iron:Chromium oxides	N/A	Lithium and Potassium Phthalates	N/A
	Chromium oxide	N/A		

The additional particulate could not be quantified, however they represent a portion of the Unidentified Inorganic concentration.

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Reported By: J.Newton

Sample #: **Sample 0543 - A256 Lab**

Nuisance Particulate:		(%)	**Biological Particulate:**		(%)
Asbestos:	(T)	ND	Mold:	(Total)	ND
			Pollen:	(Total)	ND
MMVF's:	Fibrous Glass	5	Diatoms:	(Total)	ND
	Mineral Wool	ND	Insect Fragments:	(Total)	ND
	Glass Fragments	35		Spider silk	ND

Common Particulate:		(%)		(%)
Cellulose:	Processed	2	Rust (iron Oxides)	<1
	Natural	<1	Aluminum Oxide	<1
	Wood	ND	Zinc Oxide	ND
	Paper Pulp	3	Paint Fragments	ND
	Starch	ND	Quartz	<1
Synthetics:	Nylon	ND	Calcite/ Dolomite	ND
	Polyester	ND	Gypsum/ Anhydrite	15
Hair:	Human	ND	Clay	ND
	Animal	ND	Plaster	ND
	Skin Fragments	<1	Cement	<1
Unidentified:	Inert Organics	20	Unidentified: Inorganics	14

Additional Particulate:			
Iron:Chromium oxides	N/A	Lithium and Potassium Phthalates	N/A
Chromium oxide	N/A	Lithium Hydride	N/A

The additional particulate could not be quantified, however they represent a portion of the Unidentified Inorganic concentration.

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Sample	#0542	Sample	#0543
C	70	C	50
Al2O3	18.8	Al2O3	16.8
SO3	4.38	SiO2	10.4
Fe2O3	2.05	SO3	5.43
Cl	1.7	ZnO	4.34
SiO2	1.6	CaO	2.88
NiO	0.82	Fe2O3	2.38
Cr2O3	0.29	Na2O	2.3
CuO	0.22	Cl	1.37
CaO	0.2	MgO	0.71
P2O5	0.093	P2O5	0.59
ZnO	0.09	K2O	0.32
TiO2	0.04	NiO	0.21
K2O	0.031	Cr2O3	0.11
		TiO2	0.063
		MnO	0.023

Table 1: XRF data showing the total elemental concentration of the samples as a function of oxide percent.

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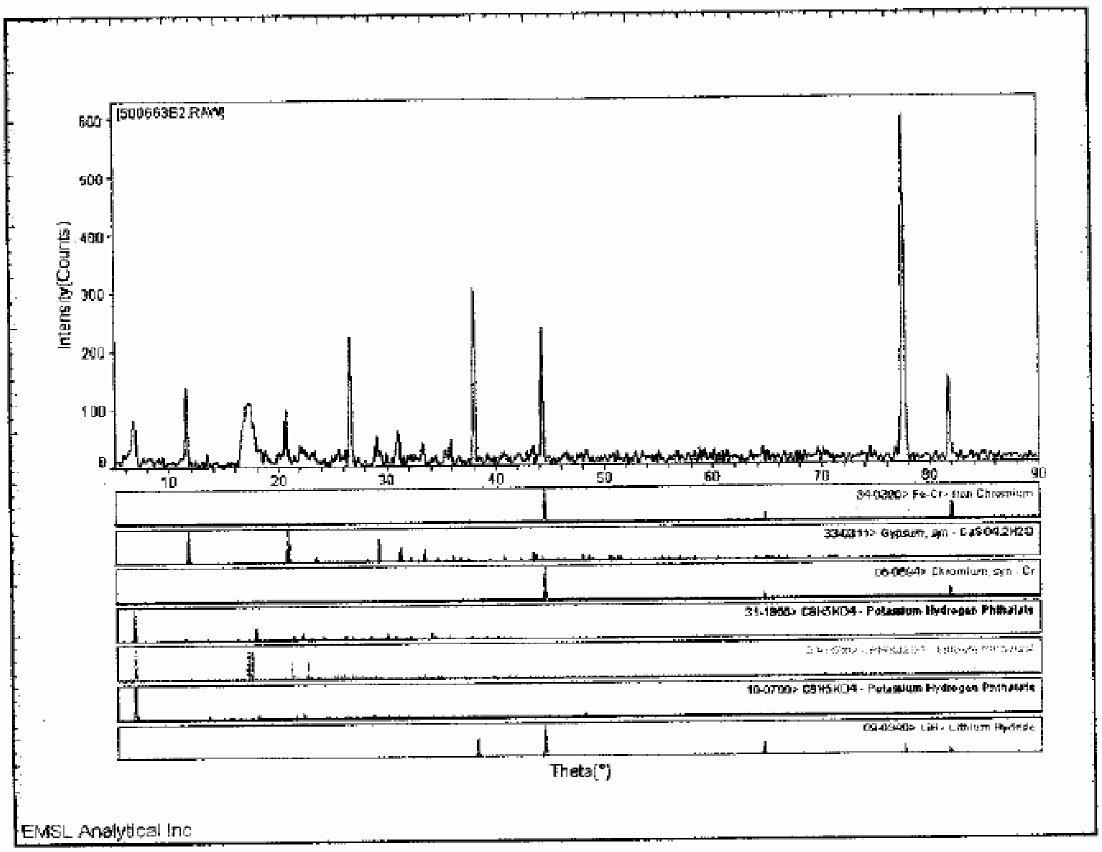

Figure 1: XRD Spectra showing the identification of several crystalline compounds noted in the sample # 0543.

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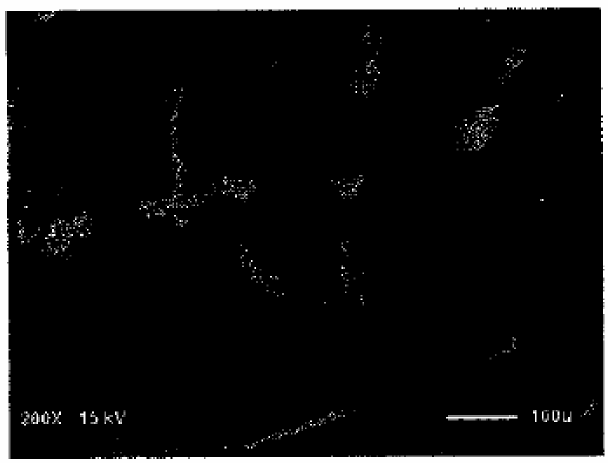

Figure 2: SEM image of sample #0543 showing the aluminum-silicate glass particles, gypsum and fibrous glass.

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Figure 3: PLM 200x image of sample #0542 showing isotropic glass fragments and cellulosic particles.

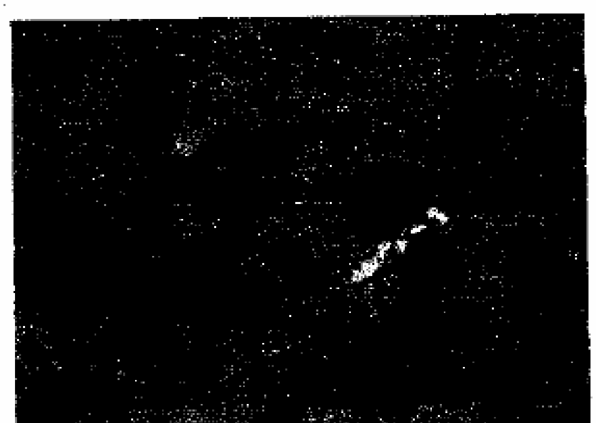

Figure 4: PLM 200x image of sample #0543 showing glass fragments, fibrous glass and cellulosic particles.

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Figure Plate 5: XRF spectra of various elements in sample #0542.

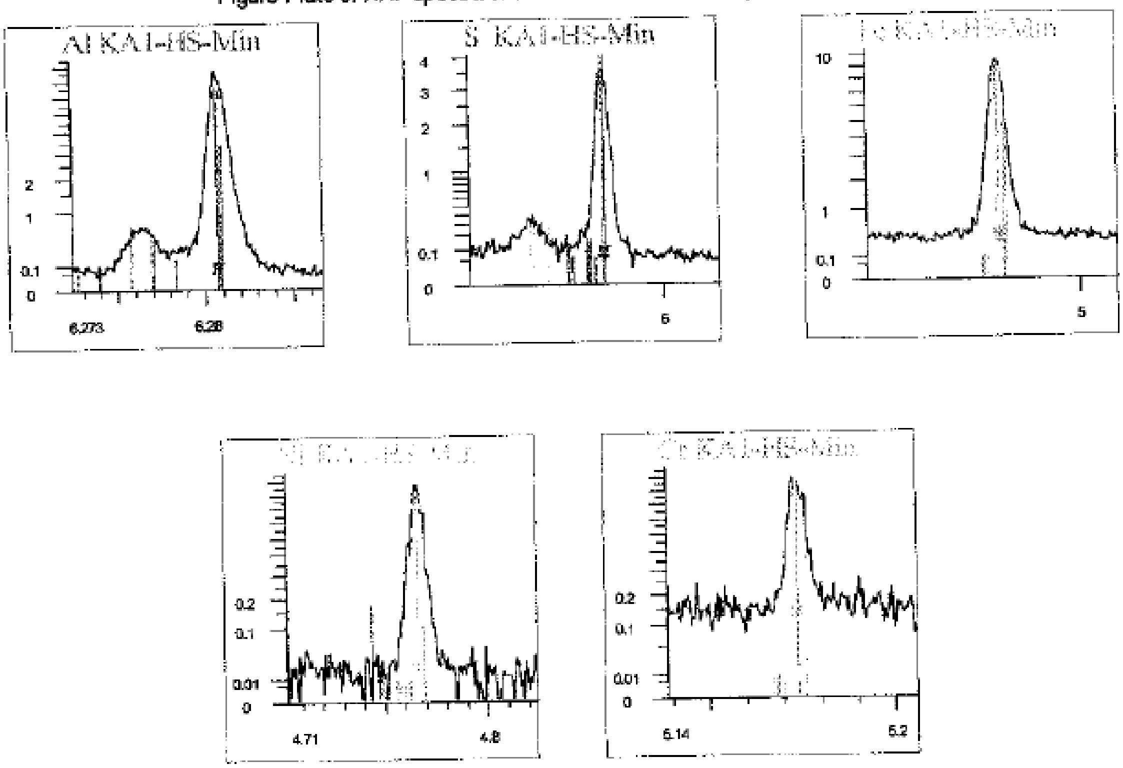

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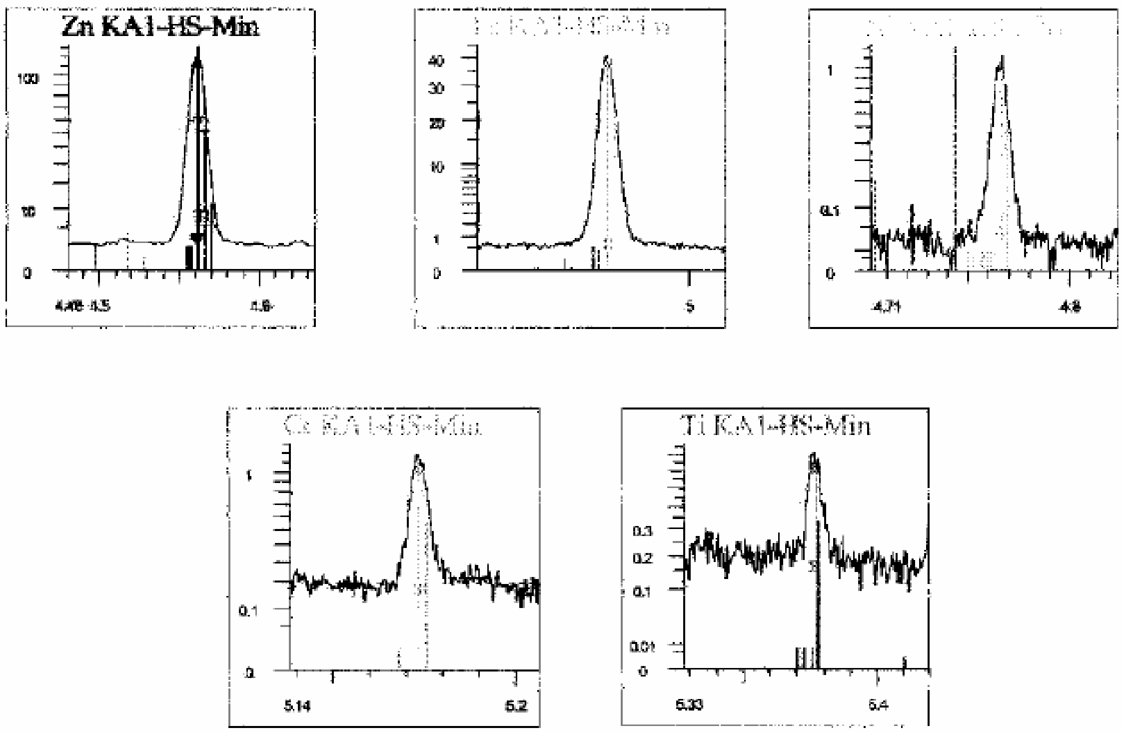
Figure Plate 6: XRF spectra of various elements in sample #0543.



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Descriptions & Definitions:

None Detected (ND) denotes the absence of an analyte in the subsample analyzed. Trace levels of the analyte may be present in the sample below the limit of detection (LOD).

Limit Of Detection (LOD): The minimum concentration that can be theoretically achieved for a given analytical procedure in the absence of matrix or sample processing effects. Particle analysis is limited to a single occurrence of an analyte particle in the sub-sample analyzed.

Limit of Quantitation (LOQ): The minimum concentration of an analyte that can be measured within specified limits of precision and accuracy during routine laboratory operating conditions

Concentrations for bulk samples are derived from Visual Area Estimation (VAE) unless otherwise noted. Air sample concentrations are calculated to particles per unit volume.

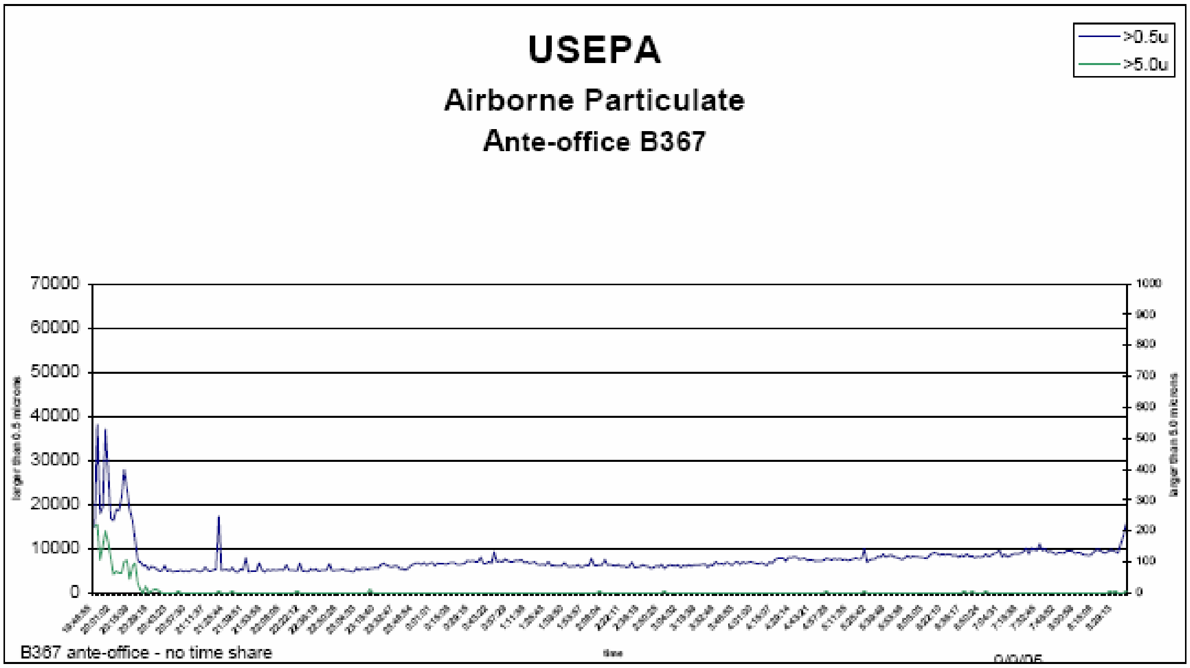
VAE technique estimates the relative projected area of a certain type of particulate from a mixture of particulate by comparison to data derived from analysis of calibration materials having similar texture and particulate content. Due to two-dimensional nature of the measurements, in some cases the particle thickness could affect the results.

The particulates included in the Inert Unidentified Organics category consist of particulates with carbon-based composition. They are inert (they do not react with the surrounding media) and they could not be isolated for individual identification by Fourier Transform Infrared Spectroscopy.

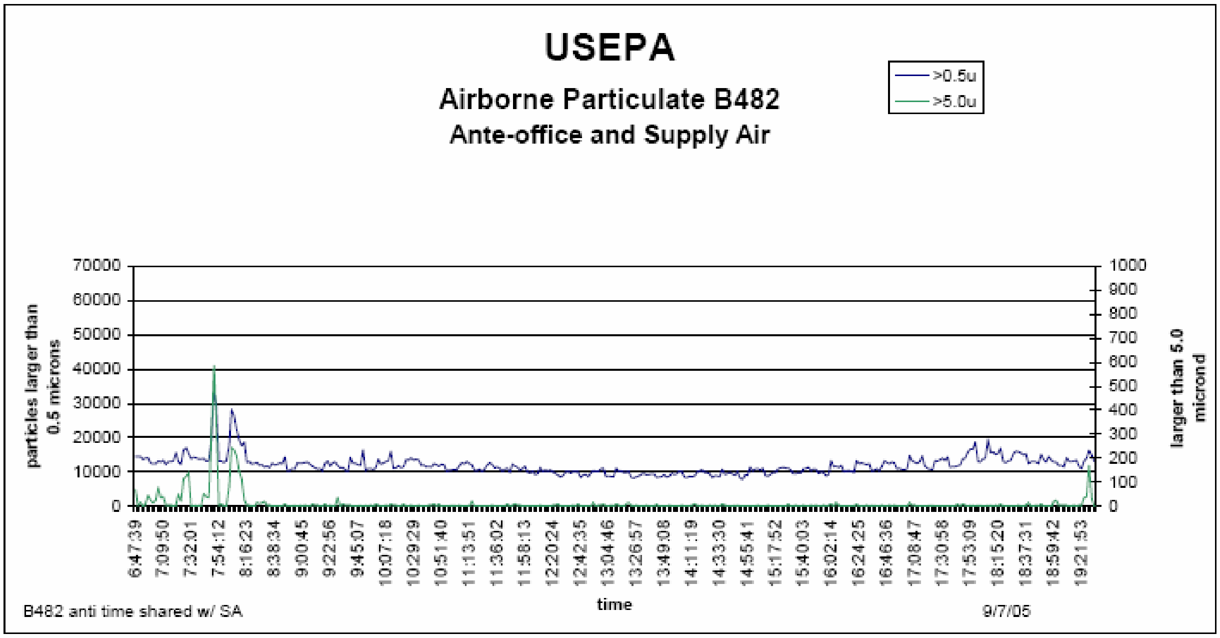
The particulates included in the Unidentified Inorganics category consist of particulates that do not have carbon as main component. They are usually a mixture of substances and they could not be isolated for individual identification by PLM, SEM/EDX and X-Ray Diffraction.

Appendix B

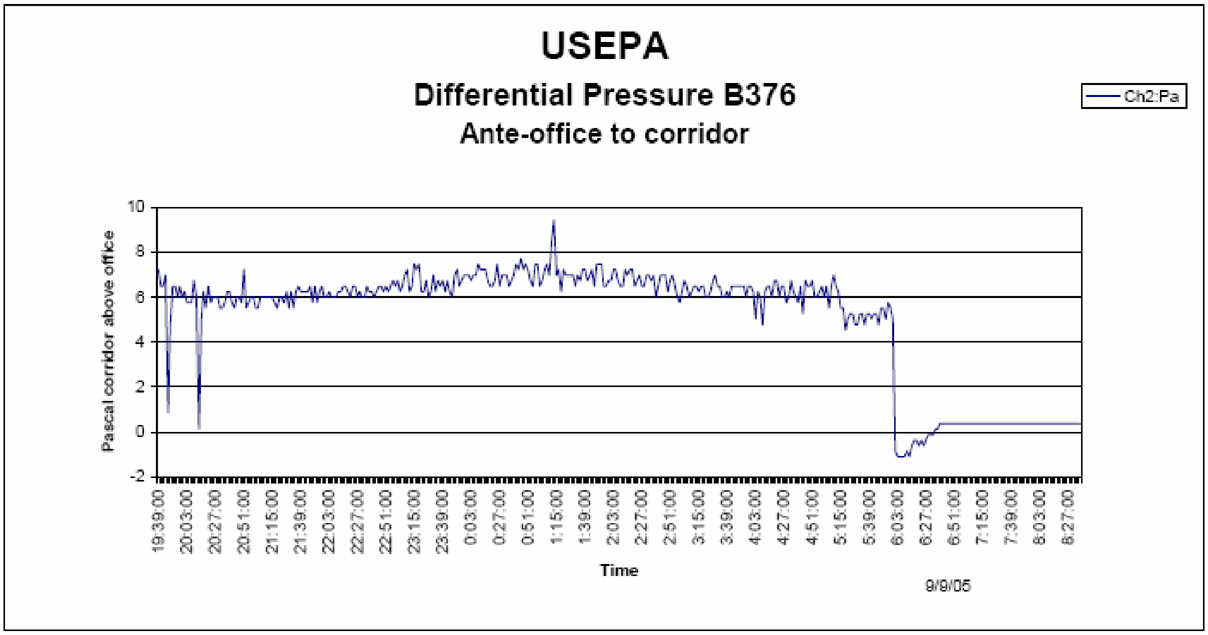
Particle Monitoring Results and Pressure Differential Results



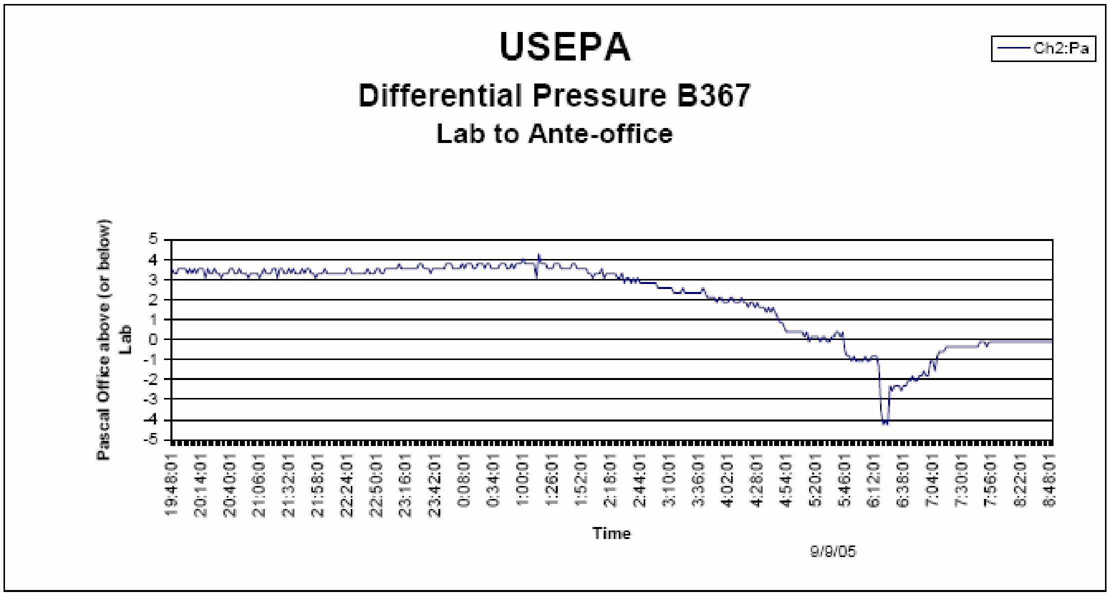
Peaks at left are from burnishing activities occurring in corridor.



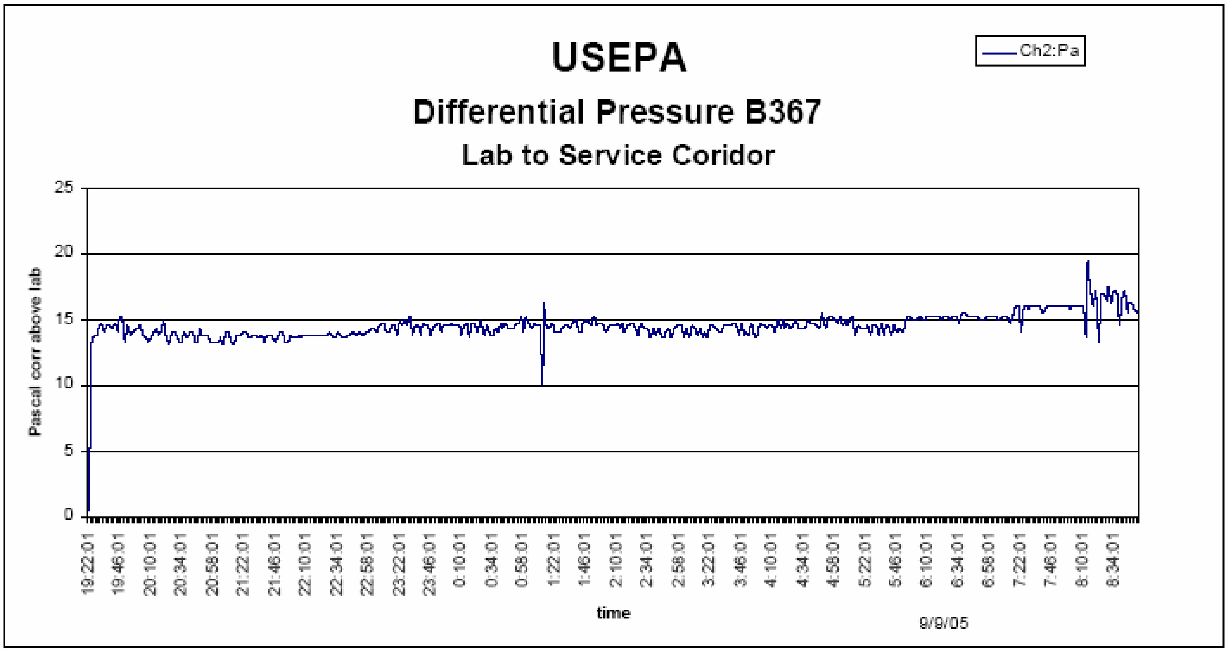
Peaks at left between approximately 7:13 and 8:20, were recorded during burnishing.
Time-share was used for supply air (from supply duct) and office air.
Valleys (between peaks) reflect sampling of supply air during burnishing event.



Pressure drop at right and subsequent level pressure is unexplainable at this time.



Drop in pressure difference between ante-office and laboratory is unexplained. Additional engineering study and ATC work is recommended.


USEPA
Differential Pressure B367
Lab to Service Coridor
Ch2:Pa
Pascal corr above lab
25
20
15
10
5
0
19:22:01
19:46:01
20:10:01
20:34:01
20:58:01
21:22:01
21:46:01
22:10:01
22:34:01
22:58:01
23:22:01
23:46:01
0:10:01
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5:46:01
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6:34:01
6:58:01
7:22:01
7:46:01
8:10:01
8:34:01
time
9/9/05

APPENDIX B

Summary of EPA/RTP Documents Provided for NIOSH Review

1. Industrial hygiene surveys performed by EPA staff
   a. $PM_{2.5}$ air concentrations for sodium, magnesium, silicon, sulfur, chlorine, potassium, calcium, iron, zinc, and bromine were measured over time at different locations in Buildings A, B, D, E, and H and outside. The highest concentrations reported were 69.5 ug/m^3 (micrograms per cubic meter) for sodium and 55.4 ug/m^3 for chlorine in a laboratory in Building A (A462A) on December 15 and 20, 2004. These were reported to be "exceptionally cold days" where humidification would have occurred. Sampling on January 4, 2005 showed $PM_{2.5}$ levels to be mostly below levels of detection in most laboratories except for the laboratory sampled in Building A. January 4, 2005 was reported to be "an exceptionally warm day" where humidification would not have occurred except in areas of Building A where animals are housed.
   b. In April 2004, air sampling for total particulate in laboratory D381 for 23 hours before shutdown of the ventilation system and then for 23 hours after restarting the ventilation system showed an increase of 40% in the amount of total particulate (722 ug before shutdown and 1169 ug after restart).
   c. A report of sampling for total particulate (sampling location not reported) "before, during, and after" ventilation system shutdown in June 2004 (24 hours for each sample) indicated a total mass of 140 ug before shutdown, 165 ug during shutdown, and 267 ug after restart of the ventilation system. This report stated that "The before and during sampling periods were basically the same with Sulfur, Calcium, and Potassium, in the air. After we resumed operation there was a lot of NaCl in the air in addition to the Ca, S, Si, and K."
   d. "Real-time particulate grab samples" in July 2004 showed particulate air concentrations ranging from 45-58 ug/m^3 in laboratories in Buildings A, B, D, and E (measurements reported for one laboratory in each building). Concentrations in non-laboratory areas in Buildings B, C, and E ranged from 33-94 ug/m^3. The concentration outside an elevator in Building C "while dusting floor" was 167 ug/m^3. Measurements of 191 and 212 ug/m^3 were recorded outside the buildings.
   e. "Real-time particulate grab samples" in April 2005 showed particulate air concentrations ranging from 2-4 ug/m^3 in laboratories and offices in Building B (with 33 ug/m^3 measured in the "B-3 atrium"). The report noted that there was no humidification in Building B on the day of sampling. Air concentrations in laboratory areas of Building A ranged from 41-286 ug/m^3 (seven of nine measurements were greater than 190 ug/m^3). Outside air concentrations were 10-11 ug/m^3, and all measurements made in Buildings C, D, and E (including in laboratory areas) were 11 ug/m^3 or less (except for 15 ug/m^3 measured at the "guard desk" in Building C).
   f. A graph showing $PM_{2.5}$ levels in a Building A laboratory (A560) on April 8, 2005 indicated that the air concentration that day was 122 ug/m^3 when first measured at 9:25 am, climbed to 242 ug/m^3 at 1:30 pm, and then declined to 57 ug/m^3.
   g. A graph showing $PM_{2.5}$ levels in a Building A laboratory (A557) over several days from May 17 through June 27, 2005 indicated that mean air concentrations ranged from 5 ug/m^3 to 84 ug/m^3.
   h. From August 2003 to October 2004, wipe samples were obtained from surfaces in multiple laboratories in Buildings A, B, D, and E (several in each building) and analyzed with scanning electron microscopy and energy-dispersive x-ray spectrometry

(SEM/EDX). The predominant elements identified in the particles aluminum, silicon, sodium, chloride, oxygen, iron, calcium, and zinc.

2. Reports of outside laboratories and consultants:
    a. **Hazmat, Health and Hygiene** obtained approximately 25 wipe samples from laboratories and offices in Buildings A, B, D, E in May 2004. Most of these were analyzed for mass of aluminum, calcium, copper, iron, sodium, and zinc present. Others were analyzed for anions (bromide, chloride, fluoride, nitrate, phosphate, and sulfate). Also collected and submitted for analyses were bulk samples from two HVAC units (analyzed for all elements and anions listed above) and bulk samples of the water softener (analyzed for the elements listed above, chloride, pH, hardness and alkalinity).
    b. **Evans Analytical Group** analyzed "white contaminant" on two "boards" ("Main Heater Control Board" and "smaller board with aluminum heat sink") "from an EPA lab". The report summary stated: "The contaminant on the Main Heater Control Board exhibited coated fibers. EDX analysis identified varying peak intensities of oxygen, sodium, magnesium, silicon, sulfur, chlorine, potassium, calcium, iron, and aluminum." "EDX analysis identified oxygen, fluorine, sodium, magnesium, silicon, sulfur, chlorine, potassium, and calcium" on the smaller board.
    c. **Air Quality Sciences, Building Consulting, Inc. (AQS/BC)** performed an assessment at EPA/RTP in June 2004. They performed direct reading measurements of airborne particulate concentrations in several laboratories (mostly in Buildings B, D, and E; none in Building A), where they also obtained wipe samples, settled dust samples, and air samples for light microscopy (stereo and polarized light microscopy, PLM) and scanning electron microscopy coupled with energy dispersive x-ray spectroscopy (SEM-EDX). Microscopy was also performed on bulk samples of particulate scraped off of cooling coils in two HVAC units; dust samples were also analyzed for volatile organic compounds (VOCs). Air concentrations of particulate ranged from 0.006 to 0.090 mg/m^3 (milligrams per cubic meter) in laboratories (all measurements except for one were less than 0.014 mg/m^3) compared to 0.022-0.024 mg/m^3 measured outdoors. With regard to VOC levels, the AQS/BC report stated that "Review of the data in terms of both total VOC (TVOC) levels and in the number and types of individual VOCs found show the sampled dust to have a lower organic chemical content than many indoor environments that have been evaluated." The bulk samples from the HVAC cooling coils "appeared to consist mainly of crystalline aluminum oxide or hydroxide particles derived from corrosion of aluminum metal (consistent with visual observations made on site)." AQS/BC reported that these corrosion products were also a major constituent (10% or greater by volume as a semi-quantitative estimate) in most of the dust and wipe samples and in one of two air samples. Soil minerals and construction debris, glass fibers, rust/metal flakes, cotton, and paint were also major constituents in many of the dust and wipe samples. AQS/BC concluded that the findings "suggests the cooling coils to be the source of the corrosion-related particulate in the occupied space" and stated that "Their removal should begin with cleaning the coils, then follow with duct inspection to determine if residues have accumulated in the duct system, and lastly, with deep cleaning of occupied spaces." Due to its potential to cause skin, eye, and respiratory irritation, AQS/BC also recommended identifying the sources of glass fibers (e.g. various types of insulation and ceiling tiles) and developing procedures for clean up anytime the above-ceiling space is accessed.
    d. **Gobbell Hays Partners, Inc.** (GHP) performed a visual assessment of the HVAC system in November 2004. Their report indicates that they examined all aspects of the air distribution system (HVAC units, main supply plenum, medium pressure ducts, low pressure ducts, variable air volume (VAV) boxes, and diffusers) at multiple locations in Building B. GHP's findings included: (1) "…isolated areas containing a minor amount

of particulate, rust/mineralization, and small amounts of construction debris. This particulate was generally in the main supply plenum in the Penthouse, lower portions of the medium pressure duct and at the metal pans of diffusers." (2) "A small isolated amount of particulate, apparently residue from mineral deposits of the humidification system, was identified in the air handlers and main supply plenum located in the Penthouse." (3) Moderate amounts of construction debris (defined by GHP as 25-50% of horizontal surfaces) above ceiling tiles. GHP recommended cleaning of the isolated areas of settled debris in the air handlers, ducts, and diffusers as noted in their report, as well as cleaning low pressure ducts and diffusers in "complaint areas." They stated that "Overall the HVAC system appeared to be in good condition."

e. Analyses performed by **Galson Laboratories** on bulk samples in July 2004 revealed fibrous glass content ranging from 65% to 100% in bulk samples from a reheat coil, HEPA filter, "ceiling cavity", and "ceiling tiles". One ceiling tile had a fibrous glass content of 10%. Fibrous glass was not detected in bulk samples from new and used "prefilters".
f. **Analytical Services, Inc**.'s x-ray diffraction analysis of a dust sample from laboratory A462A in July 2004 revealed the major components to be NaCl and SiO_2 (quartz). $NaSO_4$ was reported to be a minor component.
g. Air samples from laboratories in Buildings A, B, D, and E analyzed for fibrous glass by **Galson Laboratories** in August 2004 showed all samples to have less than 0.007 fibers per cubic centimeter of air.
h. Analyses performed by **Galson Laboratories** in August 2004 showed a bulk sample from an "acoustical tile" to be 80% cellulose and fibrous glass (35% fibrous glass) and a bulk sample of fireproofing material to be 60% cellulose.
i. In June and July 2005, **Eastern Research Group, Inc.** performed wipe and tape lift sampling in four laboratories (two in Building B, one in Building D, and one in Building E) and in HVAC units in Buildings A, B, D, and H. The samples were analyzed (by Elemental Analysis, Inc.) "…using a Proton Induced X-ray Emission (PIXE) scan" and also analyzed (by Analytics Corporation) with polarized light microscopy (PLM). The PIXE scans of the samples from the HVAC units indicated that iron had the highest mean percentage of the total mass (45.7%), followed by aluminum (28.9%), silicon (6.6%), and zinc (6.4%). (Sodium and carbon were not included in the analysis.) In the samples from the laboratories, iron had the highest mean percentage of the total mass (24.9%) followed by calcium (14%), silicon (12.1%), aluminum (8.8%), zinc (8.6%), sulfur (7.6%), and potassium (6.7%). By PLM, 80-90% of the samples from the HVAC units and from the laboratory in Building E (which had recently experienced a "dump") were made up of "glass-like chips". In the samples from the other laboratories, glass-like chips made up 35-65% of the samples. Fibrous glass was present in the samples from two laboratories, making up 5% and 15% of the samples.
j. In July 2005, EPA staff submitted wipe samples from two laboratories in Buildings A and E to ***ESML Analytical, Inc***. By light microscopy, "glass fragments" were reported to make up 25% of the sample from one laboratory and 35% of the sample from the other. The samples also contained 34-38% unidentified organics and inorganics, 15% gypsum/anhydrite, 5-10% cellulose, and 2-5% fibrous glass. By x-ray fluorescence spectrometry (XRF), the samples were reported to contain 50-70% carbon, 18.8% Al_2O_3, 4.4-5.4% SO_3, 2.1-2.4 % Fe_2O_3, 1.7-10.4% SiO_2, and 0.1-4.4% ZnO. Many other elements and oxides were present in smaller percentages. ESML Analytical, Inc., concluded that "The samples were found to contain primarily alumino-silicate glass fragments and organic dust."

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