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United States Postal Service
Omaha, Nebraska

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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 Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer 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.

The 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 Daniel J. Hewett, CIH, and Gina Buono, MD, MPH, of the Respiratory Disease Hazard Evaluations and Technical Assistance Program, Division of Respiratory Disease Studies (DRDS). Special assistance in paper dust characterization was provided by Bill Jones, Ph.D., Environmental Investigations Branch (EIB), DRDS. Field assistance was provided by Patrick Hintz (EIB, DRDS), Jean Mead, Pathology and Physiology Research Branch (PPRB), Health Effects Laboratory Division (HELD), and Scott Manetz, (PPRB, HELD). Desktop publishing by Terry Stewart. Review and preparation for printing was performed by Penny Arthur.

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SUMMARY

In October 1997, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the National Postal Mailhandlers Union, AFL-CIO (NPMU) to conduct an HHE at the United States Post Office Mail Processing and Distribution Center, Omaha, Nebraska. A NPMU representative requested an evaluation of worker exposure to paper dust, mold spores, and ink mist/dust in the first and second floors of the mail processing plant and the basement of a warehouse annex. In the request, the NPMU listed concerns regarding inhalation and skin exposures resulting in adult-onset asthma cases, recurrent sinus and respiratory infections, allergy treatments for paper dust and mold, lung infections, and recurrent dermatitis.

On December 9 - 12, 1997, NIOSH investigators performed a walkthrough survey of the worksite and met with NPMU and US Postal Service representatives to discuss health issues related to worker exposure to paper dust, mold spores, and ink dust/mist. Material safety data sheets (MSDSs) of products used in the mail processing and warehouse areas were reviewed. Potential organic dust exposures include paper dust, dusts associated with the operation of heating, ventilating, and air conditioning (HVAC) systems, and dusts created by mail sack handling in the annex. Investigators performed quantitative area air sampling for fungal spores in the second floor plant and warehouse areas; aerosols and bulk dusts were collected for microscopy. Bulk dusts from mail sorting machines were collected and analyzed for microbial contaminants. Of approximately 897 mailhandlers, clerks, and maintenance personnel, 14 individuals chose to participate in worker interviews with the NIOSH physician; 11 participated in person, and 3 via telephone. Work histories, health effects, and medical histories were discussed during the interviews.

On January 27, 1998, NIOSH investigators returned to inspect 18 HVAC systems. HVAC maintenance procedures were reviewed. Bulk material and water samples from HVAC drain pans were collected and analyzed for microbial contaminants. Qualitative and quantitative aerosol concentrations and particle size distribution data were obtained for general areas of the second floor plant, and during cleaning of mail sorters (delivery point bar code sorters).

A total of 9 airborne spore samples were collected and analyzed for fungal concentration and fungal identification. A total of 15 bulk dust samples were collected and analyzed for colony counts per gram of dust and fungal identification. Five particle size selective area samples were collected.

No exposure limits as enforced by the Occupational Safety and Health Administration (OSHA) or recommended by NIOSH or the American Conference of Governmental Industrial Hygienists (ACGIH) were exceeded for paper dust concentrations in air.

In the main plant, no airborne fungi concentrations were significantly elevated compared to outdoors. Airborne concentrations of *Aspergillus* and *Penicillium* fungi were significantly elevated in the annex during mail sack stacking compared to outdoors.

Compared to bulk dusts collected from a return air grate, freshly generated paper dust from mail sorters is not a significant source of fungi in the plant. Bulk dust from a return air grate on the second floor of the plant contained fungi at concentrations 60 to 100 times higher than that of bulk dusts from mail sorters, which indicates paper dust is a matrix which supports the growth of fungi in close proximity to the air distribution system.

On the basis of environmental data and information gathered from employee interviews, NIOSH investigators did not find clear evidence that employee symptoms were caused by exposure to microbial contaminants or paper dust.

Since inks sprayed onto mail pieces were very quick drying, applied inside enclosed areas of sorters, and any volatile fraction was diluted by the relatively large volume of air in the workspace, exposure to inks was not considered to present a significant health risk to workers in proximity to machines which spray ink onto mail pieces.

Recommendations are made to control the accumulation of paper dust, improve the operation and cleaning of HVAC systems, and provide respiratory protection from paper and non-specific dusts if exposures initiate or aggravate respiratory conditions. Recommendations for respirator selection are presented in this report.

Keywords: SIC 7331 (Mailing service), Paper Dust, Fungi, HVAC, Mail Handling, Mail Processing, Mail Sorting, Bulk Dust, Particle Size, PNOR, PNOC, Ink, Culling.

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INTRODUCTION

In October 1997, the National Institute for Occupational Safety and Health (NIOSH) received a request from union representatives of the National Postal Mailhandlers Union, AFL-CIO (NPMU) to conduct a health hazard evaluation (HHE) at the United States Post Office Mail Processing and Distribution Center, Omaha, Nebraska. The Omaha Mail Processing and Distribution Center (OMPDC) receives, sorts, and prepares mail for delivery.

The request was initiated by reports of inhalation and skin exposures among 20 to 30 workers identified by union representatives as having adult-onset asthma, recurrent sinus and respiratory infections, and allergy with surgery required to remove infected passages in the sinus cavity. The request reported that allergy treatments were required for paper dust, mold, and other infections, and that workers also experienced recurrent dermatitis. The requesters associated the health effects with dust, mold, and inks aerosolized by mail processing and maintenance of mail processing machines in the main building, and construction of cardboard boxes and handling mail sacks in the warehouse (annex). Some workers expressed concern for the long-term health effects of paper dust inhalation.

In response to this request, NIOSH investigators performed a walkthrough survey on December 9 - 12, 1997. Material safety data sheets (MSDSs) of products used in the mail processing and warehouse areas were reviewed, heating, ventilating, and air conditioning (HVAC) systems were inspected, and occupational safety and health program records were reviewed. Interviews were conducted with management, OSHA representatives, and workers. NIOSH investigators performed quantitative area air sampling for fungal spores in the second floor of the main OMPDC plant and annex areas; aerosols and bulk dusts were collected for microscopy. Bulk dusts from sorting machines and return air grates were collected and analyzed for microbial contaminants.

On January 27, 1998, NIOSH investigators returned to the OMPDC to perform an environmental survey which included an inspection of 18 HVAC systems and a review of HVAC maintenance procedures. Bulk material and water samples from HVAC drain pans were collected for analysis of microbial contaminants. Qualitative and quantitative aerosol concentrations and particle size distribution data were obtained for three general areas of the second floor plant and in areas in proximity to delivery point bar code sorter cleaning.

The purpose of this report is to provide observations from the two site visits, report the results of airborne dust and microbiological sampling, and offer conclusions and recommendations based on observations, worker interviews, and measurement results. This is the final report of this NIOSH safety and health evaluation.

BACKGROUND

The OMPDC is a two building complex in downtown Omaha, Nebraska. One building is a four story steel frame and concrete structure. The building contains loading docks, mail sorting machinery, administrative offices, a post office, and conveyors for transporting packages and trays filled with letters. This building, hereafter referred to as the "plant," is where packages and letters are received, sorted, and shipped. The first and second floors of the plant are the primary work areas for mail sorting; the second floor contains automated equipment for high-speed sorting of letters. Packages are manually handled and sorted on the first floor. The second floor sorting machines generate most of the paper dust in the plant.

The other building is a two-story steel frame and concrete structure, which is leased space. Only the basement of the building is used by postal workers; it contains a loading/unloading bay, large open storage areas, and two box-making machines that create cardboard trays for letters or packages. This building, hereafter referred to as the "annex," is where mail boxes, mail processing carts, cardboard boxes, and mail sacks are stored and re-distributed. Materials are handled manually or with a natural gas fueled forklift.

The plant employs approximately 897 mailhandlers, clerks, and maintenance workers throughout three work shifts. Shifts are referred to as Tour 1, 10:00 p.m.-6:30 a.m. (358 workers); Tour 2, 6:00 a.m.-2:30 p.m. (218 workers); and Tour 3, 2:00 p.m.-10:30 p.m. (351 workers). The annex employs up to eight boxmakers or mailhandlers within the same tours.

Packages enter the plant culling area where they are sent to first floor staging areas or manual sorting areas. Packages are loaded into bags and sent to a loading dock. Letters entering the culling area are sized and sorted; some letters are sent to manual key coders who route mail manually. After machine sorting or manual coding, letters are sent to the second floor (Figure 1) optical character readers (ISS, OSS, and Mark 2 machines) where routing information is applied in the form of a bar code. Next, letters enter auto facer counter sorters or delivery point bar code sorters where they are set into cardboard trays according to mail routes. Letter trays are sent to first floor flat sorting machines or robotic sorters, then to a loading dock for subsequent delivery.

The second floor contains 5 delivery point bar code sorter 150 stackers, 9 delivery point bar code sorter 190 stackers, 4 auto facer counter sorters, and 13 optical character readers in a large open bay with a 25 foot ceiling. The floor also contains breakrooms, restrooms, locker rooms, ceiling-suspended conveyors, and HVAC ducts and diffusers. Mezzanines about 15 feet above the plant floor house seven HVAC systems which ventilate the second floor. The HVAC system air handlers (AH) are single-zone, constant volume heating and cooling-coil equipped units. Outdoor and return air is filtered by roll-type filters composed of spun synthetic material of relatively low efficiency (less than 30% efficiency, dust spot testing method).

Maintenance workers clean readers and sorters to keep paper dust from inhibiting the flow of mail through the machines and clean paper dust from optics to prevent malfunctions. Maintenance work is conducted throughout the tours; auto facer counter sorters are typically cleaned on Tour 1. However, most maintenance workers (77 of 114) work on Tour 2, when lower mail volume allows greater access to DBCS mail sorters and other sorters/readers for routine cleaning. Sorter and reader cleaning (hereafter referred to as "blowout") procedures require workers to open machine panels and vacuum as many interior and exterior surfaces as possible before using compressed air (about 30 psi) to blow the remaining paper dust from the machines. Workers performing blowouts are required to wear "goggles or face mask" eye protection when using compressed air.

METHODS

Environmental

Because most sorters and readers are on the second floor of the plant, this area was selected for paper dust sampling in proximity to blowout operations. Since many HVAC system drain pans were covered in dry flaky deposits, and other pans were filled with water from supplemental humidification by water spray, the investigators decided to perform bioaerosol and bulk sampling to identify a potential source of microbial contamination that could plausibly explain certain respiratory complaints among employees. The second floor plant was chosen for microbiological sampling because its airspace is serviced by seven HVAC systems, and the sack storage area of the annex was chosen because workers identified the area as one of concern for aerosolization of fungi.

The first environmental evaluation took place on December 9 - 12, 1997, from approximately 8:00 a.m. to 8:00 p.m. Samples of the ground, first, second, and rooftop AHs were inspected.

Area airborne fungal spore samples were collected from one outdoor (1st floor loading dock) and two indoor plant locations (delivery point bar code sorter #6 and auto facer counter sorter #2) and one outdoor (alleyway) and two indoor (sack storage) annex locations. Spores were collected for approximately 100 minutes with short-cowl open face cassettes onto 25 millimeter (mm) polyvinyl chloride (PVC) filters attached to air pumps calibrated at 25 liters per minute (lpm). Spores were identified and enumerated.

Duplicate bulk dust samples were collected for viable fungi characterization and enumeration. Dusts were collected in sterile polypropylene tubes. Paper dust samples were collected from the interior of delivery point bar code sorters #6 and #7. Dust was also collected from the return air grate in the floor of the mezzanine underneath AH S3, and in the annex from the desk in the sack storage area and from the box maker conveyor belt. Bulk dust was cultured onto cornmeal agar (CMA) and malt extract agar (MEA) for the enumeration of mesophilic fungi, and DG18 agar for enumeration of xerophilic fungi. Agar plates were incubated at 25 °C. Fungi were identified and enumerated.

In order to microscopically characterize particulate exposures in the plant and annex, a variety of settled dust and air samples were collected. For settled dust sampling, two types of samples were obtained. On surfaces where heavy loading was detected, dust was scraped directly into collection vials. On surfaces with lighter loadings, sticky tape samplers were used. Samples were collected from delivery point bar code sorters #6 and #7, and from a window sill east of the auto facer counter sorters. These samples were analyzed by stereomicroscopy, polarized light microscopy, and scanning electron microscopy. Air samples for microscopy were collected by drawing air at a flow rate of 2.0 liters per minute (L/min) through both polycarbonate and cellulose ester filters. These samples were collected with an open-faced inlet in order to achieve an even density of particles across the filter. Samples were collected in the plant adjacent to and during blowout of delivery point bar code sorters #6 and #7 at points 10 and 30 feet from the machines. Samples were collected in the annex at points 10 and 30 feet from mail sack handling and stacking. The cellulose ester filters were examined by light microscopy. The polycarbonate filters were gold/palladium coated prior to examination by scanning electron microscopy.

The second environmental evaluation took place on January 27, 1998, from approximately 8:00 a.m. to 6:00 p.m. Area particle size distribution samples were collected using 8-stage Anderson Marple 298 impactors with impaction grease coated Mylar substrates at a calibrated flow rate of 2.0 lpm. Ambient air samples were collected from three locations in the second floor plant, and one each during blowout of delivery point bar code sorters #7 and #13. In parallel with particle size sampling during blowout of delivery point bar code sorters #7 and #13, qualitative real-time aerosol concentrations were characterized with a DUSTRAK™ Model 8520 Aerosol Monitor laser photometer. Nineteen HVAC systems were inspected and HVAC maintenance procedures were reviewed. Bulk material and water samples from HVAC drain pans were collected and analyzed for microbial contaminants. Dried material was collected from AHs F5, S6, and S7; two water samples were collected from S4. Samples were cultured onto cellulose agar, rose bengal agar, DG18, and MEA.

Medical

Confidential open-ended personal and telephone interviews were conducted of postal workers. Interview times were set up at the post office in a private area. The interview times overlapped various shifts to provide convenient times for the workers to come for an interview, as well as to minimally disrupt the job. Interviews were also conducted off the work site for those individuals who expressed reluctantance to be interviewed at the workplace.

NIOSH investigators invited all postal workers to be interviewed. Workers who had previously identified themselves to the Union as having work related health complaints were contacted by the Union and informed of the interviewer's availability. Flyers were posted informing workers of the reason for the NIOSH visit as well as times and locations of interviews. Times and locations of the interviews were also broadcast over the workers' network TV "bulletin board." Workers were allowed to leave their work stations for medical interviews which were conducted onsite. Interviews were also conducted off site at the NPMU union hall. If a convenient time was not available for workers, interviews via telephone at the workers' convenience were arranged through the Union. Open-ended health questions were asked regarding work related respiratory problems. Telephone interviews were also conducted with local community practitioners to assess the prevalence of health complaints of the postal workers, as well as the prevalence of respiratory disease in the community. The practitioners were selected because they had previously rendered care to one of the postal workers. The OMPDC accident and illness reports were reviewed, as well as any available medical records.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs™)[2], and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[3]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Paper Dust

Paper dust generated by mail processing is obviously a complex and uncontrolled mixture of papers of unknown origin; the aggregate dust generated by mail sorters and aerosolized by maintenance procedures is difficult to characterize. It is likely that exposures to chemicals used in the manufacture of paper, in association with paper dust, would be well below any applicable occupational exposure limits for paper dyes, bleaching agents, and other chemicals associated with paper manufacturing.

Paper dust exposure has been regulated under the OSHA "nuisance dust" or particulate not otherwise regulated (PNOR) PEL. In 1986, OSHAs Occupational Health Review Commission ruled that paper dust is an organic dust; therefore the nuisance dust standard did not apply to paper dust.[4] In 1993, OSHA issued a notice that all inert, nuisance, and organic particulate would be covered under the PNOR standard if no other exposure limit was applicable. Presently, paper dust exposures are limited under the OSHA PNOR standard (15 micrograms per cubic meter [mg/m^3] total dust, 5 mg/m^3 respirable dust).[5,6] The PNOR criteria were established to minimize mechanical irritation of the eyes and nasal passages, and to prevent visual interference. Since wood contains about 50 to 70% cellulose[7], the cellulose content of paper could plausibly limit an 8-hour TWA exposure to paper dust by OSHA (15 mg/m^3 total dust, 5 mg/m^3 respirable dust), NIOSH (10 mg/m^3 total dust, 5 mg/m^3 respirable dust) or ACGIH (10 mg/m^3 total dust) exposure limits.

Formerly referred to as nuisance dust, the ACGIH TLV preferred terminology for non-specific particulate is particulates not otherwise classified (PNOC)[2] The criteria for the classification of a substance as a PNOC include the following lung pathology: (1) the architecture of the air spaces remains intact; (2) collagen (scar tissue) is not formed to a significant extent; and 3) the tissue reaction is potentially reversible.[7] The ACGIH recommended TLV for exposure to a PNOC is 10.0 mg/m^3 total dust, 8-hour TWA. NIOSH has not developed specific evaluation criteria for PNOR/C exposures.

Paper dust can be categorized as an organic dust because it is of vegetable origin. Some types of organic dusts have been associated with acute responses (irritation or toxic pneumonitis), long-term responses (chronic bronchitis), or hypersensitivity responses.[8]

Microbiological Contaminants

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. The saprophytic varieties (those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an ample supply of a nutrient substrate. Under the appropriate conditions (optimum temperature and pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or in association with soil, dust, or water. In the outdoor environment, the levels of microbial aerosols will vary according to the geographic location, climatic conditions, and surrounding activity. Indoors, the concentration of certain microorganisms may vary somewhat as a function of the cleanliness of the HVAC system and the numbers and activity level of the occupants. With the exception of certain human-shed bacteria, indoor levels are expected to be below outdoor levels (depending on HVAC system filter efficiency) with consistently similar ranking among the microbial species.[9,10]

Some individuals manifest increased immunologic responses to antigenic agents encountered in the environment. These responses and the subsequent expression of allergic disease is based, partly, on a genetic predisposition.[11] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic bronchopulmonary aspergillosis (ABPA), and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[12] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agricultural, biotechnology, office, and home environments.[13,14,15,16,17,18,19,20]

Individual symptoms vary according to disease. Allergic rhinitis is characterized by paroxysms of sneezing; itching of the nose, eyes, palate, or pharynx; nasal stuffiness with partial or total airflow obstruction; and rhinorrhea (runny nose) with postnasal drainage. Allergic asthma is characterized by episodic or prolonged wheezing and shortness of breath in response to bronchial (airways) narrowing. Allergic bronchopulmonary aspergillosis is characterized by cough, lassitude, low-grade fever, and wheezing.[12,21] Heavy exposures to airborne microorganisms can cause an acute form of extrinsic allergic alveolitis which is characterized by chills, fever, malaise, cough, and dyspnea (shortness of breath) appearing four to eight hours after exposure. In the chronic form, thought to be induced by continuous low-level exposure, onset occurs without chills, fever, or malaise and is characterized by progressive shortness of breath with weight loss.[22]

Acceptable levels of airborne microorganisms have not been established, primarily because allergic reactions can occur even with relatively low air concentrations of allergens, and individuals differ with respect to immunogenic susceptibilities. The current strategy for on-site evaluation of environmental microbial contamination involves an inspection to identify sources (reservoirs) of microbial growth and potential routes of dissemination. In those locations where contamination is visibly evident or suspected, bulk samples may be collected to identify the predominant species. In limited situations, air samples may be collected to document the presence of a suspected microbial contaminant. A significantly higher concentration of airborne microorganisms (about 10 times or greater) in the area of interest compared to outdoor or control areas indicates that growth may have occurred.

RESULTS

Environmental

Airborne Microbial Sampling

Indoor spore counts in the plant areas surrounding delivery point bar code sorter #6 and auto facer counter sorter #2 were not considered to be significantly elevated relative those detected outdoors. Fungi concentrations in the sack storage area of the annex (6,000 spores per cubic meter of air, Spores/m^3) during sack stacking were significantly elevated compared to outdoor concentrations (< 463 Spores/m^3); *Aspergillus* and *Penicillium* were dominant (75% of total spores).

Bulk Microbial Sampling

Annex bulk dust fungi counts on the conveyor in the box making area averaged 16,200 colony forming units per gram (CFU/g); *Penicillium* was dominant (43% of CFUs). On the sack storage area desk, counts averaged 92,000 CFU/g; *Cladosporium* was dominant (47%) followed by *Penicillium* (32%).

Concentrations of fungi in paper dust samples from delivery point bar code sorter #7 averaged 5700 CFU/g; no species of fungi were dominant. Concentrations of fungi in paper dust from delivery point bar code sorter #6 averaged 2900 CFU/g; *Penicillium* was dominant (46%). Concentrations of fungi in paper and other dusts accumulated on the return air grate underneath AH S3 averaged 323,000 CFU/g; four fungi were predominant- *Penicillium* (26%), yeasts (20%), *Aspergillus* species (20%), and *Cladosporium* (13%).

Concentrations of fungi in the dry, flaky deposits in a sample of AH (F5, S6 and S7) drain pans averaged 262,000 CFU/g; yeasts, *Fusarium*, *Penicillium*, *Phoma*, *Cladosporium*, *Alternaria*, and *Aspergillus* were predominant. Concentrations of fungi in drain pan water samples from AH S4 averaged 215,000 CFU/g; *Fusarium*, yeasts, *Paecilomyces*, and *Aspergillus* were predominant.

Air Handler Inspections in the Plant

Air handlers on the ground floor and the high velocity unit on the rooftop were in good condition with no notable problems. The following observations pertain to the AHs on the first and second floors. Most outdoor air (OA) dampers were nearly closed; two were open an estimated 10 to 15%. The design of these AHs is such that the drain pans are not located directly underneath the cooling coils; the floor of the AHs downstream of the coils is recessed to form a large condensate collection pan. This large pan is drained; condensate is pumped to the rooftop to serve as makeup water for the cooling towers. Pans are filled with a foam layer of insulation about one to two inches thick. Condensate accumulates in this pan on top of the foam layer. All dry drain pans exhibited a layer of black to brown flaky debris which was a combination of flaking foam and microbial contamination. Most drain pans contained one or two chemical pads designed to leach biocide into the drain pan water. Two AHs had rotating disk humidifiers attached to return air ducts; two others had water spray wands inserted into drain pans. Roll-type air filters were of low efficiency (estimated less than 30%), were not clogged, and were advanced by static pressure gauge readings. Maintenance crews clean AHs annually before the cooling season and perform scheduled maintenance checks up to two times per week.

Dust Concentrations

No airborne dust concentrations exceeded OSHA or ACGIH exposure limits for PNOR/C. Unless otherwise noted, concentrations are based on full-shift TWA exposures (in milligrams dust per cubic meter air, mg/m^3). Area airborne dust concentrations at sample locations 1 and 5 (Figure 1) ranged from 0.11 to 0.13 mg/m^3 total dust; 0.064 to 0.082 mg/m^3 respirable. Closer to blowout operations at location 4, the total dust concentration was 0.24 mg/m^3 total, 0.082 respirable.

A partial shift sample was collected for 17 minutes at location 2, about 10 feet from blowout of delivery point bar code sorter #13. The partial shift total dust concentration was 2.0 mg/m^3 total, 0.94 respirable.

Qualitative aerosol concentrations were measured with a real-time aerosol monitor operated parallel in time to vacuuming and blowout of delivery point bar code sorters #7 and #13. The monitor was positioned approximately 10 feet from, and in between the delivery point bar code sorter machines (Figure 1, locations 2 and 3) at a height of five feet. Time and concentration graphs during vacuum and blowout of delivery point bar code sorters #7 (Figure 2) and #13 (Figure 3) indicate that paper dusts aerosolized by compressed air increase in concentration rapidly and settle rapidly. Dust concentrations in close proximity to blowout increased from 100 to 1000 times above dust concentrations during vacuuming.

Particle Size Distributions (Gravimetric)

Only samples from locations 1, 2, 4, and 5 (Figure 1) had sufficient mass per stage for size distribution calculations; the sample from location 3 (during blowout of delivery point bar code sorter #7) was voided due to insufficient mass on some impactor stages. Most of the mass of airborne particulate sampled during blowout of delivery point bar code sorter #13 exceeded 10 micrometers (µm) in aerodynamic diameter. Therefore, most of the mass was not of respirable size. Approximately 27 % of the mass of airborne particulate from the blowout was below 10 µm in aerodynamic diameter, therefore in the respirable fraction. The blowout sample had a mass median aerodynamic diameter (MMAD) of 19 µm, with a geometric standard deviation (GSD) of approximately 3.7. Close to delivery point bar code sorter blowout operations (Figure 1, location 4), 20% of the mass was respirable, with a MMAD of 19 µm and a GSD of 2.6. Aerodynamic diameters were more polydisperse farther away from delivery point bar code sorter blowout. In location 5, 36% of the mass was respirable, with a MMAD of 16 µm and a GSD of 4.3. About 300 feet from blowout at location 1, 47% of the mass was respirable, with a MMAD of 8 µm and a GSD of 6.8.[23] See Table 1 for mass distribution data by aerodynamic diameter.

Aerosol and Bulk Dust Microscopy

See the Appendices for particle descriptions, electron micrographs, and particle size distribution data.

Medical

Community Practitioner Interviews

Two local medical practitioners were interviewed via telephone prior to the HHE investigators' arrival in Omaha. They were asked about increased numbers of respiratory complaints in postal workers and in the population in general. This information was sought in order to serve as a comparison for the incidence and prevalence of respiratory disease between the community and the postal workers. One of the practitioners who is a pulmonary specialist, had not noted any increase in respiratory problems, including asthma, in the area other than what was expected for that time of the year with the prevailing weather conditions. She currently was treating only a single employee of the OMPDC. A general practitioner who treated postal employees had not noted any increase in incidence or prevalence of respiratory disease or asthma in his practice.

Worker Interviews

Of approximately 897 mailhandlers, clerks, and maintenance personnel, 14 self-selected individuals participated in worker interviews with the NIOSH physician; 11 did so in person, and 3 via telephone. Work histories, current symptoms, and medical histories were discussed during the interviews. The numbers of individuals who presented for interviews represented less than 1.6% of the work force. The sample was not considered to be random or representative. Half of the respondents were female. The respondents ranged in age from 31-67 years of age, with a median age of 50 years. Forty-two percent (6/14) of the individuals were smokers, or ex-smokers. The majority of respondents (5/14) worked on the second floor of the plant. Respondents represented various job categories such as mailhandler, clerk, flat-sorter, general expediter, and union official.

Postal workers were asked general questions regarding their health and any recent or chronic respiratory illnesses that they believed were work related. Of those interviewed, complaints centered on the upper respiratory system. Seventy-nine percent (11/14) of respondents complained of upper respiratory symptoms of congestion, nasal discharge, post nasal drip and recurrent sinus infections. Six complained of allergic symptoms such as scratchy throat and itchy eyes. There was a single complaint each of asthma, skin rash, and fungal lung infection.

The physician walked through the plant and initiated discussion of work related health symptoms with several groups of workers. Many workers complained of upper respiratory allergic symptoms (itchy throats and eyes) as well as recurrent sinusitis.

Medical Records

Incomplete medical records were supplied by one individual. His records from a pulmonary specialist attributed his recurrent exacerbations of sinus infections and perennial allergic rhinitis to exposure to heavy allergen loads. That individual was also known to have asthma prior to beginning work at the post office. The pulmonary specialist could not say if the exposure had occurred in the work place since a site visit was not made. The pulmonary specialist could not comment on the permanence of any respiratory difficulty the patient may have.

A letter supplied by an ENT physician stated the belief that there was a contribution to the patient's condition from the dust at the work place. However, no permanent impairment resulted.

Accident and Illness Reports

Review of the accident and illness reports from 1993-1997 showed only one report of a problem coded as a "respiratory condition due to a toxic substance." No workers compensation claims had been filed for respiratory illness.

DISCUSSION

Cellulose, a substance which is a natural polysaccharide widely distributed in nature and a large component of paper, is considered to be biologically non-toxic. Airborne cellulose dust has been described as both non-irritating and non-toxic with little adverse effects on the lung at concentrations of less than 10 mg/m^3.[7]

Most of the studies showing adverse health effects of paper dust have been done in paper mills where concentrations of airborne dust are 15 to 20 mg/m^3.[24,25] One study, done in British Columbia, in a soft paper mill with paper dust levels under 10 mg/m^3, showed no increase in the prevalence of lower or upper respiratory symptoms.[26]

Studies of lower levels of dust exposure (1 to 3 mg/m^3) in soft paper mills showed an increase in complaints of nasal irritation and nasal crusts, but no increase in coughing, chronic bronchitis, asthma, dyspnea or sinusitis. However, there is some evidence that sinusitis can be induced or exacerbated by occupational exposures. A possible mechanism is the impaired clearance of mucous from the nasal passages as a result of swelling of the nasal mucosa secondary to allergic or irritant rhinitis.[27] There was no decline in respiratory function noted after low levels of exposure.[28,29,30] Pulmonary function tests did not show any changes in lung function for workers exposed to dust levels less than 5 mg/m^3 for greater than ten years. Though there was an increase in the prevalence of upper respiratory symptoms with dust exposure, no dose-response relationship could be found.[31]

A study of other types of dust exposures has shown an association between an increased rate of upper respiratory symptoms and various types of non-specific occupational dusts. Interestingly, this study also showed a higher prevalence of upper respiratory symptoms in never-smokers than in current smokers.[32] It has been suggested in other studies that this phenomenon is probably due to impaired mechanisms of mucosal clearance in smokers, so that they do not exhibit upper respiratory symptoms as seen in non-smokers.[27]

Most OMPDC workers that were interviewed had medical complaints which involved the upper respiratory system. Problems such as allergic rhinitis, recurrent sinusitis, itchy eyes and throat as well as nasal congestion and discharge were common. Rare complaints of lower respiratory symptoms were also made. It is difficult to make conclusions based on the small percentage of individuals interviewed. It is also difficult to separate out the effects of smoking from those of occupational dust exposure. It is of interest to note that there were a larger number (9/14) of workers who suffered recurrent sinusitis among the current and ex-smokers. However it is important to note that since the number of workers interviewed were too small and not randomly selected, valid generalized conclusions are difficult to make.

OSHA paper dust sampling data obtained in July 1996 from areas in the annex and 2nd floor plant indicate that 8-hour TWA paper dust concentrations are 0.08 mg/m^3 in the box making area, and range from 0.06 to 0.54 mg/m^3 near culling and delivery point bar code sorter areas. Partial shift samples collected for about 80 minutes in proximity to blowout ranged from 0.34 to 0.61 mg/m^3. Neither OSHA nor NIOSH exposure data obtained at OMPDC exceed PNOR/C exposure limits.

As determined by a literature search for references on the subject, health effects associated with exposure to paper dust generated from mail handling are not well characterized. A basis for limiting exposure to the paper dust in mail handling environments is impeded by the variability in the sources of paper dust. Because paper dust is likely to vary widely in composition, the ACGIH PNOC standard cannot be applied with certainty to all types of paper dusts. It is not certain that the PNOR standard, the cellulose content of paper, or of any other substance and/or impurity is appropriate for limiting exposure to paper dust. Many types of dust exposures are without applicable exposure limits. For example, fungi concentrations were significantly elevated (compared to outdoor levels) in the annex during mail sack stacking. However, there are presently no quantifiable exposure limits for fungi.

The question of what kind of respirator is acceptable for non-specific dusts has been raised by OMPDC employees. OMPDC management does not have a respiratory protection program and does not consider paper dust exposures at OMPDC to be sufficiently elevated to warrant the use of respiratory protection because paper dust exposures, even during mail sorter cleaning, are well below the PNOR standard. However, some employees have linked paper dust exposures to their own respiratory problems.

According to an OSHA interpretation letter on dust exposure of Postal employees dated September 25, 1990, "certain individuals who are allergic to non-specific dusts should be allowed to wear protective dust masks." If a worker's private physician "prescribes a dust mask" then "a letter from his/her private physician explaining the individual's susceptibility should be placed on file in the Health Unit." According to the interpretation letter, "OSHA policy is not to cite an employer for lack of a respiratory protection program unless there is a potential for employee over exposure or an adverse health condition occurs due to the respirator. Therefore, the use of disposable dust masks to limit exposure to low levels of nuisance dusts would not, in itself, necessitate the need for a respiratory protection program."[33] This exemption from a written respiratory protection program is repeated in the

1998 OSHA respiratory protection final rule with clarification that a disposable dust mask is a "filtering facepiece (dust mask)."[34]

According to the 1998 OSHA respiratory protection final rule, even if exposures don't require use of respirators because exposures are below applicable limits, employers may provide respirators or allow employees to use their own respirator. The employer must ensure that the respirators in use do not present a hazard to the health of employees. If only filtering facepiece respirators are voluntarily worn, the employer is not required to implement a written respiratory protection program. According to OSHA, it is the employer who must rely on "professional judgement and available data sources when selecting respirators for protection against hazardous chemicals that have no OSHA PEL." According to OSHA, it is prudent to select more rather than less protective respirators.[33,34]

CONCLUSIONS

On the basis of environmental and medical information obtained during the survey, NIOSH investigators did not find clear evidence that employee symptoms were caused by microbial contaminants or paper dust. NIOSH investigators could find no published research that indicated that paper dust at levels less than 5 mg/m^3 generated by paper manufacturing is a recognized respiratory hazard, although the type of paper dust generated by mail handling and sorting was not the subject of any published research. Research is available that supports the occurrence of upper respiratory symptoms (nasal crusts, congestion, rhinitis, itchy throat) at paper dust levels less than 3 mg/m^3.

This does not mean that there is no basis for respiratory health effects experienced by those workers exposed to non-specific dusts or paper dust; nor does it invalidate worker requests for respiratory protection, based on the advice and direction of personal physicians, or based on respiratory symptoms experienced by workers.

Paper dust blowout involves relatively short-term, elevated paper particulate exposures in the areas immediately surrounding blowout. Most of the particulate settles quickly and is not of respirable size. Paper dust has accumulated on surfaces within the plant, particularly the return air grates leading to air handlers.

Airborne fungal spore concentrations in the plant were not significantly elevated compared to outdoor concentrations. Fungi cultured from bulk paper dust collected from the inside of sorters are common in indoor and outdoor environments. Compared to bulk dusts collected from a return air grill, freshly generated paper dust is not a significant source of fungi in the plant. Fungi were about 60 to 100 times more concentrated in the dust under the return air grate of AH S3 compared to freshly generated paper dust. Many fungal species in return air grate dust and from drain pan samples favor moist conditions for growth. The cellulose content of paper dust provides a good food source for fungi, and paper dust absorbs moisture from the air. The accumulation of bulk paper dust will likely provide a matrix for fungal growth, and appears to be a significant source of fungal material, specifically *Aspergillus, Penicillium*, and yeasts. However, a significantly elevated concentration of airborne fungal contamination was not measured in the plant during this evaluation. Airborne fungi, particularly *Aspergillus*/*Penicillium*, were significantly elevated in the annex, when compared to outdoor levels, during mail sack handling and stacking.

Overall, AHs were in good mechanical condition. However, drain pans, humidification units, and metal panels within AHs did not appear to be free of accumulated debris. Some drain pans were filled with water; these pans should drain rapidly enough not to accumulate water. In some cases, AHs were dusty inside. The most likely cause is low filtration efficiency afforded by the roll-type filters in use, which do not prevent the accumulation of debris in drain pans and interior AH surfaces. The foam in the drain pans holds moisture within the drain pans, and is friable, which inhibits the aggressive cleaning of drain pan surfaces. Biocide packets used in the drain pans were not effective in preventing the accumulation of microbial materials in the pans; these packets are not effective unless a sufficient pool of water in the pan enables the biocide to dissolve evenly throughout the pan. Since pans should not accumulate water and should drain rapidly, the use of biocide packets is not recommended.

Since workers were concerned about exposure to inks used by sorting machines to spray bar codes on mail, MSDSs for inks in use were reviewed to determine if exposures to the inks could be considered a hazard. The inks are very quick drying; considering the air dilution volume for the volatile fraction of the inks and their use within enclosed machinery, workers not directly handling bulk ink containers were judged not to be exposed to a significant health risk. Workers who directly handle inks should follow the guidelines in the MSDSs regarding personal protective equipment and engineering controls.

RECOMMENDATIONS

In a letter dated July 23, 1997, to OMPDC management, an OSHA area director observed that "employees with pre-existing respiratory ailments such as seasonal allergies, chronic asthma, [or] bronchitis are routinely exposed to paper dusts that initiate or aggravate these health conditions." In the letter, OSHA recommended controls that include respiratory protection, smoking cessation, administrative rotation, and/or engineering solutions which minimize dust generation at the optical character reader delivery point bar code sorter areas with air filtration or wet vacuuming of surfaces.[35]

The following NIOSH recommendations focus on the control of non-specific and paper dust exposures, control of paper dust accumulation within the plant, and maintenance of HVAC system components:

Control of Non-specific Dust Exposures

NIOSH investigators agree with OSHA that concentrations of certain non-specific dusts or paper dust can be elevated at times at the OMPDC such that dusts might initiate or aggravate pre-existing respiratory conditions. Examples of activities that were assessed by NIOSH that resulted in elevated dust levels include mail sack handling (in terms of fungi concentrations) and paper dust blowout (in terms of short-term elevated dust concentrations). We further agree with OSHA recommendations to provide respiratory protection for employees with chronic respiratory conditions, provide a smoking cessation program for affected individuals, and experiment with permanent administrative job rotations for affected workers.

According to OSHA, if the employer decides that voluntary respirator use is permissible and will not present a hazard to the health of the employee, the employer is responsible for selecting the type of respirator facepiece and filter. According to the latest OSHA Final Rule for Respiratory Protection, selection is determined by "informed professional judgement" and "available data sources."[34] Filter selection is straightforward, even if the mass median aerodynamic diameter (MMAD) of the particulate is not known; any Part 84 filter may be used. If a physician prescribes a "dust mask", then a respirator which uses a Part 84 filter is a good selection. A loose-fitting filtering facepiece respirator is a good first choice for respiratory protection against non-specific dust exposures that initiate or aggravate employee health conditions. Because of their higher efficiency against 0.3 micron particulate, Part 84 filters are a good choice for these respirators. Part 84 filters provide from 95 to 99.97% efficiency in the removal of 0.3 micrometer particles. After July 10, 1998, non-powered, air-purifying, particulate-filter respirators should be approved under Part 84.[36]

If respiratory symptoms are not controlled with a loose-fitting filtering facepiece respirator, then a tighter-fitting filtering facepiece respirator should be selected in the proper size for the worker's face. These respirators are specially molded to form a more complete seal with the face. If symptoms persist with a tight-fitting filtering facepiece respirator that has been fit tested for the worker, then respirators which progressively minimize facepiece penetration should be selected.

If any respirator other than a filtering facepiece respirator is used, the employer must implement a medical evaluation to ensure that the worker is medically able to wear the respirator, and ensure that the respirator is cleaned, stored, and maintained so that its use does not present a health hazard to the worker.[33,34]

It is important to note that the level of protection provided by a negative-pressure respirator without a fit test could be any value. The level of protection provided by a negative-pressure respirator will be more dependent on the quality of the fit testing than on the respirator. When respirators are used voluntarily without fit testing (or other training) no level of protection is assured.

Control of Paper Dust Exposures

According to the NIOSH Guide to the Selection and Use of Particulate Respirators Certified Under 42 Part 84, Part 11 dust/mist (DM) or dust/fume/mist (DFM) filters may be used for protection against dusts with a MMAD of greater than 2 micrometers. Therefore, DM or DFM filters under Part 11 may be used when necessary to protect employees from paper dust exposures at the OMPDC since the MMAD of paper dust at the facility is greater than 2 micrometers. In addition, any Part 84 filter may be used. Other respirator selection logic should follow that of non-specific dusts as outlined above.

Control of Paper Dust Accumulation

In a letter to the OMPDC dated July 23, 1997, OSHA suggests engineering control of airborne paper dust in the form of auxiliary air filtration or wet vacuuming of floors or machines to remove paper dust. NIOSH investigators encourage the control of paper dust accumulation within the building on the grounds that paper dust provides a good matrix for microbial growth, and microbial growth, particularly within HVAC systems, should be minimized. Ideally, paper dust should be controlled at the source to prevent accumulation within the building. At a minimum, its accumulation should be controlled within HVAC return and supply airstreams. Control by prefilters, increased efficiency of primary filters, and prevention of filter blow-by are some options. NIOSH investigators do not encourage the application of water to collect paper dust unless moistened surfaces are dried within 24 hours.

HVAC Systems

1. Water should be removed from HVAC systems, when possible. Eliminate standing water in air handling systems by providing free-flowing drains.

2. To help minimize the accumulation of debris within air handlers, ensure all HVAC systems have OA filters that are securely fastened into filter racks that minimize blow-by of unfiltered air. Filters should be 50 to 70% efficient (according to the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) dust spot efficiency test) in order to remove most microbial particulate from the airstream. Upgraded filters should be within the limit of pressure drop the systems can handle.

3. Clean and disinfect humidifiers and mechanical components on a routine basis, as recommended by equipment manufacturers. Avoid the use of water sprays in HVAC systems. Water containing biocide residues or water treatment chemicals should never be used for humidifying. The porous and friable foam in the drain pans is not conducive to aggressive cleaning and will likely become contaminated unless regularly cleaned and disinfected. Drain pan should not accumulate water, thus rendering the use of biocides unnecessary. Cleaning should be performed often enough to prevent the accumulation of slime in drain pans. When cleaning and sanitizing HVAC components, never disinfect or use biocides in water or air in an operating HVAC system. Ensure that the HVAC system is not operating until it is cleaned, sanitized, and dried. Loosen and remove mold, slime, dirt, and organic debris, then sanitize using a dilute aqueous household bleach solution (10% bleach in water). Bacterial endospores, produced by some thermophilic actinomycetes, may be slightly resistant to chlorine disinfectants; therefore, surfaces should be kept moist with the bleach solution for a sufficient contact time to allow for disinfection to occur (about 10 to 15 minutes). A clean water rinse should follow cleaning and sanitizing.

4. Since all OA intakes were nearly closed, the NIOSH investigators suspect that OA requirements are not known. Current design air flow controls should be verified by an engineering firm. The firm should adjust all HVAC systems to ensure that they will operate such that ASHRAE recommended standards are satisfied. These ASHRAE standards include recommended outdoor air flow per occupant, and seasonal recommended limits for indoor temperature and relative humidity. Any changes in the systems which affect current designs should be recorded as an addendum to existing HVAC documentation.

5. The floor of fan rooms, including surfaces underneath the air handlers, should be kept

free of debris which could become entrained into the supply air stream.

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Table 1
Particle Size Distribution Data From Locations In the Plant
Omaha Mail Handling and Distribution Center, Omaha, Nebraska

Sampling Location	Impactor Stage Number	Median Stage Cutoff Size for Particles (µm)	Cumulative Percent Mass Less than Particle Size
North 2nd Floor ISS Stacker Area Grid Location E13	1 2 3 4 5 6 7 8 Final	21 15 10 6 3.5 2 0.9 0.5 0.25	74.7 64.2 47.4 44.2 36.8 25.3 18.9 4.2 0
Central 2nd Floor ECA DSS Area Grid Location E8 / E9	1 2 3 4 5 6 7 8 Final	21 15 10 6 3.5 2 0.9 0.5 0.25	59.3 33.5 19.8 8.2 4.9 3.3 3.3 2.7 0
Southeast 2nd Floor Delivery Point Bar Code Sorter Staging Area Grid Location H6	1 2 3 4 5 6 7 8 Final	21 15 10 6 3.5 2 0.9 0.5 0.25	72.1 55.8 36.0 12.8 11.6 5.8 5.8 2.3 0
Southwest 2nd Floor ECA Delivery Point Bar Code Sorter (Phase II) 190 Stacker #13 Blowout Grid Location A5.5 / B5.5	1 2 3 4 5 6 7 8 Final	21 15 10 6 3.5 2 0.9 0.5 0.25	49.0 47.1 26.5 22.1 10.3 4.4 0 0 0

Figure 1
2nd Floor Plant Airborne Dust Sampling Locations (1 - 5)
Omaha Mail Handling and Distribution Center, Omaha, Nebraska
HETA 98-0017-2699

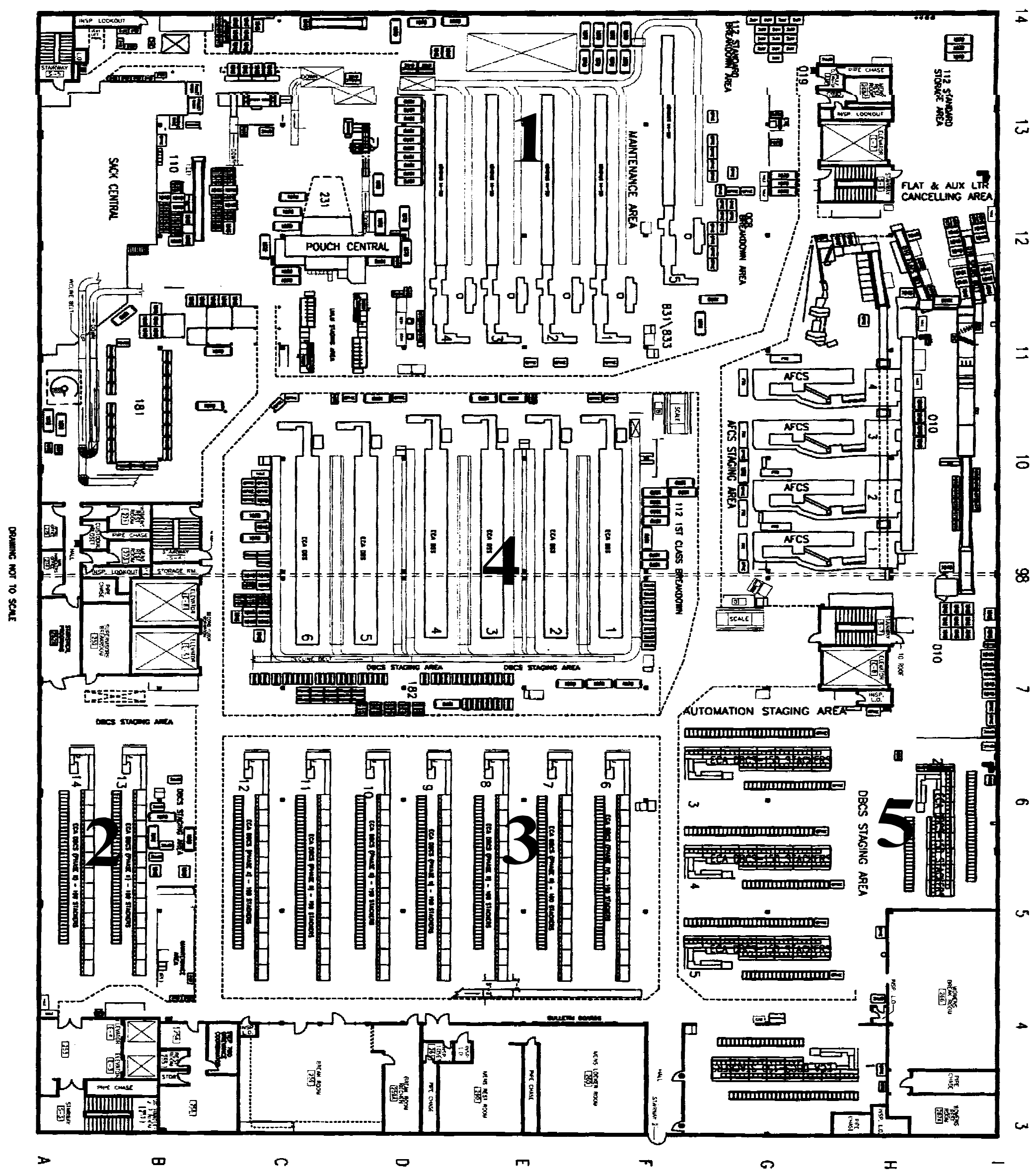


Figure 2
Graph of Qualitative Aerosol Concentrations During
Vacuum / Blowout of Delivery Point Bar Code Sorter #7, January 27, 1998
Omaha Mail Handling and Distribution Center, Omaha, Nebraska
HETA 98-0017-2699

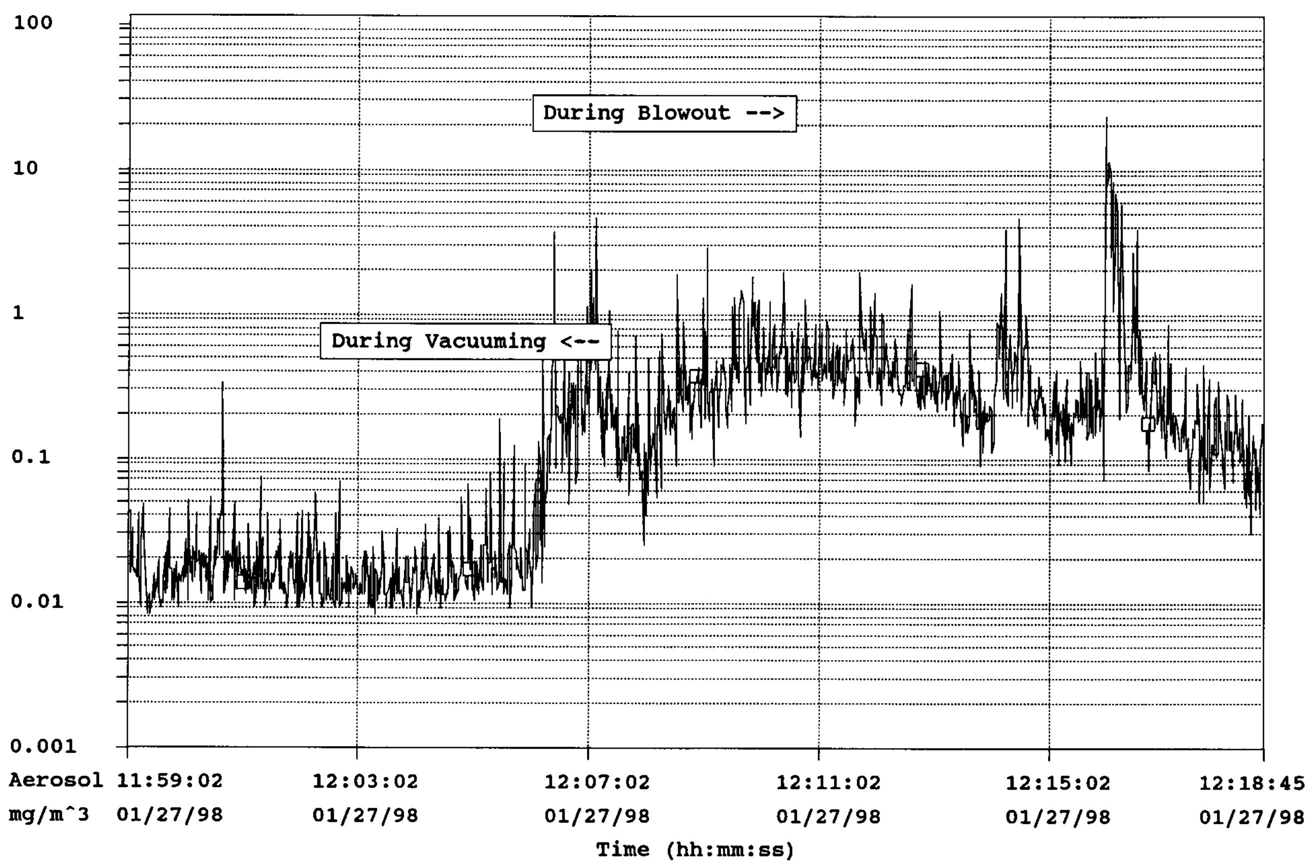
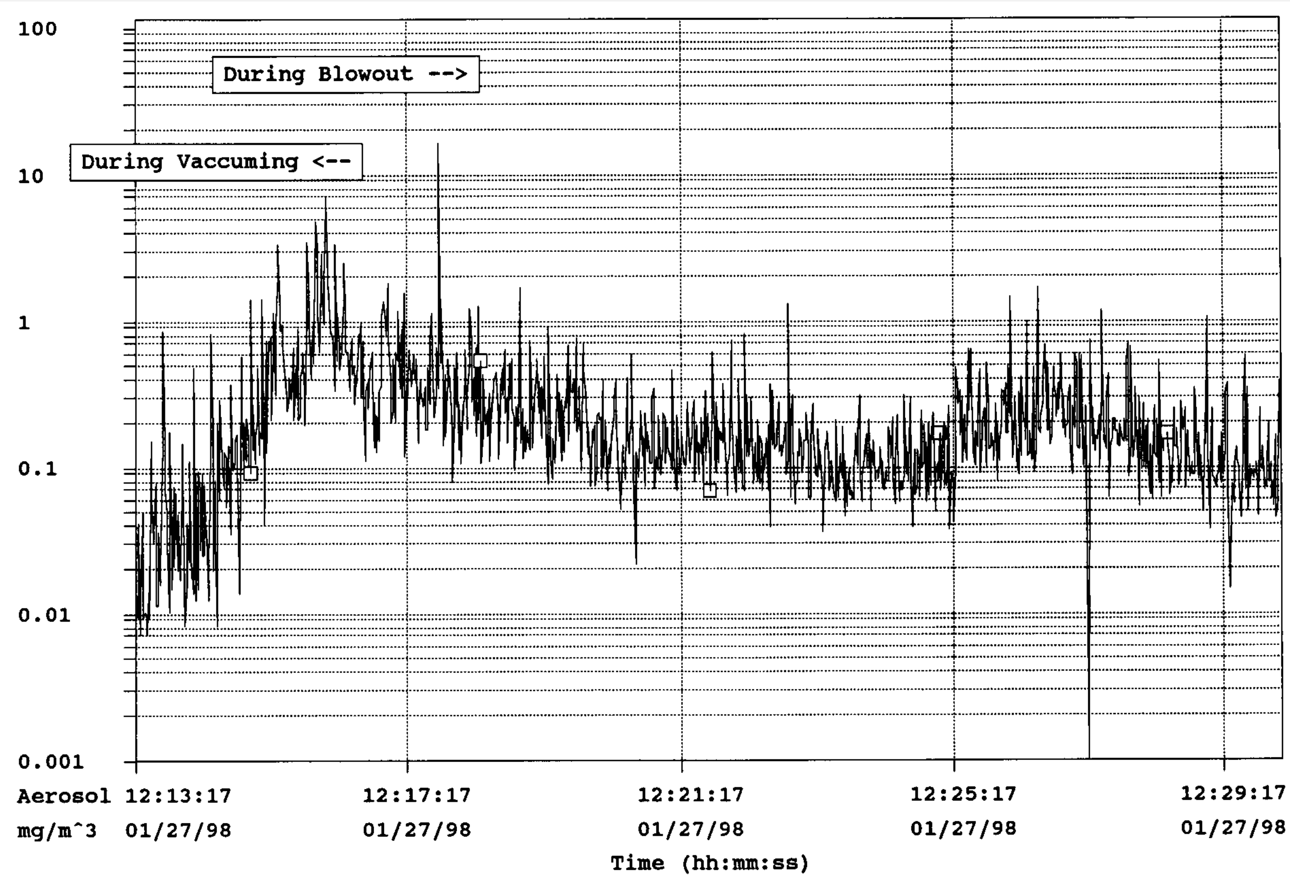


Figure 3
Graph of Qualitative Aerosol Concentrations During
Vacuum / Blowout of Delivery Point Bar Code Sorter #13, January 27, 1998
Omaha Mail Handling and Distribution Center, Omaha, Nebraska
HETA 98-0017-2699



APPENDICES

Cellulose was a predominant particle observed in both settled dust and air samples collected in the second floor plant. Polarized light microscope images of settled dust collected on surfaces of delivery point bar code sorter #6 revealed birefringent, predominantly fibrous particles as cellulose. Cellulose fibers were rather tightly curled and knotted.

Figure 1 contains scanning electron microscope images of the same material. Although cellulose fibers are characteristically twisted, the degree of curling seen here is considered unusual and may perhaps be due to forces applied to the letters as they are fed through the delivery point bar code sorter.

Particle images of airborne dust obtained 10 feet from delivery point bar code sorter #7 during blowout indicate many of the airborne particles are non-fibrous. Observation of optical features of these particles under polarized light microscopy indicate that many of these particles are cellulose. Although less frequent than in the settled dust samples, particles with a curled or knotted structure were also observed in the air samples. The relative scarcity of these particles in air samples is likely due to the fact that tightly curled particles would have larger aerodynamic diameters and thus be more likely to settle-out close to their point of generation.

Figure 2 provides a graphical representation of the length and width distributions for measurements made on an air sample collected 10ft from delivery point bar code sorter #6 during blowout. All particles with a length to width ratio > than 3:1 were sized. Measurements were made using scanning electron microscopy at a magnification of 2000X. Mean width was 3.3 µm (standard deviation 2.6). Average length was 18.9 µm with a standard deviation of 17.6. The particle lengths spanned an order of magnitude (<10 to >100 µm). Differential counts indicated that only about 20% of the particles detected would be considered fibers under the 3:1 criterion. As mentioned, many of the non-fibers are cellulose-based particles. Some of the other types of particles observed in these samples include starch grains, skin cells and minerals.

A limited number of samples were also collected in the annex. Light and electron microscopic observation of these samples indicated a different sort of aerosol. Cellulose particles are ubiquitous and some were detected. The predominant particles were mineral based. Large particles representative of much of the particulate were birefringent and X-ray analysis indicated a predominant calcium peak. The warehouse is a concrete structure and these observations are consistent with the generation of concrete particles as bags of mail are dragged across the floor. Smaller particles were present forming an agglomerate of very small roughly spherical particles. Knowledge of the operation of diesel trucks delivering mail to this warehouse provides a strong argument that these particles are diesel combustion products.

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