# HETA 2000-0356-2851
# Campbell Hausfeld
# Harrison, Ohio

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# PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) 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 (OSHA) 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.

HETAB 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 Beth Reh, Elena Page, Josh Harney, and Robert McCleery of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Greg Burr, Kevin Roegner, Chuck Mueller, and Vitaly Aizenberg. Analytical support was provided by Datachem and MSI Laboratories. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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# Highlights of the NIOSH Health Hazard Evaluation

## Evaluation of the Machining and Assembly Areas

**The management of Campbell Hausfeld asked NIOSH to see if metal-working fluids (MWFs) or some other exposure might be causing skin problems in some employees in the machining and assembly areas.**

## What NIOSH Did

- **We talked with employees who had been experiencing rashes and took pictures of any rashes present on the day of the interviews.**
- **We collected bulk samples of MWFs to analyze for bacteria.**
- **We sampled the air for MWFs and for other chemicals.**

## What NIOSH Found

- **Many workers in the machining area are exposed to MWFs above the NIOSH limit.**
- **Most of the MWF particles are small enough to be breathed into your lungs.**
- **The skin problems are not all the same and not likely caused by one specific thing in the workplace.**

## What Campbell Hausfeld Managers Can Do

- **Reduce MWF exposures by increasing dilution ventilation, enclosing some machines, and adding local exhaust ventilation to some machines.**
- **Provide respirators to employees that have high exposures to MWFs.**
- **Develop a medical monitoring program for employees exposed to MWFs.**
- **Continue to provide gloves, sleeve protectors, aprons, and coveralls, and tell the workers about the importance of protecting their skin.**

## What the Campbell Hausfeld Employees Can Do

- **Use gloves, sleeve protectors, aprons, coveralls, etc., to keep MWF and other chemicals off your skin.**
- **Wash MWF and other chemicals off your skin and change clothes that become wet with MWF.**
- **Report any health problems to your boss if you think they might be work-related.**

**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 # 2000–0356-2851

# Health Hazard Evaluation Report 2000-0356-2851
# Campbell Hausfeld
# Harrison, Ohio
# June 2001

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## SUMMARY

In July 2000, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard Evaluation (HHE) at Campbell Hausfeld in Harrison, Ohio, a producer of air compressors. This HHE request concerned several employees from the machining and assembly areas who had been reporting skin problems to management in the months prior to the request. The company had consulted an occupational dermatologist to evaluate the rashes and to determine their cause. Campbell Hausfeld followed the dermatologist's recommendations, but some workers continued experiencing rashes. NIOSH investigators conducted an initial site visit on August 31, 2000. Based on the general area (GA) particulate sampling results in the machining area, a more thorough air sampling survey was done on January 8-12, 2001.

During the first site visit, the NIOSH medical officer interviewed 12 employees, 5 of whom had a skin rash at the time of the interviews. Of the five with current rashes, two were assemblers, two were machinists, and one was an office worker. Two had a rash on their hands that appeared to be dyshydrotic eczema; two (both assemblers) had a rash on the forearms consistent with dermatitis, but it could not be determined if it was work-related; and one had folliculitis, which occurred on areas of skin not in contact with metal-working fluid (MWF), as well as on areas that may have contact with MWF. Review of the Occupational Safety and Health Administration (OSHA) 200 Injury and Illness logs revealed 15 separate cases of dermatitis since 1995; 9 in machinists, 2 in product services, and 4 in assemblers.

Over both site visits, the NIOSH industrial hygienists collected bulk fluid samples for microbial analysis, GA and personal breathing zone (PBZ) air samples for total particulate, thoracic particulate, and extractable MWF analysis, real-time particulate concentration, count, and size data, and PBZ samples for volatile organic compound (VOC) analysis. The microbial sampling did not reveal anything unusual for MWF environments, and the VOC sampling results were all below relevant criteria except for the paint-booth employee who wore a respirator. Over half of the MWF particulate sample concentrations were above the NIOSH Recommended Exposure Limit (REL) of 0.5 milligrams per cubic meter ($mg/m^3$) total mass or 0.4 $mg/m^3$ thoracic mass, for up to a 10-hour time-weighted average. The real-time data suggest that a large percentage of the particle mass concentration was in the respirable range.

NIOSH investigators concluded that a health hazard from exposure to MWF exists at Campbell Hausfeld and recommended that exposures be reduced and a comprehensive MWF safety and health program be developed and implemented. The program should include training, exposure assessment, hazard control, and medical monitoring. MWFs are known to cause irritant contact dermatitis and may cause allergic contact dermatitis. While it is unlikely that there is one single cause of the various rashes experienced by employees, work-related exacerbations of skin problems could be minimized by limiting skin contact with the MWFs, washer detergents, and rust inhibitors. MWFs are also known to cause respiratory irritation and decrease lung function. Engineering controls such as dilution ventilation, enclosures, and local exhaust ventilation are needed to reduce the MWF exposures.

Keywords: SIC 3563 (Air and gas compressors), dermatitis, rashes, metal-working fluids, MWFs, machining, coolants, microbial sampling, total particulate, thoracic particulate, extractable MWF, GRIMM, real-time particulate sampling, volatile organic compounds, VOCs, n-butyl acetate, methyl isobutyl ketone, MIBK, xylene, total hydrocarbons.

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# INTRODUCTION

In July 2000, the National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard Eevaluation (HHE) at Campbell Hausfeld in Harrison, Ohio. Several employees from the machining and assembly areas had been reporting skin problems to management in the months prior to the request. The company had consulted an occupational dermatologist who visited the plant on April 29, 2000, to evaluate the rashes and to determine their cause. He reported that if there was a single cause of the rashes, it was probably the new defoamer that had been recently added to the metal-working fluids (MWFs), and he recommended switching back to the previous defoamer. He also noted that several other substances were capable of aggravating dermatitis, including MWFs, barrier creams, and soaps, and he made recommendations to limit exposure to these agents. Campbell Hausfeld followed these recommendations, but some workers continued experiencing rashes. NIOSH investigators conducted an initial site visit on August 31, 2000, and performed a follow-up survey on January 8-12, 2001.

# BACKGROUND

Campbell Hausfeld produces air compressors, and shares a production facility in Harrison, Ohio, with one of the two other businesses that form The Campbell Group. The plant is divided into the Campbell Hausfeld side and the Wayne side, and there are approximately 500 employees at the entire Harrison, Ohio, site. Workers primarily work on only one side, but have the opportunity to work on the other side if there is a furlough and they want to remain at work. This HHE request concerned the Campbell Hausfeld side where there were about 350 employees–100 machinists, 4 material handlers, 40 assembly workers, 6 maintenance workers, 6 quality assurance workers, 9 tool room workers, 12 product service workers, 25 re-manufacturing workers, and 150 office workers. The safety and health responsibilities were shared by the Human Resources Manager and the Maintenance Manager; Campbell Hausfeld did not have a safety and health professional.

The machining area contained two main sections, single-stage and dual-stage, where aluminum and cast iron parts were machined. The parts then went through a washer and were assembled into either a single- or dual-stage pump.

Five different MWFs were in use on August 31, 2000, one straight oil, two semi-synthetic fluids (TrimHD and CimStar 540), one water soluble fluid (TrimSol), and one synthetic fluid (C-115) that was being tested as a potential replacement fluid. By the second site visit on January 8-12, 2001, many of the machines had been switched from their former MWF to the C-115. Machines in the single-stage and dual-stage machining areas each contained their own MWF tank. One coolant technician was responsible for the MWFs and emptied each machine tank and refilled it on a regular schedule. During the August site visit, the Trim® HD fluid was recycled, and then as more machines were changed from using the Trim® HD to C-115, the recycling system was switched in December to recycle the C-115 instead. The technician emptied the fluid from its machine tank and stored it in an open holding tank. It was then filtered in a bag filter and a centrifuge, mixed in a 50:50 new to recycled fluid ratio, and returned to the machines. Workers had access to spigots throughout the plant where they can obtain unused fluids to add to their tank if levels were low.

Safety glasses were the only personal protective equipment (PPE) required, but nitrile gloves, tear-away sleeves, and aprons were available. Machinists were not allowed to wear long sleeves for safety reasons. Showers were not provided.

# METHODS

## Medical Evaluation

During the first site visit, the NIOSH physician interviewed 12 employees. Five were employees who had reported work-related dermatitis to management, and the other seven were identified by the union as having had skin problems. Seven were from the machining areas, two were from product service, two were from the assembly area, and one was from an office area. Photographs were taken of active skin conditions and were reviewed by a NIOSH dermatologist. Employees were individually notified of the dermatologist's impression of their skin problems by letter and encouraged to discuss this information with their personal physician. In addition, the OSHA Log and Summary of Occupational Injuries and Illnesses (OSHA 200 log) from 1995 through 2000 was reviewed.

## Industrial Hygiene Evaluation

### *Microbial Sampling*

On August 31, 2001, 11 bulk samples of MWF were collected for microbial analysis, and 7 general area (GA) air samples were collected for total particulate analysis. The fluid samples were shipped overnight to a laboratory where several analyses were done to speciate and enumerate the fungi, bacteria, and mycobacteria. The materials and methods for these analyses are presented in Appendix A. The bulks were also analyzed for endotoxins. Samples were assayed for endotoxin content using a limulus amebocyte lysate (LAL) assay (Kinetic-QCL, BioWhittaker Inc., Walkerville, Maryland) according to the kit manufacturer's recommended procedures. The MWF samples were allowed to warm to room temperature, and vigorously mixed (vortexed) for five minutes. Two 3-milliliter (ml) samples were removed from the bulk fluids and a series of five-fold dilutions were prepared. The samples were vortexed for three minutes before being diluted and again before being dispensed in the assay plate. The concentration of endotoxin was determined by reference to a standard curve prepared for each assay and which had a linear range from 0.005 to 50 Endotoxin Units/ml (EU/ml). Airborne endotoxin levels were determined from glass fiber filters used to collect air samples which were stored at 4°C in their cassettes until extraction. The filters were aseptically transferred to sterile 50 ml centrifuge tubes, and extracted with 10 ml of pyrogen free water for 60 minutes at room temperature on a platform rocker. The samples were then centrifuged for 10 minutes at 2500 rotations per minute (rpm), and the supernatant fluid was recovered and stored at -85°C until assayed for endotoxin content.

### *Particulate Sampling*

The GA air samples were collected on 37-millimeter (mm) closed-face cassettes with 2-micrometer (µm) pore-size polytetra-fluoroethylene (PTFE) filters, Tygon® tubing, and a personal sampling pump calibrated at 2 liters per minute (Lpm) according to the NIOSH Manual of Analytical Methods (NMAM) #0500.[1] Based on these sampling results, more air sampling was performed during the January 8-12, 2001, site visit. This visit was scheduled so that the sampling could be done during the winter when the overhead doors would not be open and the exhaust fans would not be operating. As before, samples were collected on 37-mm closed-face cassettes with 2-µm pore-size PTFE filters, Tygon® tubing, and a personal sampling pump calibrated at 2 Lpm according to NMAM #5524 (draft).[2] However, a second sample was also collected along side of the first using 37-mm closed-face cassettes with tared 2-µm pore-size PTFE filters, except that a

thoracic cylcone was attached to the sampling cassette so that only the thoracic fraction of the aerosol would be collected. Tygon® tubing connecting the sampler and a personal sampling pump drew air through the sampling train at a flow rate of 1.6 Lpm.[2] The particulate weight of the filters was determined by measuring the gross weight of each filter on a electrobalance and subtracting the previously determined tare weight of the filter (total particulate and thoracic particulate result). Then the filters were extracted using a 1:1:1 blend of dichloromethane, methanol, and toluene. After drying in a vacuum oven for at least two hours, the filters were allowed to re-equilibrate to balance room conditions for at least two hours. The filters were then reweighed on the same electrobalance, and the MWF weight was calculated by subtracting the post-extraction filter weight from the pre-extraction filter weight (total extractable particulate and thoracic extractable particulate). Prior to the extraction, solubility tests were performed on bulk MWF samples to ensure that the MWFs were soluble in the trisolvent. The limit of detection (LOD) for the total particulate and thoracic particulate sample filters ranged from 0.01 milligrams (mg) to 0.02 mg, and the limit of quantitation (LOQ) ranged from 0.02 mg to 0.06 mg. The LOD for the total extractable particulate and thoracic extractable particulate sample filters ranged from 0.01 mg to 0.03 mg, and the LOQ ranged from 0.02 mg to 0.1 mg.

## Real-time Particle Count and Sizing

Real-time sampling was conducted to monitor the particulates generated by distinct events during metal working operations on January 12, 2001. The Grimm Model 1.108 Dust Monitor (Labortechnik GmbH & CoKG, Ainring, Germany) was used to collect the real–time data.[3] This portable dust monitor (PDM) is a light scattering aerosol spectrometer designed for real–time particulate measurement with particle size discrimination. Fifteen channels collect count information for particle diameter sizes greater than 0.3, 0.4, 0.5, 0.65, 0.8, 1, 1.6, 2, 3, 4, 5, 7.5, 10, 15, and 20 µm. For each operation, data were integrated for 1 minute and stored sequentially on the Grimm data card over the entire time period. This particle count and size information was then downloaded to a laptop computer. Start and stop times for distinct events were also recorded.

The mass distribution of particles is reported as a concentration in micrograms of particulate per cubic meter of air ($\mu g/m^3$). Particles are sized based upon the amount of light scattered by individual particles. The monitor operates at a flow rate of 1.2 Lpm. Estimates were made of the mass median aerodynamic diameter (MMAD) and the associated geometric standard deviation (GSD) based on the integrated particle size discrimination provided by the instrument. The MMAD is the mid–point of the aerodynamic size distribution where half the particles are larger and half are smaller. A density correction factor for the PDM was not applied during data analysis.

## Volatile Organic Compounds (VOCs)

Since many workers in the assembly area expressed concerns about the paint smells from an adjacent paint booth, NIOSH investigators collected several solvent samples in the area. Ten PBZ samples were collected on charcoal tubes at a flow rate of 100 cubic centimeters per minute. After consulting with a NIOSH chemist and reviewing the Material Safety Data Sheets (MSDSs) for the paints used in the area, investigators decided to analyze the tubes for n-butyl acetate, methyl isobutyl ketone (MIBK), xylenes, and total hydrocarbons (as Stoddard Solvent) using a combination of NMAMs 1501, 1300, 1450, and 1550.[4] After 30 minutes of desorption in 1.0 ml of carbon disulfide, the samples were analyzed by a Hewlett-Packard Model 5890A gas chromatograph equipped with a flame ionization detector and a 30 meter by 0.32 mm fused silica capillary column coated internally

with 1.0 µm of DB-5ms. The oven conditions were 40°C for 7 minutes, up to 60°C for 12 minutes at a rate of 5°C per minute, then up to 240°C for 4 minutes at a rate of 15°C per minute. The total hydrocarbon measurement was quantitated against an in-house Stoddard Solvent (AccuStandard, Inc. catalog #HS-005N).

# 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, which potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[5] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[6] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[7] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

## Metal–Working Fluids

NIOSH recommends that occupational exposures to MWF aerosols be limited to 0.4 milligrams per cubic meter ($mg/m^3$) of thoracic particulate mass as a TWA concentration for up to 10 hours (hrs) per day during a 40-hr work week, measured according to NIOSH Method 0500; the 0.4 $mg/m^3$ concentration thoracic particulate mass corresponds to approximately 0.5 $mg/m^3$ total particulate mass.[8] This REL is intended to reduce the respiratory disorders associated with MWF exposures in the workplace. However, concentrations of MWF aerosols should be kept below the REL where possible because some workers have developed work-related asthma, hypersensitivity pneumonitis (HP), or other adverse respiratory effects when exposed to

MWF at lower concentrations.[8] In addition, limiting dermal (skin) exposures is critical to preventing allergic and irritant skin disorders related to MWF exposure. In most metalworking operations, it is technologically feasible to limit MWF aerosol exposures to 0.4 mg/m$^3$, thoracic fraction, or less. Appendix B presents more detailed information about the NIOSH REL for MWFs.

## Microorganisms in MWF

Historically, microbial contamination of MWF has been a problem primarily because of the microbial growth effects on fluid quality and performance. Fluid degradation from microorganisms may result in changes in fluid viscosity, and the acid products of fermentation may lower the pH of the fluids, causing corrosion of machined parts. Anaerobic bacteria, specifically the sulfate reducers, may produce hydrogen sulfide and other toxic gases. Excessive microbial growth may result in clogged filters and ports and may interfere with the machining operations. Currently, there is evidence that allergic or hypersensitivity reactions are associated with microbially contaminated MWF, even with relatively low air concentration of allergens.

Water-based MWFs are excellent nutritional sources for many kinds of bacteria and fungi. The predominant species routinely recovered from MWFs are virtually identical to those routinely recovered from natural water systems. Many species that grow in MWFs secrete waste products that serve as a nutritional substrate for organisms that have more restrictive nutritional needs. Although some pathogenic organisms have been identified in oil emulsion MWFs in the past,[9,10] most pathogens do not persist well in MWFs.[11,12,13,14] Some researchers have suggested that well-maintained MWFs should have bacterial concentrations below $10^6$ colony forming units per milliliter (CFU/ml) of fluid.[15] There are insufficient data to determine acceptable levels of microbial contamination in the air. Bacterial endotoxin is a heat-stable, lipopolysaccharide compound from the outer cell wall of Gram–negative bacteria, which typically occur abundantly in MWFs. Exposure to airborne endotoxin can cause adverse respiratory effects. Occupational exposure limits for endotoxin have not been established by either NIOSH, OSHA, or the ACGIH. Although in some individual workplaces the air concentration of endotoxin has been reported to be correlated with the amount of endotoxin detected in the MWF,[16,17] in general, potential inhalation exposure to endotoxin may be difficult to determine based on bulk sampling results.[16] Bulk sample concentrations of endotoxin are primarily useful as another indicator (along with other measures, such as culturable bacteria levels) of whether adequate maintenance procedures are in place for the MWF system.

## Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) describe a large class of chemicals which are organic (i.e., containing carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. Many of the solvents in paints are VOCs, including xylene, MIBK and n-butyl acetate. Exposure to organic solvents can occur through inhalation of the vapors, skin contact with the liquid, or ingestion. As many organic solvents have relatively high vapor pressures and readily evaporate, inhalation of vapors is considered a primary route of exposure. Overexposure to many organic solvents can result in eye, nose, and throat irritation, central nervous system depression, headache, nausea, and possible effects on the liver, kidney, or other organs.[18,19,20] Many industrial solvents are primary irritants, and can cause defatting of the skin and dermatitis. Solvents are among the leading causes of occupational skin disease.[19] Biological effects of exposure can range from practically non-toxic

(e.g., some Freons™) to highly toxic (e.g., carbon tetrachloride) or carcinogenic (e.g., benzene).[20] The ability to detect the presence of a solvent by the sense of smell will vary widely depending on the specific substance, and individual olfactory acuity. Substances are considered to have good warning properties if an average person with normal sensory perception can detect the presence of the chemical at a level below the recommended exposure limit. Table 1 summarizes the standards, odor thresholds, and principle health effects associated with the primary solvents in the paints
used next to the machining area at Campbell Hausfeld.

# RESULTS

## Medical Evaluation

The average tenure of the interviewed workers was 13 years, ranging from 1 to 32 years. Five had a skin rash at the time of the interviews; seven did not. Of the five with current rashes, two were assemblers, two were machinists, and one was an office worker. Two had a rash on their hands that appeared to be dyshydrotic eczema. Dyshydrotic eczema is not directly related to workplace exposures; however, it may be aggravated by the hands being moist and sweaty at work. Two of the five had a rash on the forearms consistent with dermatitis. Both were assemblers. It could not be determined if their dermatitis was work-related; however, the material safety data sheets for the detergent used to wash the parts prior to their transfer to the assembly area states it can cause skin irritation. There appeared to be residue from the detergent and rust inhibitor remaining on the parts, which are then handled by the assembly workers. One of the five had folliculitis that occurred on areas of skin not in contact with MWF, as well as on areas that may have contact with MWF, which may have aggravated the condition. These five employees were sent letters stating what type of skin rash they appeared to have and recommending that they bring the letter to their personal physician.

Review of the OSHA 200 logs revealed 15 separate cases of dermatitis since 1995; 9 in machinists, 2 in product services, and 4 in assemblers.

## Industrial Hygiene Evaluation

### *August 2000 Site Visit*

On the day of the first site visit, the dual stage area was not operating because of a broken machine. Eleven bulk fluid samples were collected, four unused MWFs, five used MWFs, one washer soap fluid, and one washer rust inhibitor fluid. All 11 samples were analyzed for bacterial and fungal contamination, and all but the 4 unused fluid samples were analyzed for endotoxins. The endotoxin concentrations are in Table 2, and they can be used to qualitatively assess the amount of viable and non-viable gram-negative bacteria present in the sample. Table 3 presents the total bacteria counts and the three most prevalent bacteria species identified in each sample. The results are typical of species and concentrations identified by NIOSH in machine shops. Most of the species identified in these samples are found on or in humans or naturally in the environment (soil, water, air). Neither fungi nor mycobacteria were detected in the fluid samples.

During the first site visit, seven GA air samples were collected throughout the single-stage machining area, and the results are shown in Table

4. The total particulate results ranged from 0.06 $mg/m^3$ to 0.30 $mg/m^3$ as a TWA over the approximately two-hour sampling time. Since some of the manufacturing processes were not running on the day of the site visit and some of the airborne particulate concentrations were more than half of the NIOSH REL, we decided to conduct further air sampling. This second round of sampling was planned during the winter when the overhead doors would be closed, which provided a worst-case scenario in terms of dilution ventilation.

## *January 2001 Site Visit - Particulate Sampling*

NIOSH investigators returned to the plant on January 8, 2001, and collected five consecutive days of PBZ and GA side-by-side air samples throughout the machining and assembly area (121 PBZ samples and 27 GA samples). The purpose of the side-by-side air sampling was to provide results for both types of sampling referenced in the NIOSH Criteria Document on MWFs, total particulate and thoracic particulate. The NIOSH REL is primarily for thoracic particulate with a conversion factor to allow for total particulate sampling, while the proposed OSHA MWF standard of 0.5 $mg/m^3$ is for total particulate. The filters were then extracted using a 1:1:1 blend of dichloromethane, methanol, and toluene and reweighed to calculate the extractable MWF weight. Although this measurement does not correspond to any exposure standards, it does help to determine how much of the total weight can be attributed to MWFs. In cases where the extractable concentration is much lower than the total concentration, we must consider that other particulate, such as metal fines or nuisance dust, might be the major contributor to particulate exposure. This is obviously the case with the samples collected at the rotamills. If the exposure is to particulates not otherwise regulated (such as dust), the relevant exposure criteria would be the OSHA PEL of 15 $mg/m^3$ for total particulate or 5 $mg/m^3$ for respirable particulate (NIOSH does not have an REL for nuisance dust). None of the total particulate results approached these criteria. Depending on the machine, the dust exposure might contain either iron or aluminum particulate, but the criteria for these exposures are not approached either. The NIOSH REL for iron is 5 $mg/m^3$; the REL for aluminum is also 5 $mg/m^3$.

Table 5 describes each machine or job, degree of enclosure, and MWF used where we sampled, and Tables 6 through 10 present the results for each day of sampling. As was presented in the interim letters dated March 26, 2001, and April 2, 2001, more than half of the samples were at or above the NIOSH REL. Table 11 presents the same data in a format that permits comparison by location and date. It also provides a GM (a way to present an average for sampling data like this) for samples collected in the same location on different days. The total particulate GMs ranged from 0.17 $mg/m^3$ to 1.76 $mg/m^3$ (GM of 0.51 $mg/m^3$); the total extractable particulate GMs ranged from 0.11 $mg/m^3$ to 0.99 $mg/m^3$ (GM of 0.30 $mg/m^3$); the thoracic particulate GMs ranged from 0.11 $mg/m^3$ to 0.78 $mg/m^3$ (GM of 0.31 $mg/m^3$); and the thoracic extractable particulate GMs ranged from 0.03 $mg/m^3$ to 0.67 $mg/m^3$ (GM of 0.21 $mg/m^3$).

## *January 2001 Site Visit - Real-time Particulate Sampling*

PDM measurements were collected during machining activities at Campbell Hausfeld on January 12, 2001. Measurements were collected at machines 6125, 6116, 6112, 1164, 6349, 6166, on the table near 2522/2523, and near the worker involved with activities at 2522 and/or 2523 during the workday. At each station, the PDM collected mass and particle count information. Table 12 presents the MMAD, GSD and % respirable

fraction from the PDM mass measurements. Table 13 presents the particle count information. Figures 1 to 15 present the particulate concentration from the mass distribution of particles and the particle count concentration for each machine.

### *January 2001 Site Visit - VOC Sampling*

Ten PBZ samples were collected on January 11-12, 2001 (Table 14), and after consulting with a NIOSH chemist and reviewing the MSDS the samples were analyzed for n-butyl acetate, MIBK, xylenes, and total hydrocarbons based on Stoddard Solvent. All the concentrations were several orders of magnitude below applicable criteria, except for MIBK. However, all the MIBK samples were less than half of the NIOSH REL except for the samples collected on painter in the large paint booth. Fortunately, this employee wears a half-face organic vapor cartridge respirator that has an assigned protection factor of 10, so the exposure limit for that employee would be ten times the REL, or 10 ppm for MIBK.

## DISCUSSION AND OBSERVATIONS

P Several employees have reported rashes since 1995, with machinists most often affected. Based on the rashes observed on the day of the site visit, the type and etiology of the eruptions may vary. MWFs are known to cause irritant contact dermatitis and may cause allergic contact dermatitis. The fluids may exacerbate a non-work-related skin problem, such as eczema. While it is unlikely that there is one single cause of the various rashes experienced by employees, work-related exacerbations of skin problems can be minimized by limiting skin contact with MWFs, washer detergents, and rust inhibitors. Workers who continue to have skin problems should be evaluated by an occupational dermatologist.

P Many of the total particulate (56%) and thoracic particulate (34%) concentrations are at or above the NIOSH REL.

P The real–time monitoring with the PDM assisted in characterizing the generated particulate size of some machines at Campbell Hausfeld. The MMAD values ranged from 2.6 µm to 4.3 µm with GSDs between 2.5 and 3.4, and the percent respirable mass measurements ranged from 36% to 59%. This indicates that a relatively large portion of the material is in the respirable range. Normal body clearance mechanisms for particles (sneezing, nose hair, mucous) efficiently handle particle sizes >10 µm. All machines had MMAD values <10 µm and all but one machine had percent respirable fractions at 50% or above, which suggests that a large portion of the particles generated during machine operations have the potential to be inhaled into the lower reaches of the lung. However, in addition to the particle size, there are other important factors in determining potential health effects. These factors include, but are not limited to: the type of particulate, the time period of exposure (hours, days, years), and the particulate concentration.

P Most machines in the single- and dual-stage machining areas are not outfitted with mist collectors, but some machines are outfitted with plastic curtains near the point of operation. This can be a good means for containing aerosol mists. A mist collection system that services two grinding machines in the single stage area was recently installed, and the company had plans to install additional mist collectors.

P The production area has about eight Smoke Hogs™ (electrostatic precipitators) for the removal of airborne mists and dusts. Electrostatic precipitators are known to generate ozone, which causes reversible decrements in lung function.

P While most employees were observed wearing protective gloves, a few employees were not using them, including one worker who was

handling MWF concentrate with bare hands. Another worker was observed operating a machine without an apron and had saturated the abdominal area of the work shirt.

P There are no standards or guidelines for bacterial or endotoxin concentrations in MWFs, but the microbial sampling results were similar to other NIOSH results in machine shops.

P The VOC concentrations in the painting and assembling area are relatively low, except possibly for MIBK in the paint booth. However, even at low concentrations, solvents can have irritative effects. Note that many of the sampling results are greater than the odor thresholds, and individuals have varying degrees of ability to detect odors. Individuals also have varying degrees of responses, such as eye/nose/throat irritation or headache, to low level solvent exposures.

# CONCLUSIONS

It is unlikely that there is one single cause of the various rashes experienced by employees, but MWFs and their additives are dermal irritants. Work-related exacerbations of skin problems can be minimized by limiting skin contact with the MWFs, washer detergents, and rust inhibitors. Workers who continue to have skin problems should be evaluated by an occupational dermatologist.

**NIOSH investigators conclude that a health hazard exists in the machining area of Campbell Hausfeld. Based on the sampling results, many Campbell Hausfeld employees are overexposed to MWFs (at least during the heating season) and corrective action is necessary.** Considering the age and type of machine, the present degree of enclosure, and the sampling results, Campbell Hausfeld management should decide the best type of engineering control for each machine or area. To aid in prioritizing on which machines to focus first, Table 15 presents a list of machines where high exposures were measured, separated into four categories of decreasing severity.

The calculated MMADs for all the machine areas monitored were smaller than 10 µm, and the percent respirable fraction calculated from the PDM measurements was greater than or equal to 50% in all but one of the machine areas monitored. This data suggests that a large percentage of these MWF exposures are inhaled into the lung.

# RECOMMENDATIONS

Several recommendations are offered to improve worker health and safety in the machining environment.

1. In many areas, MWF exposures exceed the NIOSH REL. To reduce exposures, Campbell Hausfeld should install engineering controls to the machines highlighted in this report– enclosures to machines that have none and local exhaust ventilation to machines that are already enclosed. Until exposures can be reduced, employees that work at machines where high exposures were measured should be equipped with appropriate respiratory protection, any air-purifying, half-mask respirator, including a disposable respirator, equipped with any P- or R- series particulate filter number (P95, P99, P100, R95, R99, or R100).[8] All employees using respirators should be part of the comprehensive respiratory protection program required by OSHA (29 CFR 1910.134) and outlined in the *NIOSH Respirator Decision Logic*.[21]

2. Dermal contact with MWFs and washer fluids should be reduced as much as possible by the use of appropriate PPE and modification of work practices. The employer should provide, and many machinists should be required to wear,

rubber gloves, tear-away sleeves, and a rubber–front apron. Nitrile rubber is a good selection for gloves and aprons because it is flexible and resistant to chemicals, abrasions, tears, and punctures. Wearing a clean cotton inner glove can help wick away moisture from the hands, but MWF-saturated cotton can increase exposures so they must be kept free of MWFs. Employees should be trained to use work techniques that minimize the amount of MWF that drips, spills, or sprays onto them.

3. The recommendations made by the consulting dermatologist should continue to be followed.

4. Eating, drinking, and smoking should never be allowed on the production lines. Workers should be encouraged to wash their hands before engaging in these activities.

5. Workers should be educated about the importance of not contaminating MWF with cigarettes, saliva, or other inappropriate materials. When cleaning the floor and machines at the end of the shift, workers should ensure that floor debris, floor cleaners, machine cleaners, etc., are not washed into the MWF.

6. Irritants and allergens that have come in contact with exposed skin should be washed off with soap and water as soon as possible. Residual soap should be washed off the skin surface. Moisturizing creams are useful in preventing skin damage from the defatting and drying effect of soaps and skin cleansers.

7. A comprehensive MWF safety and health program should be developed and implemented as part of the employer's management system. The major elements of a comprehensive, effective safety and health program are (1) safety and health training, (2) worksite analysis and exposure assessment, (3) hazard prevention and control, and (4) medical monitoring of exposed workers. Details of a medical monitoring program are included in Appendix C.

8. Increased dilution ventilation, such as adding more general building exhaust that operates year round, could help to reduce some of the particulate exposures and alleviate the irritant effects from the paint solvents.

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**Table 1**
**Evaluation Criteria for Solvents**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**August 31, 2000**

| Chemical | OSHA PEL* | NIOSH REL** | Odor Threshold & Description † | Principle Health Effects ‡ |
|---|---|---|---|---|
| n-butyl acetate | 150 ppm TWA | 150 ppm TWA 200 ppm STEL | 7 ppm fruity | eye/skin/respiratory irritation, headache, drowsiness, narcosis |

| | | | | |
|---|---|---|---|---|
| methyl isobutyl ketone (MIBK) | 100 ppm TWA | 1 ppm TWA | 0.1 ppm sweet, sharp | eye/nose irritation, peripheral neuropathy, weakness, headache, drowsiness, dermal effects |
| xylene | 100 ppm TWA | 100 ppm TWA 150 ppm STEL | 0.08 ppm sweet | eye/respiratory irritation, narcosis, headache, dermal effects |
| total hydrocarbons (as Stoddard Solvent) | 2900 $mg/m^3$ TWA | 350 $mg/m^3$ TWA | 5.25 $mg/m^3$ kerosene-like | eye/nose/throat irritation, dizziness, dermal effects |

* PEL = Permissible Exposure Limit
** REL = Recommended Expousre Limit

TWA - time-weighted average concentration for up to 8 (OSHA) or 10 (NIOSH) hours/day
STEL - short-term exposure limit - 15 minute average
ppm - parts per million
$mg/m^3$ - milligrams per cubic meter

† Ruth JH [1986]. Odor Thresholds and Irritation Levels or Several Chemical Substances: A Review. American Industrial Hygiene Association Journal. 47, A142-A151.

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**Table 2**
**Bulk Fluid Endotoxin Sampling Results**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**August 31, 2000**

| Sample | Machine | Endotoxin Concentration (EU/mL*) |
|---|---|---|
| Soap solution | Main parts washer | 23,828.13 |
| Rust inhibitor solution | Main parts washer | 7.38 |
| Trim HD | Holding tank (before recycling) | 8750.00 |
| Trim HD | Cinturn 12CU (#1163) | 35,234.38 |
| Trim Sol | Excello (#6285) | 9453.13 |
| Cimstar 540 | Edlund (#2593) | 9843.75 |
| Trim C-115 | Kingsbury | 2.15 |

*EU/mL - endotoxin units per milliliter

**Table 3**
**Bulk Fluid Microbial Sampling Results.**
**Location: Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**Sampling Conducted on August 31**

| Sample | Machine | Total Bacteria (CFU/mL*) | Top Three Bacteria Species (CFU/mL*) |
|---|---|---|---|
| Trim HD | unused | $1.1x10^2$ | $1.1x10^2$ *Propionibacterium porpionicum* |
| Trim Sol | unused | $3.3x10^2$ | $3.0x10^2$ *Pseudomonas pseudoalcaligenes*<br>$2.7x10^1$ *Pseudomonas alcaligenes/pseudoalcaligenes* group |
| Cimstar 540 | unused | no growth | no growth |
| Trim C-115 | unused | no growth | no growth |
| Soap solution | Main parts washer | $3.5x10^4$ | $1.4x10^4$ *Micrococcus luteus*<br>$9.0x10^3$ gram-positive coccobacilli, resembling *Entercoccus avium*, morphotype 1<br>$7.0x10^3$ gram-positive coccobacilli, resembling *Entercoccus avium*, morphotype 2 |
| Rust inhibitor solution | Main parts washer | $2.7x10^3$ | $2.0x10^3$ *Brevibacillus brevis*, morphotype 1<br>$3.0x10^2$ *Bacillus polymyza*<br>$3.0x10^2$ *Brevibacillus brevis*, morphotype 2 |
| Trim HD | Holding tank (before recycling) | $2.8x10^4$ | $1.6x10^4$ gram-negative rod, resembling *Citrobacter freundii*, morphtype 1<br>$1.1x10^4$ gram-negative rod, resembling *Citrobacter freundii*, morphtype 2<br>$9.0x10^2$ gram-negative rod, resembling *Citrobacter freundii*, morphtype 3 |
| Trim HD | Cinturn 12CU (#1163) | $3.0x10^6$ | $2.5x10^6$ *Pseudomonas pseudoalcaligenes*<br>$2.7x10^5$ *Citrobacter freundii*<br>$1.7x10^5$ *Citrobacter braakii* |
| Trim Sol | Excello (#6285) | $3.8x10^4$ | $2.4x10^4$ *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 1<br>$1.4x10^4$ *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 2<br>$9.0x10^2$ *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 3 |
| Cimstar 540 | Edlund (#2593) | $1.5x10^4$ | $1.1x10^4$ gram-negative rod, resembling *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 1<br>$2.7x10^3$ gram-negative rod, resembling *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 2<br>$1.2x10^3$ gram-negative rod, resembling *Pseudomonas alcaligenes/pseudoalcaligenes* group, morphotype 3 |
| Trim C-115 | Kingsbury | no growth | no growth |

*CFU/mL - colony forming units per milliliter

**Table 4**
**General Area Air Sampling Results for Total Particulate Concentrations**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**August 31, 2000**

| Machine (#) | Operation | MWF | Degree of Enclosure | Total Particulate ($mg/m^3$) |
|---|---|---|---|---|
| Edlund (2593) | drilling | Cimstar 540 | <25% | 0.23 |
| K&T (6112) | boring, drilling | Trim HD | >75% | 0.13 |
| T-10 (1164) | milling, drilling, boring | Trim HD | >75% | 0.06 |
| Mazak (6158) | boring, drilling | Trim HD | <25% | 0.30 |
| Cinturn 12CU (1163) | lathing | Trim HD | >75% | 0.21 |
| Cincy Grinders (2580, 2581) | grinding | Cimstar 540 | <25% | 0.28 |
| Cinturn 8C CNC (6125) | lathing | Trim HD | >75% | 0.10 |
| NIOSH Recommended Exposure Limit | | | | 0.5 |

MWF = metal working fluid  $mg/m^3$ = milligrams per cubic meter

**Table 5**
**Machines where PBZ or GA Air Samples were Collected**
**HETA 2000-0356-2851, Campbell Hausfeld, January 8-12, 2001**

| Machine ID | Job | Degree of Enclosure | MWF Used |
|---|---|---|---|
| n/a | Start-up | not applicable | all |
| 1003 & 1004 | lathes | dry, so not important | dry |
| 1007 & 1008 | journal lathes | dry, so not important | dry |
| 1024 & 1028 | grinder | <25% | Cimstar 40 |
| 1026 & 1025 | throw grinder | 25-75% | C-115 |
| 1027 | centerless grinder | <25% | C-115 |
| 1045 | boring | >75% | C-115 |
| 1119 | slab mill & centerless | >75% | TrimSol |
| 1121 | piston bore | <25% | TrimSol |
| 1132 | rotomill* | dry, so not important | dry |
| 1156 | Burgmaster drill & tap | <25% | C-115 |
| 2522, 2523 | grinders | <25% | Cimstar 40 |
| 2528 | Warner &Swaysey | >75% | C-115 |
| 2580 &2581 | grinders | <25% | Cimstar 40 |
| 2593 | tap and drill | <25% | Cimstar 40 |
| 6112 (K&T1) | machine center | >75% | Trim HD |
| 6166 | rod bore | >75% | TrimSol |
| 6184 | five spindle (chucker) | >75% | C-115 |
| 6185 | five spindle | >75% | TrimSol |
| 6259 | six spindle | >75% | C-115 |
| 6292 | mill | >75% | TrimSol |
| 6295 | multidrill | dry, so not important | dry |
| 6296 | rotomill* | <25% | C-115 |
| 6329 | Kingsbury | >75% | C-115 |
| 6335 | boring mill robot | 25-75% | C-115 |
| 6349 | five spindle | >75% | TrimSol |
| n/a | Coolant Tech | not applicable | all |
| 1001 | lathe | >75% | C-115 |
| 1012, 1013 | journal lathes | >75% | straight oil |
| 1029 | grinder | <25% | C-115 |
| 1043 & 1037 | bore & drill | 25-75% | C-115 |
| 1043 | boring mill | <25% | C-115 |

**Table 5**
**Machines where PBZ or GA Air Samples were Collected**
**HETA 2000-0356-2851, Campbell Hausfeld, January 8-12, 2001**

| Machine ID | Job | Degree of Enclosure | MWF Used |
|---|---|---|---|
| 1110, 1108 | honing | <25% | straight oil |
| 1126 | drill | 25-75% | C-115 |
| 1163 lathe, 6127 mill | lathe & mill | >75% | C-115 |
| 1164, 8029 | drill center | 25-75% | C-115 |
| 2506 Excello | boring | <25% | TrimSol |
| 2536, 2537 | honing | <25% | straight oil |
| 2554 | key seater | dry, so not important | dry |
| 2555 | balancer | dry, so not important | dry |
| 2558 | mill | dry, so not important | dry |
| 2583 | honing | <25% | straight oil |
| 6116/6115 G&D | machine center | >75% | C-115 |
| 6115 (K&T5) | machine center | >75% | Trim HD |
| 6120 (K&T5) | machine center | >75% | TrimSol |
| 6125 | lathe | >75% | C-115 |
| 6141 | drill & tap | <25% | C-115 |
| 6158 | Mazak drill | >75% | C-115 |
| 6206 | plunge grinder | <25% | Cimstar 40 |
| 6285 | boring | <25% | TrimSol |
| 6293 | centerless grinder | >75% | C-115 |

**Table 6**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/8/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless designated "GA") | Sample Volume (L) | Total or Thoracic Conc.* ($mg/m^3$) | Total or Thoracic 8-hr TWA* ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-10 | 1024 & 1028 | 825.5 | 1.04 | **0.89** | 0.75 | 0.64 | 72.1 |
| B-10 | | 658.2 | 0.62 | **0.53** | 0.50 | 0.43 | 80.5 |
| A-3 | 2580 & 2581 | 801.2 | 1.02 | **0.86** | 0.66 | 0.55 | 64.6 |
| B-3 | | 651.4 | 0.75 | **0.64** | 0.58 | 0.49 | 77.6 |
| A-28 | K&T 1 (6112) | 789.2 | 0.52 | 0.43 | 0.19 | 0.16 | 36.6 |
| B-28 | | 630.6 | 0.33 | 0.27 | 0.22 | 0.18 | 66.7 |
| A-8 | 6116 G&D, | 781.4 | 0.38 | 0.31 | 0.27 | 0.22 | 70.0 |
| B-8 | 6120 K&T5 | 626.5 | 0.24 | 0.19 | 0.15 | 0.12 | 64.0 |
| A-15 | 1110, 1108 | 763.6 | 0.30 | 0.24 | 0.22 | 0.18 | 73.9 |
| B-15 | | 607.4 | 0.20 | 0.16 | trace | na | na |
| A-18 | 1012, 1013 | 760.5 | 0.46 | 0.36 | 0.25 | 0.20 | 54.3 |
| B-18 | | 603.4 | 0.25 | 0.20 | trace | na | na |
| A-7 | beginning of assembly | 751.9 | 0.28 | 0.22 | 0.21 | 0.17 | 76.2 |
| B-7 | | 600.5 | 0.22 | 0.17 | trace | na | na |
| A-11 | piston table | 756.0 | 0.30 | 0.24 | 0.21 | 0.17 | 69.6 |
| B-11 | | 599.5 | 0.22 | 0.17 | trace | na | na |
| A-12 | coolant Tech | 765.6 | 0.37 | 0.29 | 0.18 | 0.15 | 50.0 |
| B-12 | | 608.1 | 0.20 | 0.16 | trace | na | na |
| A-20 | 2593 Edlund | 751.2 | 0.41 | 0.32 | 0.20 | 0.16 | 48.4 |
| B-20 | | 601.0 | 0.18 | 0.14 | trace | na | na |
| A-1 | 1163 lathe, 6127 mill | 853.8 | 0.21 | 0.19 | 0.12 | 0.10 | 55.6 |
| B-1 | | 679.1 | 0.11 | 0.10 | 0.07 | 0.06 | 59.7 |
| A-2 | 6158 | 846.1 | 0.35 | 0.31 | 0.19 | 0.17 | 53.3 |
| B-2 | | 677.3 | 0.19 | 0.17 | 0.10 | 0.09 | 51.5 |
| A-6 | 1164, 8029 | 839.8 | 0.45 | 0.39 | 0.32 | 0.28 | 71.1 |
| B-6 | | 666.9 | 0.33 | 0.29 | 0.25 | 0.22 | 77.3 |
| A-22 | 2536, 2537 | 835.5 | 0.48 | 0.42 | 0.35 | 0.30 | 72.5 |
| B-22 | | 667.2 | 0.34 | 0.30 | 0.22 | 0.20 | 65.2 |
| A-14 | 2522, 25231 | 835.2 | 1.14 | **0.98** | 0.89 | 0.77 | 77.9 |
| B-14 | | 657.6 | 0.88 | **0.76** | 0.76 | 0.66 | 86.2 |
| A-24 | 1027 | 755.7 | 0.67 | **0.53** | 0.37 | 0.29 | 54.9 |
| B-24 | | 600.0 | 0.43 | 0.34 | 0.30 | 0.24 | 69.2 |
| A-19 | 6293 | 260.1 | 0.81 | 0.22 | 0.58 | 0.16 | 71.4 |
| B-19 | | 210.2 | 0.57 | 0.15 | 0.48 | 0.13 | 83.3 |
| A-27 | 1132 | 841.8 | 1.43 | **1.25** | 0.33 | 0.29 | 23.3 |
| B-27 | | 662.5 | 0.36 | 0.32 | 0.17 | 0.14 | 45.8 |
| A-23 | 6329 | 830.8 | 0.73 | 0.63 | 0.51 | 0.44 | 68.9 |

**Table 6**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/8/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless designated "GA") | Sample Volume (L) | Total or Thoracic Conc.* ($mg/m^3$) | Total or Thoracic 8-hr TWA* ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| B-23 | | 661.5 | 0.47 | 0.41 | 0.36 | 0.31 | 77.4 |
| A-17 | Arrow 500, 6292 | 798.2 | 0.75 | **0.63** | 0.55 | 0.46 | 73.3 |
| B-17 | | 638.0 | 0.52 | **0.43** | 0.42 | 0.35 | 81.8 |
| A-21 | 6166 | 793.8 | 1.51 | **1.25** | 1.39 | 1.14 | 91.7 |
| B-21 | | 626.3 | 0.83 | **0.69** | 0.72 | 0.59 | 86.5 |
| A-16 | 1119 | 780.5 | 0.88 | **0.72** | 0.47 | 0.39 | 53.6 |
| B-16 | | 625.9 | 0.50 | **0.41** | 0.35 | 0.29 | 71.0 |
| A-25 | 6349 | 774.3 | 1.16 | **0.94** | 1.01 | 0.81 | 86.7 |
| B-25 | | 621.4 | 0.55 | **0.44** | 0.43 | 0.35 | 79.4 |
| A-4 | 1043 | 806.0 | 0.58 | 0.49 | 0.19 | 0.16 | 31.9 |
| B-4 | | 645.4 | 0.22 | 0.18 | 0.13 | 0.11 | 62.1 |
| A-13 | 6335 | 797.2 | 1.76 | **1.46** | 0.33 | 0.27 | 18.6 |
| B-13 | | 641.0 | 0.36 | 0.30 | 0.13 | 0.11 | 35.2 |
| A-9 | 6185 | 955.9 | 0.53 | **0.53** | 0.32 | 0.32 | 60.8 |
| B-9 | | 757.0 | 0.32 | 0.32 | 0.22 | 0.22 | 70.8 |
| A-30 | floating (near 6335) | 811.1 | 0.43 | 0.37 | 0.22 | 0.19 | 51.4 |
| B-30 | | 651.0 | 0.23 | 0.20 | 0.14 | 0.11 | 58.7 |
| A-29 | GA near 6295 & 1045 | 747.9 | 0.57 | 0.45 | 0.25 | 0.20 | 44.2 |
| B-29 | | 600.2 | 0.28 | 0.22 | 0.17 | 0.13 | 58.8 |
| A-5 | GA at 6285 | 793.8 | 0.25 | 0.21 | 0.18 | 0.15 | 70.0 |
| B-5 | | 635.6 | 0.19 | 0.16 | trace | na | na |

* The total mass samples are labelled A, and the thoracic mass samples are labelled B.
Each numbered A-B set was collected side-by-side at the same location.

** The bolded numbers are above the NIOSH REL of 0.5 $mg/m^3$ total mass, or 0.4 $mg/m^3$ thoracic mass.

L = liters
mg/m3 = milligrams per cubic meter
8-hr TWA = 8-hour time-weighted average
PBZ = personal breathing zone (air sample)
GA = general area (air sample)
trace = detectable quantities below the minimun quantifiable concentration
na = not applicable

**Table 7**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/9/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample† | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-59 | 1126 | 518.3 | 0.41 | 0.22 | 0.27 | 0.15 | 66.7 |
| B-59 | | 410.5 | 0.27 | 0.14 | 0.20 | 0.11 | 73.6 |
| A-50 | 6292 | 912.9 | 0.69 | **0.66** | 0.51 | 0.49 | 74.6 |
| B-50 | | 712.6 | 0.48 | **0.46** | 0.41 | 0.39 | 85.3 |
| A-38 | 1045, 1132 | 8916.0 | 0.07 | **0.64** | 0.03 | 0.28 | 44.3 |
| B-38 | | 732.3 | 0.26 | 0.25 | 0.16 | 0.16 | 63.2 |
| A-55 | 1026 & 1025 | 897.6 | 0.51 | 0.48 | 0.32 | 0.31 | 63.0 |
| B-55 | | 726.6 | 0.36 | 0.34 | 0.28 | 0.26 | 76.9 |
| A-37 | 1121, 1119 | 916.0 | 0.98 | **0.94** | 0.91 | 0.86 | 92.2 |
| B-37 | | 720.0 | 0.60 | **0.57** | 0.50 | 0.48 | 83.7 |
| A-64 | 1001 | 704.2 | 0.54 | 0.40 | 0.33 | 0.24 | 60.5 |
| B-64 | | 551.9 | 0.36 | 0.27 | 0.27 | 0.20 | 75.0 |
| A-60 | 6295 | 730.5 | 2.60 | **1.98** | 0.47 | 0.35 | 17.9 |
| B-60 | | 581.1 | 0.50 | 0.38 | 0.19 | 0.14 | 37.9 |
| A-46 | 1007 | 841.8 | 0.50 | 0.44 | 0.26 | 0.23 | 52.4 |
| B-46 | | 676.4 | 0.25 | 0.22 | 0.16 | 0.14 | 64.7 |
| A-63 | 1027 | 888.8 | 0.82 | **0.77** | 0.50 | 0.46 | 60.3 |
| B-63 | | 702.0 | 0.56 | **0.52** | 0.48 | 0.45 | 87.2 |
| A-39 | 1003 & 1004 | 894.0 | 0.94 | **0.88** | 0.35 | 0.32 | 64.6 |
| B-39 | | 709.0 | 0.38 | 0.36 | 0.23 | 0.21 | 94.1 |
| A-47 | 1156 | 850.9 | 1.15 | **1.02** | 0.99 | 0.88 | 85.7 |
| B-47 | | 583.8 | 0.67 | **0.51** | 0.60 | 0.46 | 89.7 |
| A-52 | 6349 | 859.1 | 0.94 | **0.84** | 0.78 | 0.70 | 82.7 |
| B-52 | | 682.3 | 0.41 | 0.37 | 0.32 | 0.29 | 78.6 |
| A-65 | set-up | 806.0 | 0.68 | **0.58** | 0.50 | 0.42 | 72.7 |
| B-65 | | 654.2 | 0.47 | **0.41** | 0.38 | 0.33 | 80.6 |
| A-51 | G&D 6116, | 824.3 | 0.30 | 0.26 | 0.17 | 0.15 | 56.0 |
| B-51 | 6115 | 621.5 | 0.21 | 0.17 | 0.16 | 0.13 | 76.9 |
| A-57 | crankshaft | 875.8 | 0.26 | 0.24 | 0.19 | 0.18 | 73.9 |
| B-57 | assembly | 676.7 | 0.21 | 0.18 | 0.18 | 0.16 | 85.7 |
| A-48 | assembly behind | 778.2 | 0.24 | 0.20 | 0.17 | 0.14 | 68.4 |
| B-48 | 6285 | 657.4 | 0.17 | 0.14 | 0.14 | 0.12 | 80.9 |
| A-62 | 1163 | 898.8 | 0.18 | 0.17 | 0.13 | 0.13 | 75.0 |
| B-62 | | 753.8 | 0.11 | 0.11 | 0.09 | 0.09 | 78.3 |
| A-36 | K&T 6112 | 906.3 | 0.75 | **0.71** | 0.30 | 0.28 | 39.7 |
| B-36 | | 718.2 | 0.29 | 0.28 | 0.18 | 0.17 | 61.9 |
| A-42 | 2537 | 893.9 | 0.44 | 0.41 | 0.28 | 0.26 | 64.1 |
| B-42 | | 711.9 | 0.25 | 0.24 | 0.18 | 0.17 | 72.2 |

**Table 7**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/9/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample† | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-61 | T-10/1164 | 874.2 | 0.41 | 0.37 | 0.18 | 0.17 | 44.4 |
| B-61 | | 686.6 | 0.31 | 0.28 | 0.20 | 0.18 | 66.7 |
| A-54 | 6141 | 854.2 | 0.29 | 0.26 | 0.18 | 0.16 | 60.0 |
| B-54 | | 698.0 | 0.16 | 0.14 | 0.14 | 0.12 | 87.3 |
| A-71 | coolant Tech | 490.8 | 0.26 | 0.14 | 0.15 | 0.08 | 57.7 |
| B-71 | | 379.5 | 0.17 | 0.09 | 0.17 | 0.09 | 100.0 |
| A-49 | 6329 | 931.8 | 0.68 | **0.65** | 0.41 | 0.39 | 60.3 |
| A-49 | | 729.8 | 0.30 | 0.29 | 0.26 | 0.25 | 86.4 |
| A-44 | 2522 & 2523 | 929.3 | 1.18 | **1.15** | 0.91 | 0.89 | 77.3 |
| B-44 | & 6206 | 758.9 | 0.82 | **0.79** | 0.71 | 0.69 | 87.1 |
| A-43 | 1024, 1028 | 888.0 | 1.07 | **0.99** | 0.74 | 0.69 | 69.5 |
| B-43 | | 704.4 | 0.84 | **0.77** | 0.64 | 0.59 | 76.3 |
| A-53 | 2583 | 881.1 | 0.32 | 0.29 | 0.14 | 0.12 | 42.9 |
| B-53 | | 689.4 | 0.17 | 0.16 | 0.12 | 0.11 | 67.5 |
| A-56 | GA at 1006, | 902.9 | 0.53 | **0.50** | 0.20 | 0.19 | 37.5 |
| B-56 | 1010 | 720.0 | 0.24 | 0.22 | 0.14 | 0.13 | 58.8 |
| A-45 | GA at 6285 | 827.8 | 0.22 | 0.19 | 0.17 | 0.15 | 77.8 |
| B-45 | | 665.1 | 0.17 | 0.14 | 0.11 | 0.09 | 63.6 |
| A-40 | GA at end | 902.6 | 0.23 | 0.22 | 0.19 | 0.18 | 81.0 |
| B-40 | of washer | 724.1 | 0.21 | 0.20 | 0.15 | 0.14 | 73.3 |
| A-41 | GA at | 849.1 | 0.59 | **0.52** | 0.38 | 0.33 | 64.0 |
| B-41 | 2580/2581 | 671.4 | 0.37 | 0.33 | 0.22 | 0.20 | 60.0 |

* The total mass samples are labelled A, and the thoracic mass samples are labelled B.
Each numbered A-B set was collected side-by-side at the same location.

** The bolded numbers are above the NIOSH REL of 0.5 $mg/m^3$ total mass, or 0.4 $mg/m^3$ thoracic mass.

L = liters
mg/m3 = milligrams per cubic meter
8-hr TWA = 8-hour time-weighted average
PBZ = personal breathing zone (air sample)
GA = general area (air sample)
trace = detectable quantities below the minimun quantifiable concentration
na = not applicable

**Table 8**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/10/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample† | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-90 | 6185 | 876.5 | 0.62 | **0.57** | 0.40 | 0.37 | 64.8 |
| B-90 | | 699.2 | 0.40 | 0.37 | 0.33 | 0.30 | 82.1 |
| A-77 | 1028 | 770.6 | 0.74 | **0.80** | 0.60 | 0.48 | 80.7 |
| B-77 | | 702.7 | 0.33 | 0.30 | 0.24 | 0.22 | 739.0 |
| A-95 | coolant tech | 769.1 | 0.31 | 0.25 | 0.20 | 0.16 | 62.5 |
| B-95 | | 618.0 | 0.21 | 0.17 | trace | trace | trace |
| A-72 | 6166 | 843.8 | 0.87 | **0.77** | 0.72 | 0.64 | 83.6 |
| B-72 | | 674.3 | 0.55 | **0.49** | 0.47 | 0.42 | 86.5 |
| A-96 | 6349 | 853.0 | 0.86 | **0.76** | 0.70 | 0.63 | 82.2 |
| B-96 | | 671.1 | 0.45 | **0.40** | 0.36 | 0.32 | 80.0 |
| A-79 | 6292 | 905.1 | 0.83 | **0.80** | 0.56 | 0.54 | 68.0 |
| B-79 | | 733.7 | 0.55 | **0.52** | 0.45 | 0.43 | 82.5 |
| A-74 | 1027 | 917.4 | 0.78 | **0.76** | 0.49 | 0.48 | 62.5 |
| B-74 | | 730.3 | 0.60 | **0.58** | 0.48 | 0.46 | 79.5 |
| A-78 | GA near 1179 | 585.6 | 0.17 | 0.10 | trace | trace | trace |
| B-78 | | 762.2 | 0.12 | 0.13 | trace | trace | trace |
| A-75 | GA near 2582 | 901.0 | 0.22 | 0.21 | 0.12 | 0.12 | 55.0 |
| B-75 | | 720.0 | 0.15 | 0.14 | trace | trace | trace |
| A-83 | GA near 6167 | 905.9 | 0.21 | 0.20 | 0.19 | 0.18 | 89.50 |
| B-83 | | 718.4 | 0.19 | 0.18 | 0.15 | 0.15 | 78.6 |
| A-91 | 1132 | 931.6 | 1.04 | **1.02** | 0.34 | 0.33 | 33.0 |
| B-91 | | 744.1 | 0.32 | 0.31 | 0.22 | 0.21 | 66.7 |
| A-93 | 1026 | 945.7 | 0.51 | **0.50** | 0.32 | 0.31 | 62.5 |
| B-93 | | 724.6 | 0.39 | 0.38 | 0.30 | 0.30 | 78.6 |
| A-73 | 1029 | 322.3 | 0.47 | 0.16 | 0.34 | 0.11 | 73.3 |
| B-73 | | 256.6 | 0.28 | 0.09 | 0.23 | 0.08 | 84.5 |
| A-94 | 6184 | 964.6 | 1.00 | **1.00** | 0.79 | 0.79 | 79.2 |
| B-94 | | 767.4 | 0.66 | **0.67** | 0.59 | 0.59 | 88.2 |
| A-80 | GA at 1045 | 941.2 | 0.62 | **0.61** | 0.28 | 0.27 | 44.8 |
| B-80 | | 764.4 | 0.31 | 0.31 | 0.21 | 0.21 | 66.7 |
| A-84 | 1007 | 854.9 | 0.94 | **0.83** | 0.67 | 0.59 | 71.3 |
| B-84 | | 675.3 | 0.50 | **0.45** | 0.37 | 0.33 | 73.5 |
| A-86 | 1001 | 789.4 | 0.53 | 0.44 | 0.28 | 0.23 | 52.4 |
| B-86 | | 641.1 | 0.30 | 0.24 | 0.30 | 0.24 | 100.0 |
| A-92 | 2588, 2554, 2555 | 859.5 | 0.41 | 0.37 | 0.19 | 0.17 | 45.7 |
| B-92 | | 674.4 | 0.18 | 0.16 | 0.13 | 0.12 | 71.7 |
| A-82 | set-up | 809.0 | 0.72 | **0.60** | 0.56 | 0.47 | 77.6 |
| B-82 | | 661.0 | 0.53 | **0.46** | 0.45 | 0.39 | 85.7 |

**Table 8**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/10/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample† | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-76 | GA at 1126 | 803.0 | 0.39 | 0.32 | 0.27 | 0.23 | 71.0 |
| B-76 | | 636.9 | 0.28 | 0.24 | 0.20 | 0.17 | 72.2 |
| A-81 | assembly | 817.5 | 0.31 | 0.26 | 0.12 | 0.11 | 40.0 |
| B-81 | | 660.6 | 0.24 | 0.21 | 0.18 | 0.16 | 75.0 |
| A-89 | assembly | 840.9 | 0.31 | 0.26 | 0.17 | 0.14 | 53.8 |
| B-89 | | 648.4 | 0.25 | 0.21 | 0.15 | 0.13 | 62.5 |
| A-87 | GA near 1156 | 823.6 | 0.51 | 0.44 | 0.32 | 0.27 | 61.9 |
| B-87 | | 641.0 | 0.36 | 0.31 | 0.28 | 0.24 | 78.3 |
| A-102 | 2537 | 588.1 | 0.43 | 0.26 | 0.29 | 0.18 | 68.0 |
| B-102 | | 719.6 | 0.32 | 0.30 | 0.24 | 0.22 | 73.9 |
| A-101 | 2522, 2523, 6206 | 920.6 | 1.19 | **1.16** | 0.91 | 0.89 | 76.4 |
| A-101 | | 733.3 | 0.65 | **0.64** | 0.55 | 0.53 | 83.3 |
| A-88 | K&T 6112 | 888.8 | 0.54 | **0.50** | 0.37 | 0.35 | 68.8 |
| B-88 | | 692.4 | 0.33 | 0.31 | 0.27 | 0.26 | 82.6 |
| A-97 | 1163 | 846.8 | 0.26 | 0.23 | 0.14 | 0.13 | 54.5 |
| B-97 | | 667.2 | 0.13 | 0.12 | 0.11 | 0.10 | 80.7 |
| A-85 | 6116 G&D, 6120 | 861.8 | 0.50 | 0.45 | 0.31 | 0.31 | 69.8 |
| B-85 | K&T 5 | 677.4 | 0.22 | 0.20 | 0.15 | 0.13 | 66.7 |

* The total mass samples are labelled A, and the thoracic mass samples are labelled B.
Each numbered A-B set was collected side-by-side at the same location.

** The bolded numbers are above the NIOSH REL of 0.5 $mg/m^3$ total mass, or 0.4 $mg/m^3$ thoracic mass.

L = liters
mg/m3 = milligrams per cubic meter
8-hr TWA = 8-hour time-weighted average
PBZ = personal breathing zone (air sample)
GA = general area (air sample)
trace = detectable quantities below the minimun quantifiable concentration
na = not applicable

**Table 9**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/11/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-116 | GA at 1126 | 915.4 | 0.44 | 0.42 | 0.31 | 0.30 | 70.0 |
| B-116 | | 737.1 | 0.37 | 0.35 | 0.27 | 0.26 | 74.1 |
| A-133 | coolant tech | 1034.0 | 0.33 | 0.36 | 0.19 | 0.21 | 58.8 |
| B-133 | | 826.8 | 0.22 | 0.24 | 0.15 | 0.16 | 66.7 |
| A-111 | 1025, 1026 | 888.4 | 0.63 | **0.59** | 0.45 | 0.42 | 71.4 |
| B-111 | | 711.2 | 0.41 | 0.38 | 0.24 | 0.23 | 58.6 |
| A-131 | 1119, 1121, | 893.3 | 0.94 | **0.86** | 0.64 | 0.60 | 67.9 |
| B-131 | 1035 | 729.7 | 0.56 | **0.53** | 0.44 | 0.41 | 78.0 |
| A-114 | 6292 | 906.2 | 0.79 | **0.76** | 0.54 | 0.52 | 68.1 |
| B-114 | | 716.0 | 0.50 | **0.48** | 0.39 | 0.37 | 77.8 |
| A-123 | 1043, 1037 | 889.8 | 0.92 | **0.86** | 0.47 | 0.44 | 51.2 |
| B-123 | | 701.1 | 0.51 | **0.46** | 0.39 | 0.36 | 75.0 |
| A-110 | GA near 6296 | 891.8 | 0.41 | 0.39 | 0.24 | 0.22 | 56.8 |
| B-110 | | 710.7 | 0.30 | 0.28 | 0.18 | 0.17 | 61.9 |
| A-117 | GA near 6293 | 847.5 | 0.55 | 0.49 | 0.38 | 0.33 | 68.1 |
| B-117 | | 670.7 | 0.45 | **0.40** | 0.33 | 0.29 | 73.3 |
| A-122 | 1001 | 487.7 | 0.64 | 0.33 | 0.35 | 0.18 | 54.8 |
| B-122 | | 547.2 | 0.42 | 0.30 | 0.27 | 0.20 | 65.2 |
| A-126 | 6166 | 811.0 | 1.60 | **1.37** | 1.36 | 1.16 | 84.6 |
| B-126 | | 645.1 | 0.90 | **0.77** | 0.78 | 0.66 | 86.2 |
| A-129 | 6349 | 831.7 | 0.77 | **0.87** | 0.59 | 0.51 | 76.6 |
| B-129 | | 653.9 | 0.49 | **0.43** | 0.38 | 0.33 | 78.1 |
| A-120 | 1007, 1008 | 812.0 | 0.57 | 0.48 | 0.25 | 0.21 | 43.5 |
| B-120 | | 641.7 | 0.30 | 0.25 | 0.16 | 0.13 | 52.6 |
| A-134 | 1145, 6328, | 782.1 | 0.77 | **0.64** | 0.38 | 0.32 | 50.0 |
| B-134 | 6296 | 637.7 | 0.38 | 0.32 | 0.25 | 0.21 | 66.7 |
| A-128 | 1145, 1139 | 791.9 | 0.44 | 0.36 | 0.25 | 0.21 | 57.1 |
| B-128 | | 618.9 | 0.32 | 0.26 | 0.21 | 0.17 | 65.0 |
| A-108 | 6259, 1113 | 793.0 | 0.81 | **0.67** | 0.53 | 0.44 | 65.6 |
| B-108 | | 627.8 | 0.53 | **0.44** | 0.38 | 0.32 | 72.7 |
| A-143 | 1132 | 447.8 | 1.09 | **0.51** | 0.34 | 0.16 | 30.6 |
| B-143 | | 355.8 | 0.34 | 0.16 | 0.19 | 0.09 | 55.8 |
| A-127 | 2536, 2537 | 899.7 | 0.39 | 0.37 | 0.24 | 0.23 | 62.9 |
| B-127 | | 688.0 | 0.29 | 0.27 | 0.19 | 0.18 | 65.0 |
| A-125 | 2522, 2523 | 878.2 | 1.14 | **1.06** | 0.92 | 0.86 | 81.0 |
| B-125 | | 786.7 | 0.76 | **0.71** | 0.67 | 0.63 | 88.3 |
| A-130 | GA at 2580, | 903.7 | 0.51 | 0.48 | 0.34 | 0.32 | 67.4 |
| B-130 | 2581 | 718.0 | 0.33 | 0.32 | 0.19 | 0.18 | 58.3 |

**Table 9**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/11/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-119 | set-up | 858.7 | 0.62 | **0.56** | 0.45 | 0.41 | 73.6 |
| B-119 | | 691.8 | 0.52 | **0.47** | 0.42 | 0.38 | 80.6 |
| A-113 | GA at end of washer | 891.9 | 0.34 | 0.32 | 0.22 | 0.21 | 66.7 |
| B-113 | | 683.5 | 0.29 | 0.27 | 0.19 | 0.18 | 65.0 |
| A-118 | 1132 | 370.1 | 0.81 | 0.31 | 0.38 | 0.15 | 46.7 |
| B-118 | | 294.2 | 0.44 | 0.17 | 0.21 | 0.08 | 47.7 |
| A-132 | G&D 6166, | 821.9 | 0.47 | 0.41 | 0.27 | 0.23 | 56.4 |
| B-132 | K&T 5 6120 | 638.9 | 0.22 | 0.19 | 0.14 | 0.12 | 63.6 |
| A-107 | 2593 | 821.7 | 0.58 | **0.51** | 0.32 | 0.27 | 54.2 |
| B-107 | | 661.7 | 0.27 | 0.24 | 0.20 | 0.17 | 72.2 |
| A-105 | 2506, 1110 | 814.8 | 0.26 | 0.22 | 0.18 | 0.16 | 71.4 |
| B-105 | | 653.3 | 0.14 | 0.12 | 0.09 | 0.07 | 62.2 |
| A-106 | assembly, | 800.0 | 0.26 | 0.22 | 0.18 | 0.15 | 66.7 |
| B-106 | tester | 631.3 | 0.17 | 0.15 | 0.12 | 0.10 | 66.4 |
| A-109 | GA at 1163 | 891.3 | 0.20 | 0.19 | 0.12 | 0.12 | 61.1 |
| B-109 | | 715.0 | 0.15 | 0.15 | 0.12 | 0.11 | 76.4 |
| A-124 | GA 1024, 1028, & 1002 | 895.8 | 0.68 | **0.65** | 0.52 | 0.50 | 77.0 |
| B-124 | in afternoon | 720.7 | 0.35 | 0.33 | 0.28 | 0.26 | 80.0 |
| A-112 | K&T 6112 | 897.4 | 0.75 | **0.70** | 0.35 | 0.33 | 46.3 |
| B-112 | | 705.8 | 0.45 | **0.43** | 0.31 | 0.29 | 68.8 |
| A-115 | GA at T-10, | 917.0 | 0.44 | 0.42 | 0.32 | 0.31 | 72.5 |
| B-115 | 1164 | 734.7 | 0.34 | 0.33 | 0.27 | 0.26 | 80.0 |
| A-121 | GA at 6285 | 919.8 | 0.25 | 0.24 | 0.16 | 0.16 | 65.2 |
| B-121 | | 721.2 | 0.25 | 0.24 | 0.14 | 0.13 | 55.6 |

* The total mass samples are labelled A, and the thoracic mass samples are labelled B.
Each numbered A-B set was collected side-by-side at the same location.

** The bolded numbers are above the NIOSH REL of 0.5 $mg/m^3$ total mass, or 0.4 $mg/m^3$ thoracic mass.

L = liters
mg/m3 = milligrams per cubic meter
8-hr TWA = 8-hour time-weighted average
PBZ = personal breathing zone (air sample)
GA = general area (air sample)
trace = detectable quantities below the minimun quantifiable concentration
na = not applicable

**Table 10**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/11/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-162 | GA near | 966.2 | 0.54 | **0.54** | 0.19 | 0.19 | 34.6 |
| B-162 | 6295 | 768.4 | 0.38 | 0.38 | 0.25 | 0.25 | 65.5 |
| A-160 | GA near | 621.7 | 0.77 | **0.50** | 0.56 | 0.36 | 72.9 |
| B-160 | 6293 | 773.5 | 0.44 | **0.45** | 0.35 | 0.35 | 79.4 |
| A-157 | 1025, 1026 | 967.6 | 0.62 | **0.63** | 0.42 | 0.43 | 68.3 |
| B-157 | | 762.3 | 0.43 | **0.44** | 0.31 | 0.32 | 72.7 |
| A-169 | 1029, 1030 | 661.7 | 0.32 | 0.22 | 0.20 | 0.14 | 61.9 |
| B-169 | | 417.1 | 0.24 | 0.13 | 0.15 | 0.08 | 61.0 |
| A-170 | 6292 | 949.7 | 0.71 | **0.70** | 0.48 | 0.48 | 68.7 |
| B-170 | | 749.6 | 0.45 | **0.45** | 0.36 | 0.36 | 79.4 |
| A-154 | coolant tech | 1009.7 | 0.29 | 0.30 | 0.19 | 0.20 | 65.5 |
| B-154 | | 787.4 | 0.19 | 0.20 | 0.11 | 0.12 | 59.3 |
| A-145 | 1043 | 925.0 | 0.65 | **0.63** | 0.37 | 0.36 | 56.7 |
| B-145 | | 736.3 | 0.57 | **0.55** | 0.46 | 0.45 | 81.0 |
| A-144 | 6295 | 862.0 | 1.08 | **0.98** | 0.45 | 0.41 | 41.9 |
| B-144 | | 723.7 | 0.28 | 0.27 | 0.18 | 0.17 | 65.0 |
| A-171 | 1119 | 459.5 | 0.89 | 0.43 | 0.72 | 0.35 | 80.5 |
| B-171 | | 374.2 | 0.59 | 0.28 | 0.51 | 0.24 | 86.4 |
| A-168 | GA near | 937.0 | 0.34 | 0.33 | 0.23 | 0.23 | 68.8 |
| B-168 | 6329 | 743.0 | 0.24 | 0.24 | 0.16 | 0.16 | 66.7 |
| A-167 | 2528 | 884.4 | 0.80 | **0.75** | 0.53 | 0.49 | 66.2 |
| B-167 | | 620.4 | 0.52 | **0.42** | 0.37 | 0.30 | 71.9 |
| A-142 | 6184 | 868.3 | 0.60 | **0.54** | 0.35 | 0.31 | 57.7 |
| B-142 | | 693.6 | 0.30 | 0.27 | 0.22 | 0.20 | 71.4 |
| A-166 | 6349 | 845.4 | 0.62 | **0.55** | 0.47 | 0.42 | 76.9 |
| B-166 | | 672.9 | 0.31 | 0.28 | 0.24 | 0.21 | 76.2 |
| A-164 | 6166 | 840.7 | 0.75 | **0.68** | 0.58 | 0.51 | 77.8 |
| B-164 | | 664.7 | 0.57 | **0.50** | 0.48 | 0.42 | 84.2 |
| A-141 | 1121 | 825.8 | 0.73 | **0.63** | 0.58 | 0.50 | 80.0 |
| B-141 | | 667.3 | 0.48 | **0.41** | 0.39 | 0.34 | 81.3 |
| A-155 | 1163 | 842.0 | 0.31 | 0.27 | 0.15 | 0.14 | 50.0 |
| B-155 | | 670.0 | 0.21 | 0.18 | 0.11 | 0.10 | 52.9 |
| A-151 | G&D 6116, | 830.2 | 0.35 | 0.30 | 0.18 | 0.16 | 51.7 |
| B-151 | K&T 5 6120 | 663.3 | 0.23 | 0.20 | 0.14 | 0.12 | 60.7 |
| A-152 | 6259 | 841.8 | 0.88 | **0.77** | 0.61 | 0.53 | 68.9 |
| B-152 | | 671.1 | 0.54 | **0.47** | 0.42 | 0.37 | 77.8 |
| A-153 | 2506, 1110 | 821.7 | 0.18 | 0.16 | 0.09 | 0.08 | 50.0 |
| B-153 | | 639.2 | 0.13 | 0.11 | 0.07 | 0.06 | 56.1 |

**Table 10**
**Total and Thoracic Mass* and Extractable Mass Concentrations for Samples Collected on 1/11/01**
**HETA 2000-0356-2851, Campbell Hausfeld**

| Sample* | Machine # or Job (all PBZ samples unless noted "GA") | Sample Volume (L) | Total or Thoracic* Conc. ($mg/m^3$) | Total or Thoracic* 8-hr TWA ($mg/m^3$) | Extractable Conc. ($mg/m^3$) | Extractable 8-hr TWA ($mg/m^3$) | % Extractable to Total Mass |
|---|---|---|---|---|---|---|---|
| A-158 | assembly | 814.2 | 0.20 | 0.17 | 0.11 | 0.10 | 58.1 |
| B-158 | behind 6285 | 643.4 | 0.37 | 0.32 | 0.15 | 0.13 | 41.3 |
| A-147 | GA at 6285 | 896.0 | 0.18 | 0.17 | 0.11 | 0.10 | 62.5 |
| B-147 | | 713.5 | 0.15 | 0.15 | 0.11 | 0.10 | 68.2 |
| A-148 | GA at end | 898.9 | 0.26 | 0.24 | 0.18 | 0.17 | 69.6 |
| B-148 | of washer | 719.6 | 0.26 | 0.25 | 0.21 | 0.20 | 78.9 |
| A-159 | pack out | 918.0 | 0.51 | 0.48 | 0.27 | 0.26 | 53.2 |
| B-159 | | 709.4 | 0.37 | 0.34 | 0.27 | 0.25 | 73.1 |
| A-150 | 2588, 1157 | 863.4 | 0.28 | 0.25 | 0.11 | 0.10 | 41.3 |
| B-150 | | 679.8 | 0.14 | 0.13 | 0.09 | 0.08 | 61.9 |
| A-156 | beginning | 890.2 | 0.34 | 0.31 | 0.19 | 0.18 | 56.7 |
| B-156 | of washer | 698.9 | 0.21 | 0.20 | 0.12 | 0.11 | 57.3 |
| A-165 | 6125 | 680.1 | 0.53 | 0.47 | 0.12 | 0.11 | 23.1 |
| B-165 | | 852.1 | 0.13 | 0.12 | 0.06 | 0.05 | 46.4 |
| A-161 | K&T 6112 | 924.3 | 0.56 | **0.54** | 0.19 | 0.19 | 34.6 |
| B-161 | | 742.4 | 0.27 | 0.26 | 0.16 | 0.16 | 60.0 |
| A-146 | 2536, 2537 | 918.4 | 0.30 | 0.29 | 0.16 | 0.16 | 53.6 |
| B-146 | | 734.1 | 0.22 | 0.21 | 0.11 | 0.10 | 49.4 |
| A-149 | 2522, 2523 | 945.1 | 1.04 | **1.03** | 0.65 | 0.64 | 62.2 |
| B-149 | | 752.3 | 0.76 | **0.78** | 0.60 | 0.60 | 78.9 |
| A-163 | GA at 2580, | 922.4 | 0.38 | 0.37 | 0.13 | 0.13 | 34.3 |
| B-163 | 2581 | 727.5 | 0.16 | 0.16 | 0.09 | 0.08 | 51.7 |

* The total mass samples are labeled A, and the thoracic mass samples are labeled B. Each numbered A-B set was collected side-by-side at the same location.
** The bolded numbers are above the NIOSH REL of 0.5 $mg/m^3$ total mass, or 0.4 $mg/m^3$ thoracic mass.
L - liters
$mg/m^3$ - milligrams per cubic meter
8-hr TWA - 8-hour time weighted average
PBZ - personal breathing zone (air sample)
GA - general area (air sample)
trace - detectable quantities below the minimun quantifiable concentration
na - not applicable

**Table 11**

**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**

**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| 1001 | PBZ | Total | | | 0.54 | 0.33 | 0.53 | 0.28 | 0.64 | 0.35 | | | 0.57 | 0.32 |
| 1001 | PBZ | Thoracic | | | 0.36 | 0.27 | 0.30 | 0.30 | 0.42 | 0.27 | | | 0.36 | 0.28 |
| 1003 & 1004 | PBZ | Total | | | 0.94 | 0.35 | | | | | | | 0.94 | 0.35 |
| 1003 & 1004 | PBZ | Thoracic | | | 0.38 | 0.23 | | | | | | | 0.38 | 0.23 |
| 1006 & 1010 | GA | Total | | | 0.53 | 0.20 | | | | | | | 0.53 | 0.20 |
| 1006 & 1010 | GA | Thoracic | | | 0.24 | 0.14 | | | | | | | 0.24 | 0.14 |
| 1007 & 1008 | PBZ | Total | | | 0.50 | 0.26 | 0.94 | 0.67 | 0.57 | 0.25 | | | 0.64 | 0.35 |
| 1007 & 1008 | PBZ | Thoracic | | | 0.25 | 0.16 | 0.50 | 0.37 | 0.30 | 0.16 | | | 0.33 | 0.21 |
| 1012 & 1013 | PBZ | Total | 0.46 | 0.25 | | | | | | | | | 0.46 | 0.25 |
| 1012 & 1013 | PBZ | Thoracic | 0.25 | 0.15 | | | | | | | | | 0.25 | 0.15 |
| 1024 & 1028 | PBZ | Total | 1.04 | 0.75 | 1.07 | 0.74 | | | | | | | 1.06 | 0.75 |
| 1024 & 1028 | PBZ | Thoracic | 0.62 | 0.50 | 0.84 | 0.64 | | | | | | | 0.72 | 0.57 |
| 1024, 1028, then 1002 | GA | Total | | | | | | | 0.68 | 0.52 | | | 0.68 | 0.52 |
| 1024, 1028, then 1002 | GA | Thoracic | | | | | | | 0.35 | 0.28 | | | 0.35 | 0.28 |
| 1025 & 1026 | PBZ | Total | | | 0.51 | 0.32 | | | 0.63 | 0.45 | 0.62 | 0.42 | 0.59 | 0.40 |
| 1025 & 1026 | PBZ | Thoracic | | | 0.36 | 0.28 | | | 0.41 | 0.24 | 0.43 | 0.31 | 0.40 | 0.27 |
| 1026 | PBZ | Total | | | | | 0.51 | 0.32 | | | | | 0.51 | 0.32 |
| 1026 | PBZ | Thoracic | | | | | 0.39 | 0.30 | | | | | 0.39 | 0.30 |
| 1027 | PBZ | Total | 0.67 | 0.37 | 0.82 | 0.50 | 0.78 | 0.49 | | | | | 0.76 | 0.45 |
| 1027 | PBZ | Thoracic | 0.43 | 0.30 | 0.56 | 0.48 | 0.60 | 0.48 | | | | | 0.53 | 0.41 |
| 1028 | GA | Total | | | | | 0.74 | 0.60 | | | | | 0.74 | 0.60 |
| 1028 | GA | Thoracic | | | | | 0.33 | 0.24 | | | | | 0.33 | 0.24 |
| 1029 | PBZ | Total | | | | | 0.47 | 0.34 | | | | | 0.47 | 0.34 |
| 1029 | PBZ | Thoracic | | | | | 0.28 | 0.23 | | | | | 0.28 | 0.23 |
| 1029 & 1030 | PBZ | Total | | | | | | | | | 0.32 | 0.20 | 0.32 | 0.20 |

**Table 11**
**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**
**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| 1029 & 1030 | PBZ | Thoracic | | | | | | | | | 0.24 | 0.15 | 0.24 | 0.15 |
| 1043 | PBZ | Total | 0.58 | 0.19 | | | | | | | 0.65 | 0.37 | 0.62 | 0.26 |
| 1043 | PBZ | Thoracic | 0.22 | 0.13 | | | | | | | 0.57 | 0.46 | 0.35 | 0.25 |
| 1043 & 1037 | PBZ | Total | | | | | | | 0.92 | 0.47 | | | 0.92 | 0.47 |
| 1043 & 1037 | PBZ | Thoracic | | | | | | | 0.51 | 0.39 | | | 0.51 | 0.39 |
| 1045 | GA | Total | | | | | 0.62 | 0.28 | | | | | 0.62 | 0.28 |
| 1045 | GA | Thoracic | | | | | 0.31 | 0.21 | | | | | 0.31 | 0.21 |
| 1110 & 1108 | PBZ | Total | 0.30 | 0.22 | | | | | | | | | 0.30 | 0.22 |
| 1110 & 1108 | PBZ | Thoracic | 0.20 | 0.10 | | | | | | | | | 0.20 | 0.10 |
| 1119 | PBZ | Total | 0.88 | 0.47 | | | | | | | 0.89 | 0.72 | 0.89 | 0.58 |
| 1119 | PBZ | Thoracic | 0.50 | 0.35 | | | | | | | 0.59 | 0.51 | 0.54 | 0.42 |
| 1119 & 1121 & 1035 | PBZ | Total | | | | | | | 0.94 | 0.64 | | | 0.94 | 0.64 |
| 1119 & 1121 & 1035 | PBZ | Thoracic | | | | | | | 0.56 | 0.44 | | | 0.56 | 0.44 |
| 1121 | PBZ | Total | | | | | | | | | 0.73 | 0.58 | 0.73 | 0.58 |
| 1121 | PBZ | Thoracic | | | | | | | | | 0.48 | 0.39 | 0.48 | 0.39 |
| 1121 & 1119 | PBZ | Total | | | 0.98 | 0.91 | | | | | | | 0.98 | 0.91 |
| 1121 & 1119 | PBZ | Thoracic | | | 0.60 | 0.50 | | | | | | | 0.60 | 0.50 |
| 1126 | GA | Total | | | | | 0.39 | 0.27 | 0.44 | 0.31 | | | 0.41 | 0.29 |
| 1126 | GA | Thoracic | | | | | 0.28 | 0.20 | 0.37 | 0.27 | | | 0.32 | 0.24 |
| 1126 | PBZ | Total | | | 0.41 | 0.27 | | | | | | | 0.41 | 0.27 |
| 1126 | PBZ | Thoracic | | | 0.27 | 0.20 | | | | | | | 0.27 | 0.20 |
| 1132 | PBZ | Total | 1.43 | 0.33 | 0.07 | 0.03 | 1.04 | 0.34 | 0.97 | 0.35 | | | 0.56 | 0.19 |
| 1132 | PBZ | Thoracic | 0.36 | 0.17 | 0.26 | 0.16 | 0.32 | 0.22 | 0.38 | 0.20 | | | 0.33 | 0.18 |
| 1145 & 1139 | PBZ | Total | | | | | | | 0.44 | 0.25 | | | 0.44 | 0.25 |
| 1145 & 1139 | PBZ | Thoracic | | | | | | | 0.32 | 0.21 | | | 0.32 | 0.21 |

**Table 11**
**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**
**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| 1145 & 6328 & 6296 | PBZ | Total | | | | | | | 0.77 | 0.38 | | | 0.77 | 0.38 |
| 1145 & 6328 & 6296 | PBZ | Thoracic | | | | | | | 0.38 | 0.25 | | | 0.38 | 0.25 |
| 1156 | GA | Total | | | | | 0.51 | 0.32 | | | | | 0.51 | 0.32 |
| 1156 | GA | Thoracic | | | | | 0.36 | 0.28 | | | | | 0.36 | 0.28 |
| 1156 | PBZ | Total | | | 1.15 | 0.99 | | | | | | | 1.15 | 0.99 |
| 1156 | PBZ | Thoracic | | | 0.67 | 0.60 | | | | | | | 0.67 | 0.60 |
| 1163 | GA | Total | | | | | | | 0.20 | 0.12 | | | 0.20 | 0.12 |
| 1163 | GA | Thoracic | | | | | | | 0.15 | 0.12 | | | 0.15 | 0.12 |
| 1163 | PBZ | Total | | | 0.18 | 0.13 | 0.26 | 0.14 | | | 0.31 | 0.15 | 0.24 | 0.14 |
| 1163 | PBZ | Thoracic | | | 0.11 | 0.09 | 0.13 | 0.11 | | | 0.21 | 0.11 | 0.14 | 0.10 |
| 1163 & 6127 | PBZ | Total | 0.21 | 0.12 | | | | | | | | | 0.21 | 0.12 |
| 1163 & 6127 | PBZ | Thoracic | 0.11 | 0.07 | | | | | | | | | 0.11 | 0.07 |
| 1164 | GA | Total | | | | | | | 0.44 | 0.32 | | | 0.44 | 0.32 |
| 1164 | GA | Thoracic | | | | | | | 0.34 | 0.27 | | | 0.34 | 0.27 |
| 1164 & 8029 | PBZ | Total | 0.45 | 0.32 | 0.41 | 0.18 | | | | | | | 0.43 | 0.24 |
| 1164 & 8029 | PBZ | Thoracic | 0.33 | 0.25 | 0.31 | 0.20 | | | | | | | 0.32 | 0.23 |
| 1179 | GA | Total | | | | | 0.17 | 0.14 | | | | | 0.17 | 0.14 |
| 1179 | GA | Thoracic | | | | | 0.12 | 0.03 | | | | | 0.12 | 0.03 |
| 2506 & 1110 | PBZ | Total | | | | | | | 0.26 | 0.18 | 0.18 | 0.09 | 0.22 | 0.13 |
| 2506 & 1110 | PBZ | Thoracic | | | | | | | 0.14 | 0.09 | 0.13 | 0.07 | 0.13 | 0.08 |

**Table 11**

**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**

**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| 2522 & 2523 | PBZ | Total | | | | | | | 1.14 | 0.92 | 1.04 | 0.65 | 1.09 | 0.77 |
| 2522 & 2523 | PBZ | Thoracic | | | | | | | 0.76 | 0.67 | 0.76 | 0.60 | 0.76 | 0.63 |
| 2522 & 2523 & 6206 | PBZ | Total | 1.14 | 0.89 | 1.18 | 0.91 | 1.19 | 0.91 | | | | | 1.17 | 0.90 |
| 2522 & 2523 & 6206 | PBZ | Thoracic | 0.88 | 0.76 | 0.82 | 0.71 | 0.65 | 0.55 | | | | | 0.78 | 0.67 |
| 2528 | PBZ | Total | | | | | | | | | 0.80 | 0.53 | 0.80 | 0.53 |
| 2528 | PBZ | Thoracic | | | | | | | | | 0.52 | 0.37 | 0.52 | 0.37 |
| 2536 & 2537 | PBZ | Total | 0.48 | 0.35 | | | | | 0.39 | 0.24 | 0.30 | 0.16 | 0.38 | 0.24 |
| 2536 & 2537 | PBZ | Thoracic | 0.34 | 0.22 | | | | | 0.29 | 0.19 | 0.22 | 0.11 | 0.28 | 0.17 |
| 2537 | PBZ | Total | | | 0.44 | 0.28 | 0.43 | 0.29 | | | | | 0.43 | 0.28 |
| 2537 | PBZ | Thoracic | | | 0.25 | 0.18 | 0.32 | 0.24 | | | | | 0.28 | 0.21 |
| 2588 & 2554 & 2555 | PBZ | Total | | | | | 0.41 | 0.19 | | | | | 0.41 | 0.19 |
| 2588 & 2554 & 2555 | PBZ | Thoracic | | | | | 0.18 | 0.13 | | | | | 0.18 | 0.13 |
| 2580 & 2581 | GA | Total | | | 0.59 | 0.38 | | | 0.51 | 0.34 | 0.38 | 0.13 | 0.48 | 0.26 |
| 2580 & 2581 | GA | Thoracic | | | 0.37 | 0.22 | | | 0.33 | 0.19 | 0.16 | 0.09 | 0.27 | 0.15 |
| 2580 & 2581 | PBZ | Total | 1.02 | 0.66 | | | | | | | | | 1.02 | 0.66 |
| 2580 & 2581 | PBZ | Thoracic | 0.75 | 0.58 | | | | | | | | | 0.75 | 0.58 |
| 2582 | GA | Total | | | | | 0.22 | 0.12 | | | | | 0.22 | 0.12 |
| 2582 | GA | Thoracic | | | | | 0.15 | 0.14 | | | | | 0.15 | 0.14 |
| 2583 | PBZ | Total | | | 0.32 | 0.14 | | | | | | | 0.32 | 0.14 |
| 2583 | PBZ | Thoracic | | | 0.17 | 0.12 | | | | | | | 0.17 | 0.12 |
| 2588 & 1157 | PBZ | Total | | | | | | | | | 0.28 | 0.11 | 0.28 | 0.11 |
| 2588 & 1157 | PBZ | Thoracic | | | | | | | | | 0.14 | 0.09 | 0.14 | 0.09 |
| 2593 | PBZ | Total | 0.41 | 0.20 | | | | | 0.58 | 0.32 | | | 0.49 | 0.25 |
| 2593 | PBZ | Thoracic | 0.18 | 0.10 | | | | | 0.27 | 0.20 | | | 0.22 | 0.14 |
| 6116 G&D, 6120 | PBZ | Total | 0.38 | 0.27 | 0.30 | 0.17 | 0.50 | 0.35 | 0.47 | 0.27 | 0.35 | 0.18 | 0.40 | 0.24 |

**Table 11**
**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**
**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| K&T5<br>6116 G&D, 6120<br>K&T5 | PBZ | Thoracic | 0.24 | 0.15 | 0.21 | 0.16 | 0.22 | 0.15 | 0.22 | 0.14 | 0.23 | 0.14 | 0.22 | 0.15 |
| 6125 | PBZ | Total | | | | | | | | | 0.53 | 0.12 | 0.53 | 0.12 |
| 6125 | PBZ | Thoracic | | | | | | | | | 0.13 | 0.06 | 0.13 | 0.06 |
| 6141 | PBZ | Total | | | 0.29 | 0.18 | | | | | | | 0.29 | 0.18 |
| 6141 | PBZ | Thoracic | | | 0.16 | 0.14 | | | | | | | 0.16 | 0.14 |
| 6158 | PBZ | Total | 0.35 | 0.19 | | | | | | | | | 0.35 | 0.19 |
| 6158 | PBZ | Thoracic | 0.19 | 0.10 | | | | | | | | | 0.19 | 0.10 |
| 6166 | PBZ | Total | 1.51 | 1.39 | | | 0.87 | 0.72 | 1.60 | 1.36 | 0.75 | 0.58 | 1.12 | 0.94 |
| 6166 | PBZ | Thoracic | 0.83 | 0.72 | | | 0.55 | 0.47 | 0.90 | 0.78 | 0.57 | 0.48 | 0.70 | 0.60 |
| 6167 | GA | Total | | | | | 0.21 | 0.19 | | | | | 0.21 | 0.19 |
| 6167 | GA | Thoracic | | | | | 0.19 | 0.15 | | | | | 0.19 | 0.15 |
| 6184 | PBZ | Total | | | | | 1.00 | 0.79 | | | 0.60 | 0.35 | 0.77 | 0.52 |
| 6184 | PBZ | Thoracic | | | | | 0.66 | 0.59 | | | 0.30 | 0.22 | 0.45 | 0.36 |
| 6185 | PBZ | Total | 0.53 | 0.32 | | | 0.62 | 0.40 | | | | | 0.57 | 0.36 |
| 6185 | PBZ | Thoracic | 0.32 | 0.22 | | | 0.40 | 0.33 | | | | | 0.36 | 0.27 |
| 6259 | PBZ | Total | | | | | | | | | 0.88 | 0.61 | 0.88 | 0.61 |
| 6259 | PBZ | Thoracic | | | | | | | | | 0.54 | 0.42 | 0.54 | 0.42 |
| 6259 & 1113 | PBZ | Total | | | | | | | 0.81 | 0.53 | | | 0.81 | 0.53 |
| 6259 & 1113 | PBZ | Thoracic | | | | | | | 0.53 | 0.38 | | | 0.53 | 0.38 |
| 6285 | GA | Total | 0.25 | 0.18 | 0.22 | 0.17 | | | 0.25 | 0.16 | 0.18 | 0.11 | 0.22 | 0.15 |
| 6285 | GA | Thoracic | 0.19 | 0.13 | 0.17 | 0.11 | | | 0.25 | 0.14 | 0.15 | 0.11 | 0.19 | 0.12 |

**Table 11**

**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**

**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| 6292 | PBZ | Total | 0.75 | 0.55 | 0.69 | 0.51 | 0.83 | 0.56 | 0.79 | 0.54 | 0.71 | 0.48 | 0.75 | 0.53 |
| 6292 | PBZ | Thoracic | 0.52 | 0.42 | 0.48 | 0.41 | 0.55 | 0.45 | 0.50 | 0.39 | 0.45 | 0.36 | 0.50 | 0.41 |
| 6293 | GA | Total | | | | | | | 0.55 | 0.38 | 0.77 | 0.56 | 0.65 | 0.46 |
| 6293 | GA | Thoracic | | | | | | | 0.45 | 0.33 | 0.44 | 0.35 | 0.44 | 0.34 |
| 6293 | PBZ | Total | 0.81 | 0.58 | | | | | | | | | 0.81 | 0.58 |
| 6293 | PBZ | Thoracic | 0.57 | 0.48 | | | | | | | | | 0.57 | 0.48 |
| 6295 | GA | Total | | | | | | | | | 0.54 | 0.19 | 0.54 | 0.19 |
| 6295 | GA | Thoracic | | | | | | | | | 0.38 | 0.25 | 0.38 | 0.25 |
| 6295 | PBZ | Total | | | 2.60 | 0.47 | | | | | 1.08 | 0.45 | 1.68 | 0.46 |
| 6295 | PBZ | Thoracic | | | 0.50 | 0.19 | | | | | 0.28 | 0.18 | 0.37 | 0.18 |
| 6295 & 1045 | GA | Total | 0.57 | 0.25 | | | | | | | | | 0.57 | 0.25 |
| 6295 & 1045 | GA | Thoracic | 0.28 | 0.17 | | | | | | | | | 0.28 | 0.17 |
| 6296 | GA | Total | | | | | | | 0.41 | 0.24 | | | 0.41 | 0.24 |
| 6296 | GA | Thoracic | | | | | | | 0.30 | 0.18 | | | 0.30 | 0.18 |
| 6329 | GA | Total | | | | | | | | | 0.34 | 0.23 | 0.34 | 0.23 |
| 6329 | GA | Thoracic | | | | | | | | | 0.24 | 0.16 | 0.24 | 0.16 |
| 6329 | PBZ | Total | 0.73 | 0.51 | 0.68 | 0.41 | | | | | | | 0.70 | 0.45 |
| 6329 | PBZ | Thoracic | 0.47 | 0.36 | 0.30 | 0.26 | | | | | | | 0.38 | 0.31 |
| 6335 | PBZ | Total | 1.76 | 0.33 | | | | | | | | | 1.76 | 0.33 |
| 6335 | PBZ | Thoracic | 0.36 | 0.13 | | | | | | | | | 0.36 | 0.13 |
| 6335 and others | PBZ | Total | 0.43 | 0.22 | | | | | | | | | 0.43 | 0.22 |
| 6335 and others | PBZ | Thoracic | 0.23 | 0.14 | | | | | | | | | 0.23 | 0.14 |
| 6349 | PBZ | Total | 1.16 | 1.01 | 0.94 | 0.78 | 0.86 | 0.70 | 0.77 | 0.59 | 0.62 | 0.47 | 0.85 | 0.69 |
| 6349 | PBZ | Thoracic | 0.55 | 0.43 | 0.41 | 0.32 | 0.45 | 0.36 | 0.49 | 0.38 | 0.31 | 0.24 | 0.43 | 0.34 |
| K&T 1 (6112) | PBZ | Total | 0.52 | 0.19 | 0.75 | 0.30 | 0.54 | 0.37 | 0.75 | 0.35 | 0.56 | 0.19 | 0.62 | 0.27 |

**Table 11**
**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**
**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| K&T 1 (6112) | PBZ | Thoracic | 0.33 | 0.22 | 0.29 | 0.18 | 0.33 | 0.27 | 0.45 | 0.31 | 0.27 | 0.16 | 0.33 | 0.22 |
| assembly -- across from piston table | PBZ | Total | 0.28 | 0.21 | | | | | | | | | 0.28 | 0.21 |
| assembly -- across from piston table | PBZ | Thoracic | 0.22 | 0.15 | | | | | | | | | 0.22 | 0.15 |
| assembly -- across from piston table | PBZ | Total | | | | | 0.31 | 0.12 | | | | | 0.31 | 0.12 |
| assembly -- across from piston table | PBZ | Thoracic | | | | | 0.24 | 0.18 | | | | | 0.24 | 0.18 |
| assembly -- near paint booth | PBZ | Total | | | | | 0.31 | 0.17 | | | | | 0.31 | 0.17 |
| assembly -- near paint booth | PBZ | Thoracic | | | | | 0.25 | 0.15 | | | | | 0.25 | 0.15 |
| assembly -- behind 6285 | PBZ | Total | | | 0.24 | 0.17 | | | | | 0.20 | 0.11 | 0.22 | 0.14 |
| assembly -- behind 6285 | PBZ | Thoracic | | | 0.17 | 0.14 | | | | | 0.37 | 0.15 | 0.25 | 0.14 |
| assembly -- tester | PBZ | Total | | | | | | | 0.26 | 0.18 | | | 0.26 | 0.18 |
| assembly -- tester | PBZ | Thoracic | | | | | | | 0.17 | 0.12 | | | 0.17 | 0.12 |
| beginning of main washer | PBZ | Total | | | | | | | | | 0.34 | 0.19 | 0.34 | 0.19 |
| beginning of main washer | PBZ | Thoracic | | | | | | | | | 0.21 | 0.12 | 0.21 | 0.12 |

**Table 11**
**Total, Total Extractable, Thoracic, and Thoracic Extractable Mass Concentrations by Location**
**HETA 2000-0356-2851, Campbell Hausfeld, 1/8-12/2001**

| Machine # or Job | Sample Type | Total or Thoracic Sample | 1/8/01 Concentration ($mg/m^3$) | | 1/9/01 Concentration ($mg/m^3$) | | 1/10/01 Concentration ($mg/m^3$) | | 1/11/01 Concentration ($mg/m^3$) | | 1/12/01 Concentration ($mg/m^3$) | | Geometric Mean Concentration ($mg/m^3$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable | Total | Extractable |
| coolant tech | PBZ | Total | 0.37 | 0.18 | 0.26 | 0.15 | 0.31 | 0.20 | 0.33 | 0.19 | 0.29 | 0.19 | 0.31 | 0.18 |
| coolant tech | PBZ | Thoracic | 0.20 | 0.08 | 0.17 | 0.17 | 0.21 | 0.15 | 0.22 | 0.15 | 0.19 | 0.11 | 0.20 | 0.13 |
| crankshaft assembly | PBZ | Total | | | 0.26 | 0.19 | | | | | | | 0.26 | 0.19 |
| crankshaft assembly | PBZ | Thoracic | | | 0.21 | 0.18 | | | | | | | 0.21 | 0.18 |
| end of main washer | GA | Total | | | 0.23 | 0.19 | | | 0.34 | 0.22 | 0.26 | 0.18 | 0.27 | 0.20 |
| end of main washer | GA | Thoracic | | | 0.21 | 0.15 | | | 0.29 | 0.19 | 0.26 | 0.21 | 0.25 | 0.18 |
| pack-out | PBZ | Total | | | | | | | | | 0.51 | 0.27 | 0.51 | 0.27 |
| pack-out | PBZ | Thoracic | | | | | | | | | 0.37 | 0.27 | 0.37 | 0.27 |
| assembly -- piston table | PBZ | Total | 0.30 | 0.21 | | | | | | | | | 0.30 | 0.21 |
| assembly -- piston table | PBZ | Thoracic | 0.22 | 0.15 | | | | | | | | | 0.22 | 0.15 |
| set-up | PBZ | Total | | | 0.68 | 0.50 | 0.72 | 0.56 | 0.62 | 0.45 | | | 0.67 | 0.50 |
| set-up | PBZ | Thoracic | | | 0.47 | 0.38 | 0.53 | 0.45 | 0.52 | 0.42 | | | 0.51 | 0.42 |

**Table 12**
**Estimated Particle Size Statistics from Real-time Particulate Measurements on January 12, 2001**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**

| Machine | Portable Dust Monitor Location | Percent Respirable Fraction | MMAD (µm) | GSD | Comments |
|---|---|---|---|---|---|
| 6125 (see also Figures 1 & 2) | Located on bench to left of machine opening | 50% | 3.5 | 3.4 | Analysis of data collected at Machine 6125 indicated an estimated MMAD of 3.5 µm with a GSD of 3.4. The respirable mass fraction of the sample mass was approximately 50%. Figure 1 presents the particulate concentration at this machine. From 0745–0752, the worker started filing the inside of each part which corresponds to a rise in particulate concentration. Figure 2 presents the particle count concentration at this machine. From 1231–1233, the employee was grinding parts as described above. The other peaks may be due to the machine doors opening and closing. |
| 6116 (see also Figures 3 & 4) | Located on bench to right of machine doors | 53% | 2.6 | 2.8 | At Machine 6116, the MMAD was estimated at 2.6 µm with a GSD of 2.8. The respirable mass fraction of the sample mass was approximately 53%. Figure 3 presents the particulate concentration at this machine. The worker responsible for this machine also has tasks close to machines 6120 and 2536/2537. The largest peak in Figure 3 is associated with the worker spraying down the part which was just removed from the machine. At 0815–0816, the worker blows out holes in a part and proceeds to begin threading holes in that same part. Figure 4 presents the particle count concentration at this machine. At the time of sampling, the worker was not in the machine area. |
| 6112 (see also Figures 5 & 6) | PDM held in general location of employee working area | 53% | 2.9 | 2.9 | The estimated MMAD for Machine 6112 was 2.9 µm with a GSD of 2.9. The respirable mass fraction of the sample mass was approximately 53%. Figure 5 presents the particulate concentration at this machine. The employee in this area spent a considerable amount of time drilling holes in pieces while the machine (6112) runs. However, there was an elevation in concentration from 0837–0838, during which the worker removed a part from 6112, rinsed the part, and removed the rinsing material with compressed air. Figure 6 presents the particle count concentration at this machine. The PDM was held in close proximity to the worker's breathing zone. The employee used compressed air on parts from 1245–1248 and on the part holder from 1250–1251. The figure indicates an increase in particles during both of these time periods with the first time period showing a more pronounced peak. |
| 1164 (see also Figures 7 & 8) | Located on tool box located where employee working | 59% | 2.3 | 2.7 | The analyzation of data collected at Machine 1164 indicated an estimated MMAD of 2.3 µm with a GSD of 2.7. The respirable mass fraction of the sample mass was approximately 59%. Figure 7 presents the particulate concentration at this machine. Figure 8 presents the particle count concentration at this machine. |

**Table 12**
**Estimated Particle Size Statistics from Real-time Particulate Measurements on January 12, 2001**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**

| Machine | Portable Dust Monitor Location | Percent Respirable Fraction | MMAD (µm) | GSD | Comments |
|---|---|---|---|---|---|
| 6349 (see also Figures 9 & 10) | Located on platform to right of worker at BZ height | 36% | 4.3 | 3.0 | At Machine 6349, the MMAD was estimated at 4.3 µm with a GSD of 3.0. The respirable mass fraction of the sample mass was approximately 36%. Figure 9 presents the particulate concentration at this machine. During this sample time period, the figure shows a reduction in concentration when the worker stops work at the machine and begins measuring areas of the completed parts. This is indicated from 0955–0957 on the figure. Figure 10 presents the particle count concentration at this machine. The worker came off break and started working at 1326, which is indicated by the appearance of a peak in the figure. From 1329–1331, the worker stops to measure areas of the completed parts, during which time the particle concentration is reduced. The worker then starts to work again (presence of peak) and leaves the area at 1336. |
| 2522/ 2523 (see also Figure 11) | Located on table between 2522/2523 & 2580/2581 | 57% | 2.6 | 2.9 | The estimated MMAD for the area by Machine 2522/2523 was 2.6 µm with a GSD of 2.9. The respirable mass fraction of the sample mass was approximately 57%. Figure 11 presents the particulate concentration at this machine. During the time period shown on the graph, the PDM was located on the table between 2522/2523 and 2580/2581. |
| 2522/ 2523 (see also Figures 12 & 13) | PDM held in general location of employee working in area | 52% | 3.3 | 3.0 | The analyzation of data collected near the worker at Machine 2522 indicated an estimated MMAD of 3.3 µm with a GSD of 3.0. The respirable mass fraction of the sample mass was approximately 52%. Figure 12 presents the particulate concentration at this machine. This figure shows the concentration near the employee. From 1014–1018, the employee is grinding material off the part. The employee stops at 1018 and gets another part which is started at 1020 and finished at 1024. Figure 13 presents the particle count concentration at this machine. The worker at this machine completed two pieces during the time period sampled and stopped at approximately 1318. |

**Table 12**
**Estimated Particle Size Statistics from Real-time Particulate Measurements on January 12, 2001**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**

| Machine | Portable Dust Monitor Location | Percent Respirable Fraction | MMAD (µm) | GSD | Comments |
|---|---|---|---|---|---|
| 6166<br><br>(see also Figures 14 & 15) | Located on top of machine w/ probe over the door opening | 50% | 2.7 | 2.5 | At Machine 6166, the MMAD was estimated at 2.7 µm with a GSD of 2.5. The respirable mass fraction of the sample mass was approximately 50%. Figure 14 presents the particulate concentration at this machine. This machine is done with a part every 10–15 seconds. The machine doors automatically open, the worker pulls out parts and inserts new ones, and the doors close. Figure 15 presents the particle count concentration at this machine. In both instances (Figures 14 & 15), the PDM was set to measure at one minute intervals. The PDM probe was placed over the opening of the doors. Since the machine opens its doors every 10–15 seconds, the PDM may be measuring at points where the doors may be opened or closed, which may explain the peaks observed in both figure, especially Figure 15. |

MMAD - mass median aerodynamic diameter
µm - micrometers
GSD - geometric standard deviation

**Table 13**
**Particle Count Information from Real-time Particulate Measurements**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**

| Particle Size Range in micrometers | Machine 6125 | Machine 6116 | Machine 6112 | Machine 1164 | Machine 6349 | Machine 2522/2523 (worker) | Machine 6166 |
|---|---|---|---|---|---|---|---|
| | Particles per liter of air* + | | | | | | |
| **0.3–0.4** | 361409 | 406393 | 544799 | 405292 | 1470945 | 594689 | 360805 |
| **0.4–0.5** | 92406 | 107921 | 151857 | 105962 | 348118 | 183786 | 90214 |
| **0.5–0.65** | 32948 | 38212 | 64900 | 43967 | 135128 | 105086 | 39258 |
| **0.65–0.8** | 11092 | 12963 | 25154 | 16191 | 51204 | 59288 | 15472 |
| **0.8–1.0** | 6987 | 7966 | 16169 | 10279 | 35972 | 55541 | 10766 |
| **1.0–1.6** | 3329 | 3849 | 7943 | 5243 | 18906 | 36378 | 5690 |
| **1.6–2.0** | 1852 | 2457 | 4702 | 3370 | 13115 | 32063 | 4128 |
| **2.0–3.0** | 1539 | 1900 | 3751 | 3013 | 11646 | 29573 | 3929 |
| **3.0–4.0** | 288 | 363 | 636 | 497 | 2875 | 7018 | 952 |
| **4.0–5.0** | 145 | 207 | 356 | 231 | 1993 | 3920 | 566 |
| **5.0–7.5** | 90 | 127 | 206 | 115 | 1454 | 1734 | 300 |
| **7.5–10** | 14 | 21 | 45 | 644 | 390 | 267 | 61 |
| **10–15** | 3 | 5 | 13 | 483 | 102 | 63 | 11 |
| **15–20** | 1 | 1 | 1 | 113 | 14 | 6 | 0 |
| **>20** | 1 | 0 | 0 | 73 | 4 | 2 | 0 |

*Multiply values by 1000 to get particles per cubic meter of air
+Values are averages over the entire time period sampled at a specific machine

**Table 14**
**Volatile Organic Compound Sampling Results**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 11-12, 2001**

| Date | Location/Job | Concentration | | | |
|---|---|---|---|---|---|
| | | n-Butyl acetate (ppm) | MIBK (ppm) | Xylene (ppm) | Total HC ($mg/m^3$) |
| 1/11/01 | Single-stage assembler | 0.34 | 0.35 | 0.71 | 12.2 |
| 1/11/01 | Dual-stage assembler | 0.08 | 0.08 | 0.19 | 4.6 |
| 1/11/01 | Painter (large paint booth)* | 0.99 | 1.2 | 1.8 | 29.5 |
| 1/11/01 | Single-stage assembler | 0.38 | 0.39 | 0.74 | 13.0 |
| 1/11/01 | Pack-out | 0.40 | 0.37 | 0.96 | 17.8 |
| 1/12/01 | Tester (next to paint booth) | 0.19 | 0.22 | 0.44 | 10.3 |
| 1/12/01 | Pack-out | 0.31 | 0.31 | 0.68 | 12.5 |
| 1/12/01 | Single-stage painter | 0.33 | 0.37 | 0.63 | 10.4 |
| 1/12/01 | Piston table assembler | 0.21 | 0.22 | 0.49 | 8.4 |
| 1/12/01 | Painter (large paint booth)* | 1.8 | 2.2 | 3.1 | 49.2 |
| Minimum Detectable Concentration (MDC) | | 0.002 | 0.001 | 0.005 | 0.2 |
| Minimum Quantifiable Concentration (MQC) | | 0.01 | 0.004 | 0.022 | 0.7 |
| Odor Threshold | | 7 | 0.1 | 0.08 | 5.25 |
| NIOSH REL | | 150 | 1 | 100 | 350 |

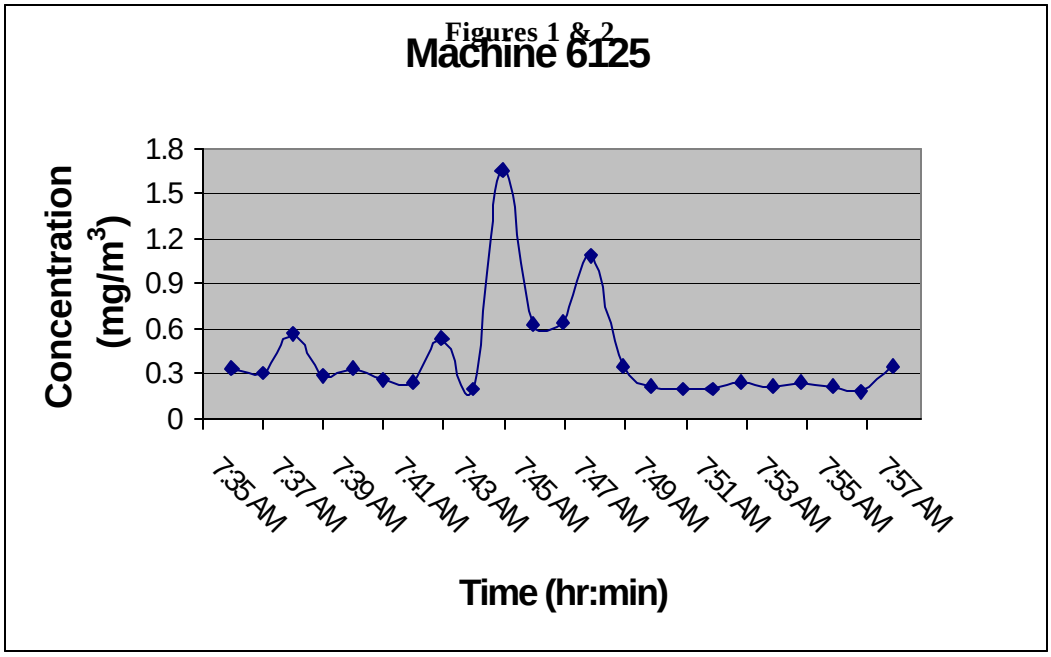
**ppm- parts per million**
**$mg/m^3$ - milligrams per cubic meter**
**MIBK = methyl isobutyl ketone**
**Total HC - total hydrocarbons, as Stoddard solvent**
***Employee wears a half-face organic vapor cartridge respirator.**

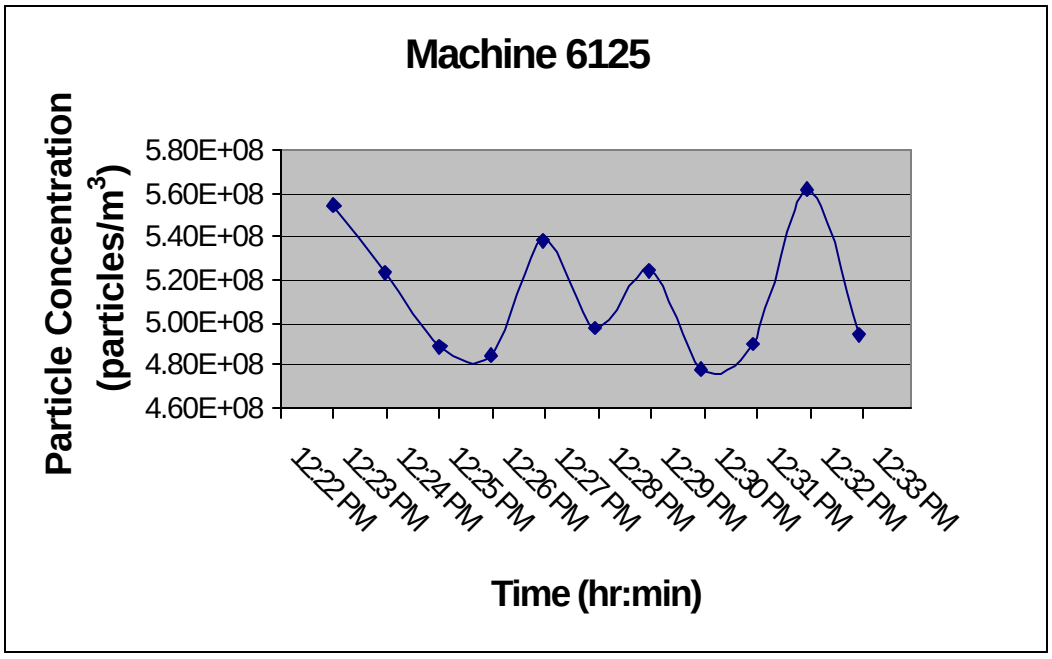
**Table 15**
**Machines where High MWF Concentrations were Measured, Separated by Severity of Overexposure†**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 8-12, 2001**

| **Highest Overexposure Machines → → → → → → → → → → → → → → → → Lowest Overexposure Machines** | | | |
|---|---|---|---|
| **Machines with Total Particulate Concentrations ≥ 1 mg/m³, Thoracic Particulate Concentrations ≥ 0.4 mg/m³, and >50% of the sample was extractable MWF** | **Machines with Total Particulate Concentrations ≥ 0.5 mg/m³, Thoracic Particulate Concentrations ≥ 0.4 mg/m³, and >50% of the sample was extractable MWF** | **Machines with Total Particulate Concentrations ≥ 0.5 mg/m³, Thoracic Particulate Concentrations < 0.4 mg/m³, and >50% of the sample was extractable MWF** | **Machines with Total Particulate Concentrations ≥ 0.5 mg/m³, Thoracic Particulate Concentrations < 0.4 mg/m³, and <50% of the sample was extractable MWF** |
| 1024/1028<br>1156<br>2522/2523/6206<br>2580/2581<br>6166<br><br>*Plus, machine 6349 because the real-time sampling data was so high (See Figure 9). | 1025/1026<br>1027<br>1043/1037<br>119/1121/1035<br>2528<br>6184<br>6292<br>6293<br><br>*Plus, the person doing set-up (or start-up) had these exposures. | 1001<br>1007/1008<br>1028<br>1121<br>6185<br>6329<br><br>*Plus, the PBZ sample on the employee doing pack-out on 1/12/01 had these exposures. | 1003/1004<br>1006/1010<br>1043<br>1045<br>1132<br>6125<br>6295<br>6296<br>6335<br>K&T1 (6112)<br><br>*Since more than 50% of each sample was not extractable MWF, the particulate exposures are likely less than half MWF. |

† To aid Campbell Hausfeld management in prioritizing on which machines to focus control measures first, this table presents a list of all the machines where high exposures were measured, separated into four categories of decreasing severity. The first column had the highest overexposures, the second one had the next highest overexposures, the third one had total particulate overexposures but not thoracic particulate overexposures, and the fourth one had total particulate overexposures that were less than 50% MWF exposure.

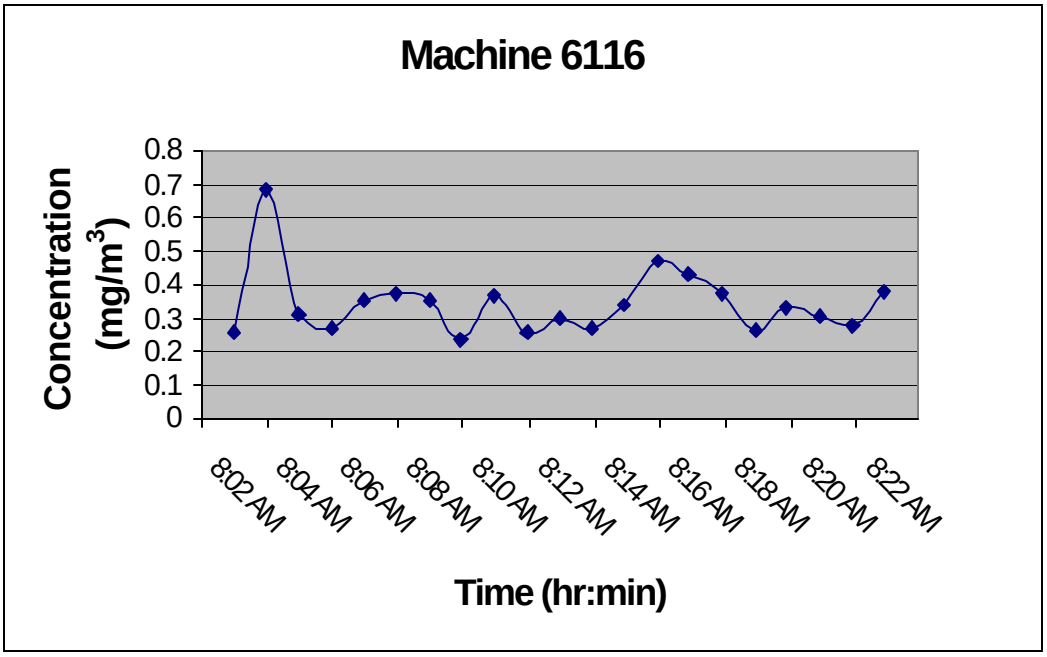
Figures 1 & 2

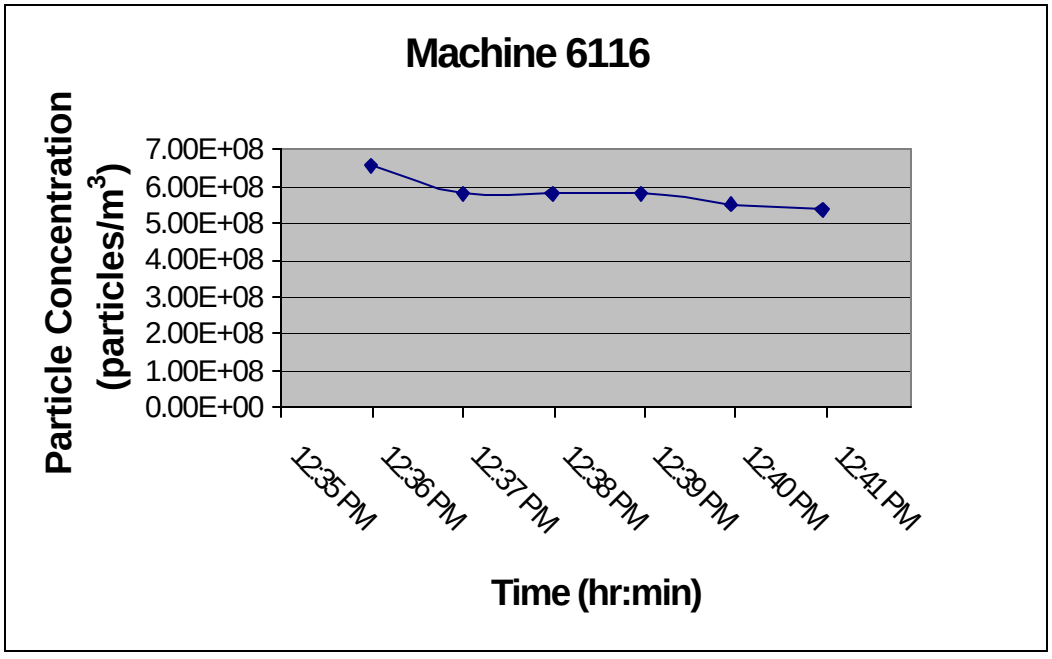


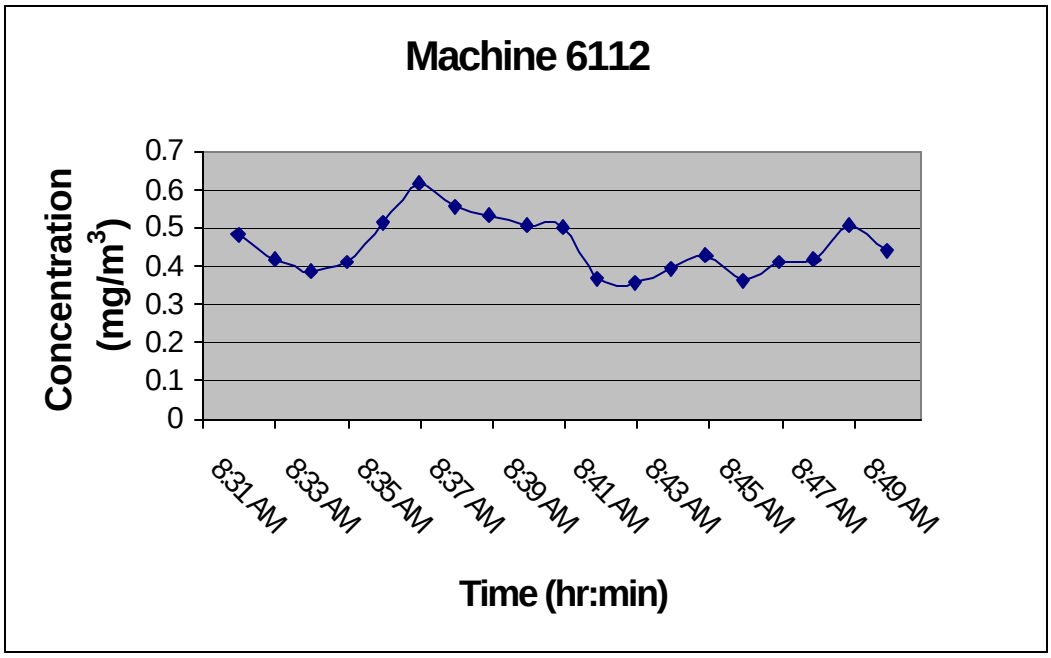

**Particle Mass Concentration and Count using PDM at Machine 6125 Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851) January 12, 2001**

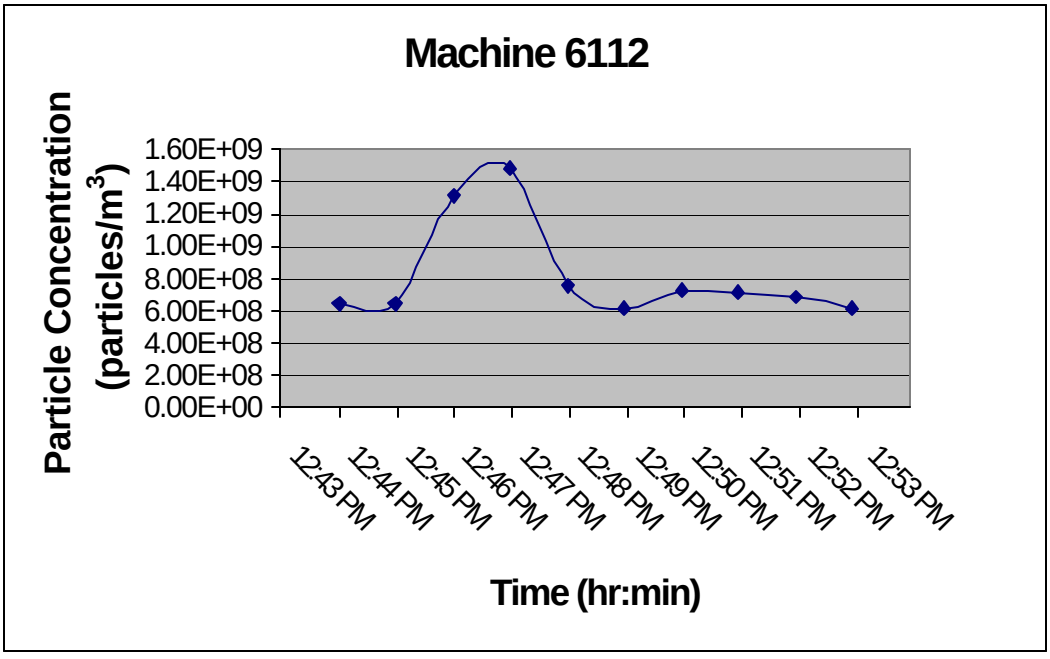
**Figures 3 & 4**
**Particle Mass Concentration and Count using PDM at Machine 6116**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



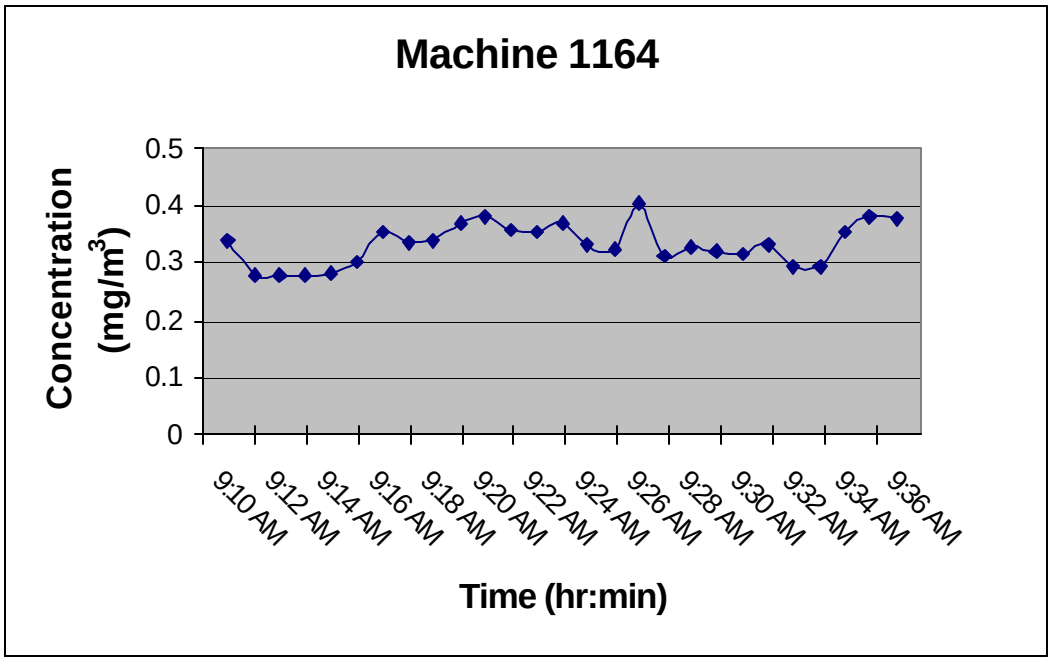



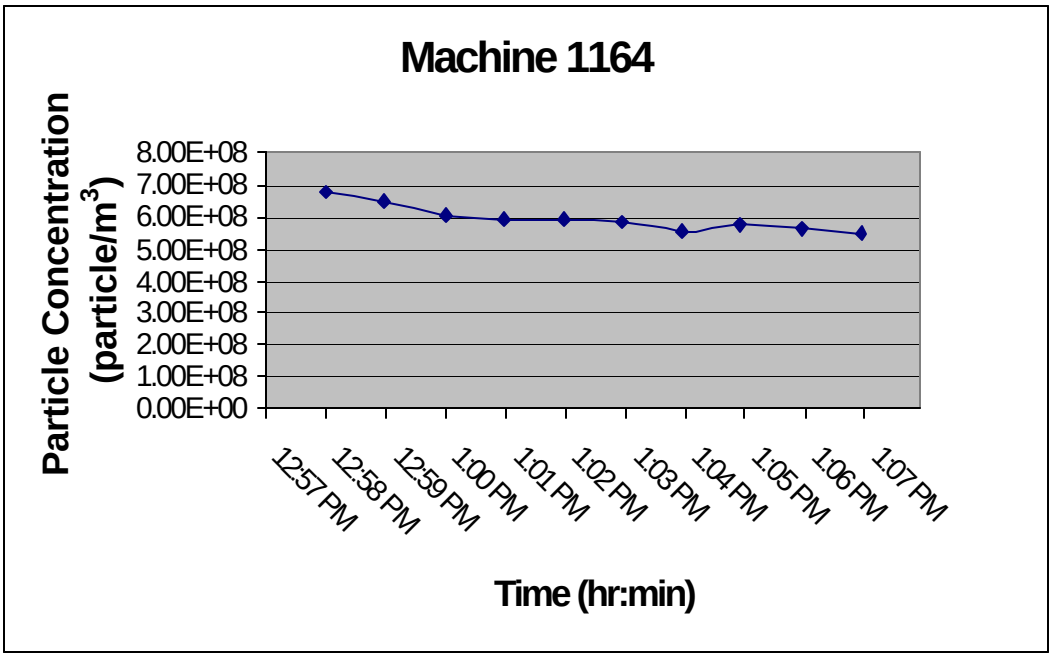
**Figures 5 & 6**
**Particle Mass Concentration and Count using PDM at Machine 6112**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



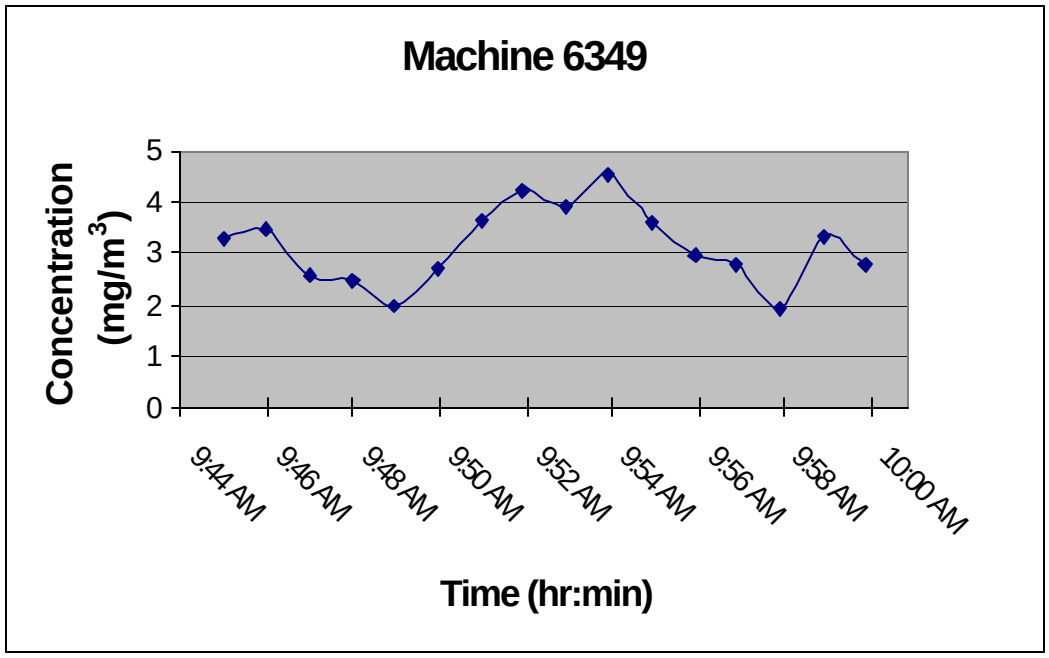



**Figures 7 & 8**
**Particle Mass Concentration and Count using PDM at Machine 1164**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



**Figures 9 & 10**
**Particle Mass Concentration and Count using PDM at Machine 6349**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



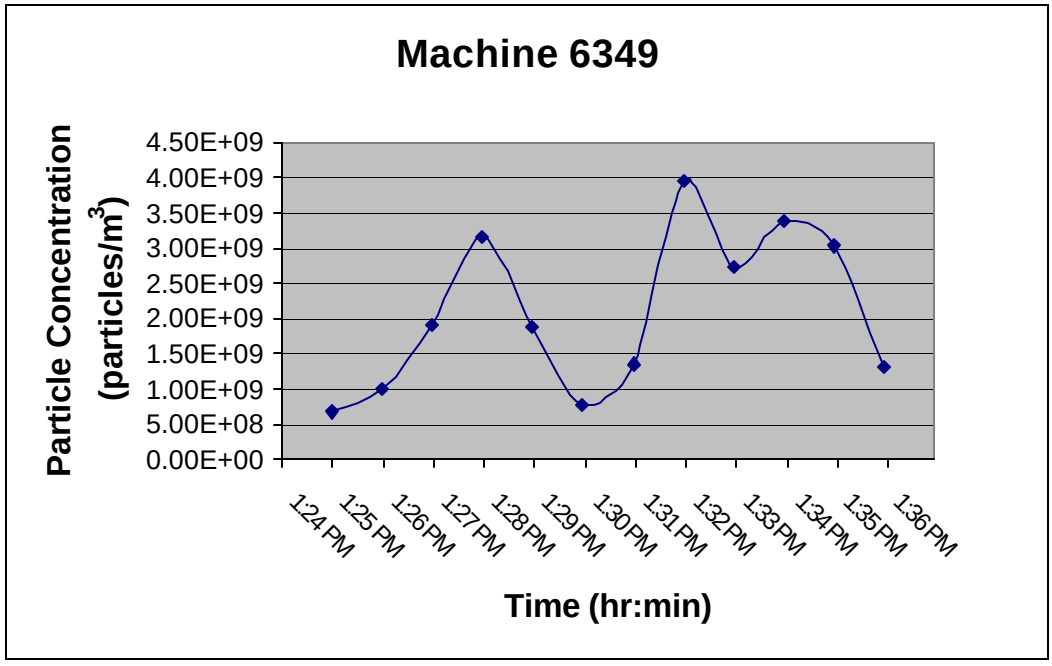
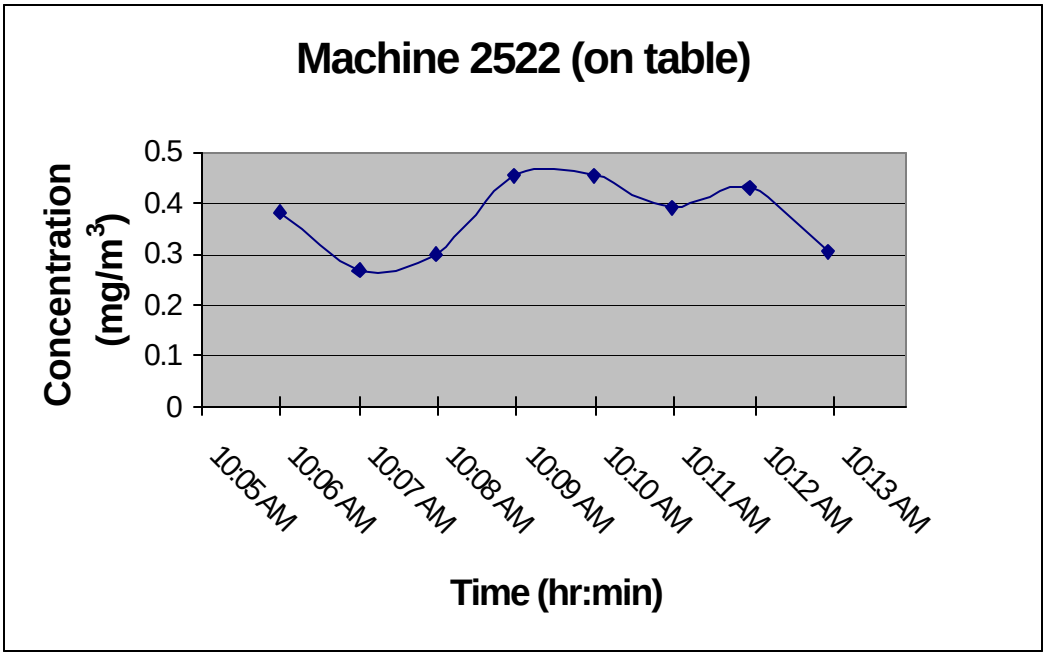
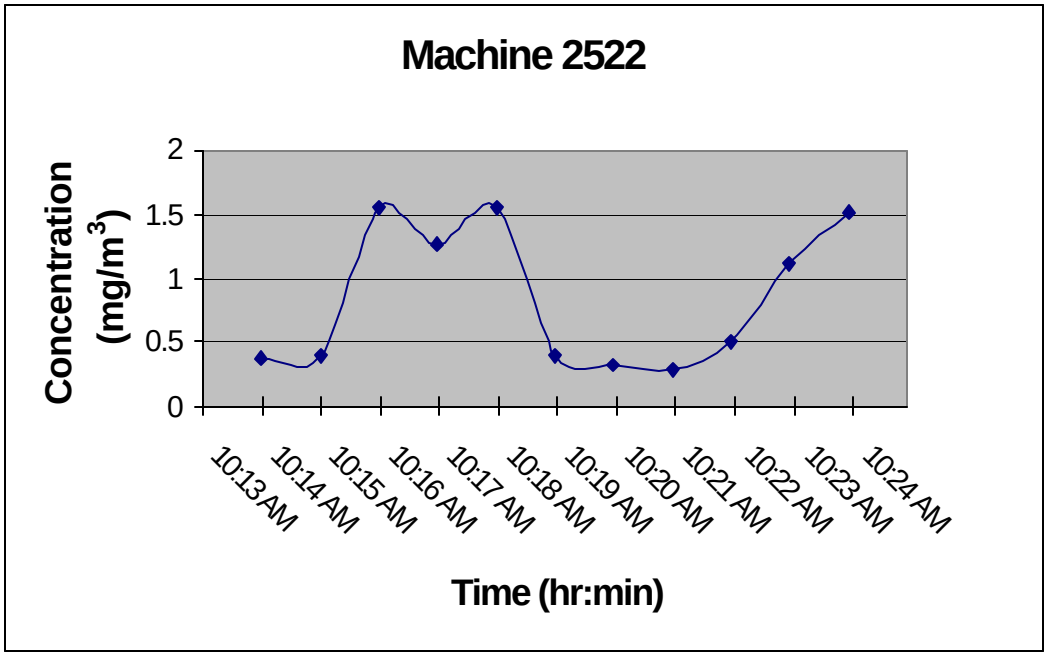
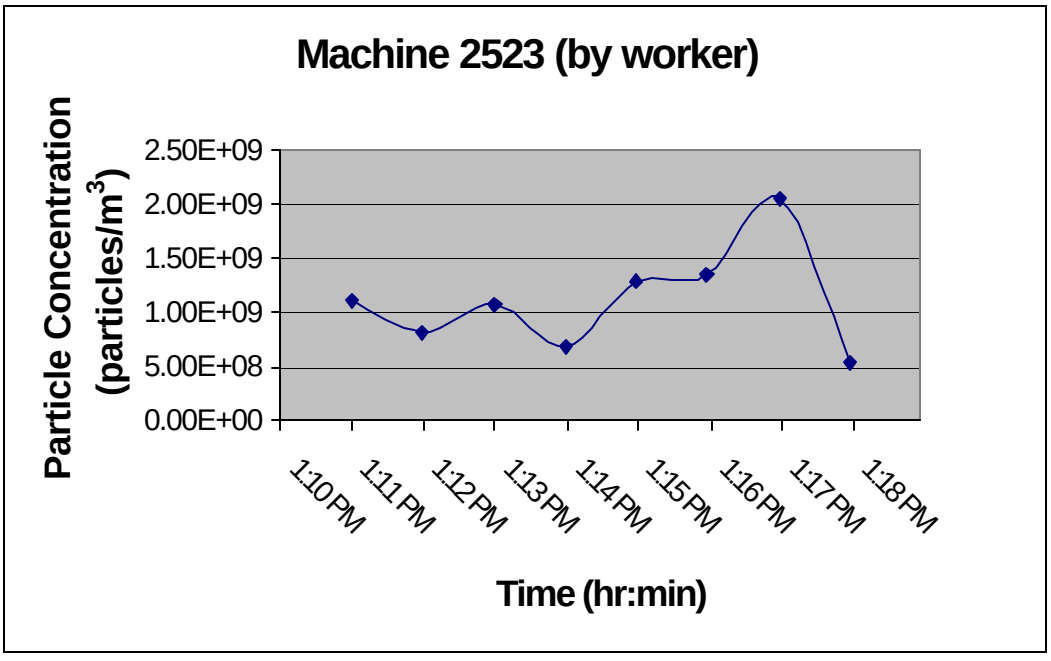



**Figure 11**
**Particle Mass Concentration using PDM at Machine 2522/2523 (on table)**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**

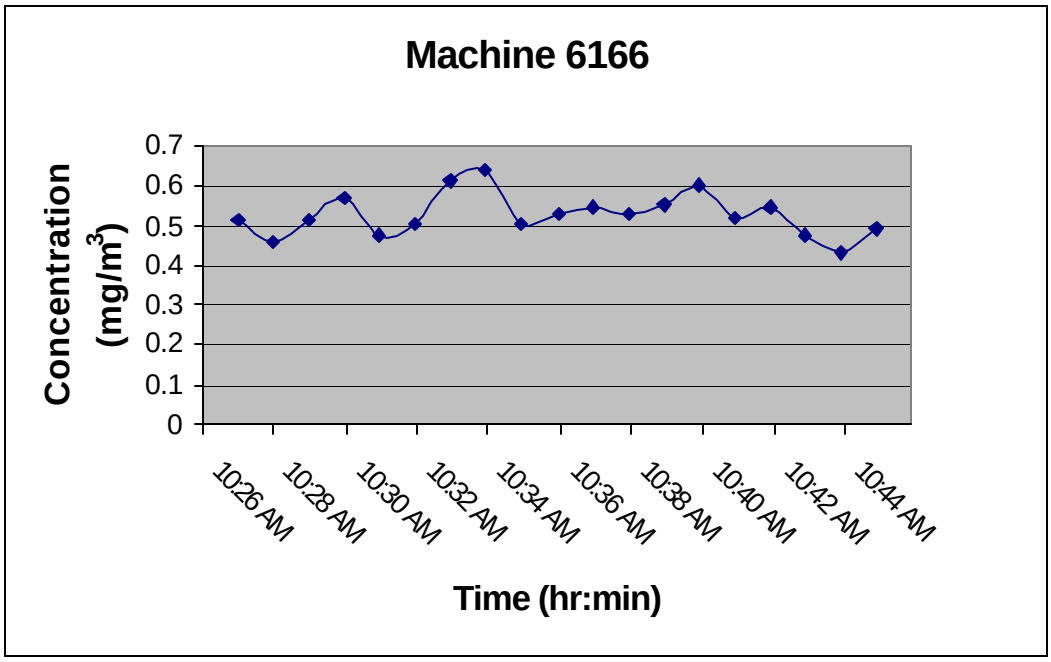


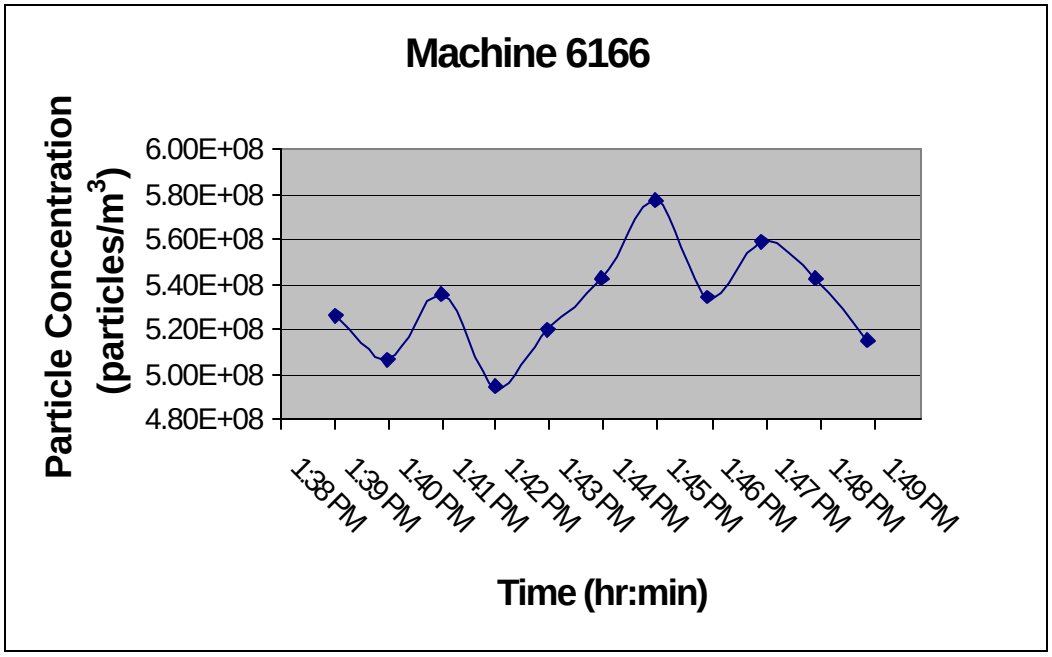
**Figures 12 & 13**
**Particle Mass Concentration and Count using PDM at Machine 2522/2523 (worker)**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



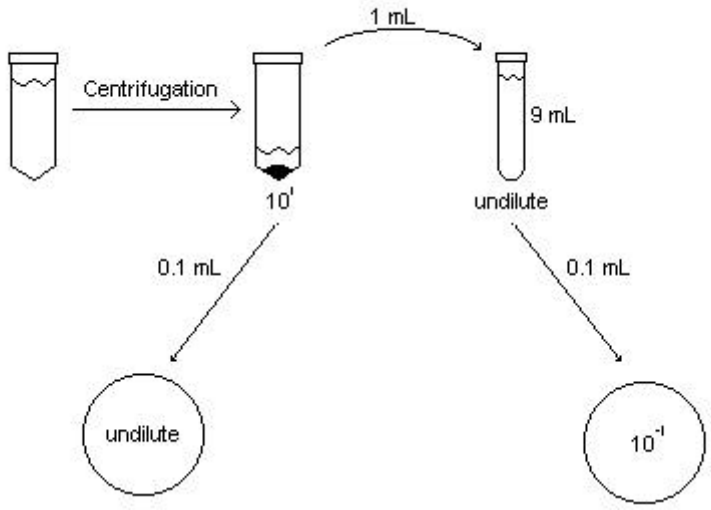
**Figures 14 & 15**
**Particle Mass Concentration and Count using PDM at Machines 6166**
**Campbell Hausfeld, Harrison, Ohio (HETA 2000-0356-2851)**
**January 12, 2001**



## Appendix A: Microbial Analysis Materials and Methods

Nine metal removal fluid samples and 2 washer water samples were analyzed for total aerobic bacterial count with speciation and count for the three predominant bacteria per sample and mycobacteria speciation and count. Each sample was transferred into 50-mL Falcon tubes and concentrated by centrifugation at 2500 RPM, 25°C, 30 minutes. Following centrifugation, the supernatant was decanted to reach $1/10^{th}$ of the original volume. Serial dilutions were made from the $10^1$ concentrated specimen using Polysorbate 80 as the diluent using the following dilution scheme:




**Aerobic Bacteria**

The original setup included inoculation of Tryptic Soy Agar with Polysorbate and Lecithin (TSAp/l) and Buffered Charcoal Yeast Extract agar (BCYE). For the field blank samples, 0.1 mL from the $10^1$ dilution, resulting in an undilute final concentration was inoculated onto a TSAp/l and a BCYE (an inoculum of 0.1 mL plated onto a standard agar Petri dish is equivalent to a 10-fold dilution). For the "used fluid" samples, 0.1 mL from the $10^1$and $10^{-1}$dilutions, resulting in final concentrations of undilute and $10^{-2}$, were inoculated onto a TSAp/l and a BCYE (some of the "used fluid" samples were overgrown at $10^{-2}$ and were diluted to $10^{-3}$ or $10^{-4}$). Agar plates were incubated in a 35°C ambient air incubator and read after 5 days.

Colonies of differing macroscopic morphologies were quantitated and subcultured to a TSA with 5% sheep's blood agar (BAP). Subculture plates were incubated in a 30°C ambient air incubator and read for 2 days (some colonies did not grow following subculture on BAP after 5 days and were subcultured from the original plate to BCYE). Following adequate growth on subculture plates, a Gram's stain, using the Gram's staining procedure, Catalase test, and Oxidase test were performed on each.

After determining the three predominant bacteria per sample, additional tests were performed on those organisms. The following is a list and brief description of the additional tests and stains utilized in identification:

***Both Gram-Positive and Gram-Negative Organisms*:**

Indole:
From a fresh subcultured BAP, an inoculum of the organism was obtained on a cotton swab and a drop of Bactidrop Indole was dropped onto the swab. Color change was noted after 5 minutes.

Temperature Studies:
After direct inoculation from a fresh subcultured BAP, temperature studies were carried out on some organisms in ambient air incubators at 25°C, 35°C, 42°C, 45°C, and 52°C.

***For Gram-Positive Cocci*:**

Penicillin Susceptibility:
A BAP was inoculated directly from a fresh subcultured BAP and a Penicillin disc was place in the first quadrant of the plate. The plate was incubated in a 35°C ambient air incubator and read after 1 day.

Vancomycin Susceptibility:
A BAP was inoculated directly from a fresh subcultured BAP and a Vancomycin disc was place in the first quadrant of the plate. The plate was incubated in a 35°C ambient air incubator and read after 1 day.

LAP (Leucine Aminopeptidase) Disc:
From a fresh subcultured BAP, a colony was inoculated on a moistened LAP disc and incubated at room temperature for 5 minutes. A single drop of cinnamaldehyde reagent was added and color change was observed for 1 minute.

PYR (Pyrrolidonyl Peptidase) Disc:
From a fresh subcultured BAP, a colony was inoculated on a moistened PYR disc and incubated at room temperature for 2 minutes. A single drop of reagent was added, the disc was incubated at room temperature for 1 minute, and color change was observed.

Carbohydrate Broth (Mannitol, Raffinose, Sorbitol, Arabinose):
After creation of a 0.5 McFarland concentration of organism in Brain Heart Infusion (BHI) broth, 2 drops of the solution were inoculated into the tubed media. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Decarboxylase Broth (Arginine):
After creation of a 0.5 McFarland concentration of organism in BHI broth, 4 drops of the solution were inoculated into the tubed media. Following inoculation, the liquid media was overlaid with mineral oil to ensure that the media was not in contact with oxygen. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Bile Esculin Azide Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 days.

Salt Tolerance Test (6.5% NaCl Broth):
After direct inoculation of 1-2 colonies from a fresh subcultured BAP, the broth was incubated in a 35°C ambient air incubator and read after 2 days.

Simmons' Citrate Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 7 days.

Pyruvate Broth:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 24-48 hours.

***For Gram-Positive Bacilli*:**

Endospore stain:
The endospore stain was performed on several gram-positive bacilli to rule out *Bacillus* spp. and aerotolerant *Clostridium* spp.

Lipase/lecithinase:
From a fresh subcultured BAP, an Egg Yolk Agar plate was inoculated with a single streak down the center of the plate. The plate was incubated in an ambient air 35°C incubator and read for 10 days for the production of lipase and lecithinase.

Triple Sugar Iron (TSI) Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 days.

Carbohydrate Bases (Dextrose, Xylose, Mannitol):
After creation of a 0.5 McFarland concentration of organism in BHI broth, 2 drops of the solution were inoculated into the tubed media. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Gelatin Liquefaction Test:
From a fresh subcultured BAP, a BHI broth was inoculated and incubated for 24 hours in an ambient air incubator at 35°C. From the BHI broth, 4-5 drops were inoculated into a tube of Thioglycollate Gelatin media and incubated in a 35°C ambient air incubator for up to 14 days. The tubed media was checked daily for gelatin liquefaction by placing the media at 4°C for sufficient time for the control to solidify, removing the media from 4°C and placing it back at room temperature, and then observing the two media for liquefaction. At room temperature, the media is semi-solid, therefore if the organism possesses gelatinases, at room temperature, the media will be a liquid instead of semi-solid.

Nitrate Test:
After creation of a 0.5 McFarland concentration of organism in BHI broth, 4 drops of the solution were inoculated into the Nitrate Broth. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Voges-Proskauer test:

From a fresh subcultured BAP, a BHI broth was inoculated and incubated for 24 hours in an ambient air incubator at 35°C. From the BHI broth, 1 drop was inoculated into the MRVP media and incubated in a 35°C ambient air incubator for 48 hours before addition of the 0.6 mL of VP solution A and 0.2 mL of VP solution B. The MRVP media is then observed for 5 minutes for color change.

Simmons' Citrate Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 7 days.

Anaerobic growth:
From a fresh subcultured BAP, another BAP was inoculated and incubated in the anaerobic chamber at 35°C for a maximum of 1 week. This BAP was used as an indicator of the organisms ability to grow anaerobically (*i.e.*, obligate aerobe, facultative anaerobe, *etc*.).

Gas chromatography:
The GC was utilized for identification of aerotolerant anaerobic bacteria (*e.g. Propionibacterium* spp.). To perform this test, colonies were inoculated into a Chopped Meat Carbohydrate (CMC) broth, sealed tightly, and incubated at 35°C until there was good turbidity. After good growth was achieved in the CMC, the volatile and non-volatile acids from fermentation were extracted and GC analysis was performed. The results of the GC analysis were compared to organism GC profiles.

***For All Gram-Negative Bacilli*:**

MacConkey Agar:
The isolates that were identified as gram-negative bacilli were subcultured to MAC and read at day 1 and 2. This was performed to determine if the organism was a lactose-fermenting organism before performing biochemical tests.

Triple Sugar Iron (TSI) Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 days.

***For Enterobacteriaceae*:**

API20E™ (BioMerieux, Inc.):
The API20E is a rapid biochemical identification system that is especially useful for identification of members of the *Enterobacteriaceae* family.

From the fresh subcultured BAP, a 0.5 McFarland concentration of the organism and saline was made. Using the 0.5 McFarland inoculum of organism, the API20E was inoculated following the manufacturer's directions. The API20E was incubated in a 35°C ambient air incubator and read after 2 days.

***For Gram-Negative Bacilli, excluding Enterobacteriaceae*:**

For gram-negative bacilli, excluding members of the family *Enterobacteriaceae*, the following biochemical tests were utilized for identification (Note: not all of these biochemical tests were necessary for each identification).

Urea Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 weeks.

Motility Agar:
After direct inoculation from a fresh subcultured BAP, the tubed media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Esculin Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 4 days.

Carbohydrate Bases (Dextrose, Xylose, Mannitol, Lactose, Sucrose, Maltose):
After creation of a 0.5 McFarland concentration of organism in BHI broth, 2 drops of the solution were inoculated into the tubed media. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Nitrate Test:
After creation of a 0.5 McFarland concentration of organism in BHI broth, 4 drops of the solution were inoculated into the broth. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

Decarboxylase Broth (Arginine, Lysine, Ornithine):
After creation of a 0.5 McFarland concentration of organism in BHI broth, 4 drops of the solution were inoculated into the tubed media. Following inoculation, the liquid media was overlaid with mineral oil to ensure that the media was not in contact with oxygen. The media was incubated in a 35°C ambient air incubator and read for 2 weeks.

SS Agar:
After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 days.

Cetrimide Agar:
Cetrimide is used for the selective isolation and identification of *Pseudomonas aeruginosa*.

After direct inoculation from a fresh subcultured BAP, the slant was incubated in a 35°C ambient air incubator and read for 2 days.

Following performance of these biochemical tests, the final quantitation and identification was then based on the macroscopic morphology, microscopic morphology (Gram's stain), Catalase test, and the Oxidase test.

**Mycobacteria**

Undiluted, untreated specimen was digested for 10 minutes using NAC-PACÔ (Alpha-Tec Systems, Inc.), a 3% solution of NaOH with N-Acetyl-L-Cysteine). Following the digestion procedure, the digested specimen was concentrated by centrifugation at 4000 RPM, 25°C, 30 minutes. The supernatant was decanted and 1 mL of the resulting $10^1$ dilution was inoculated to two BCYE, Middlebrook 7H10, and Mitcheson 7H11S agar plates, as well as two 7H9 broths with Tween. One set of media was incubated in a 22-23°C, ambient air incubator; the other set was incubated in a 35°C 7-10% $CO_2$-incubator. The plates were read once a week for 4 weeks.

Colonies of differing macroscopic morphologies were quantitated and a Ziehl-Neelson stain was performed on each. None of the colony types were Ziehl-Neelson-positive, hence they were not acid-fast and no further work was performed on these colonies. Additionally, once a week, a Ziehl-Neelson stain was performed on the growth in the 7H9 broth with Tween.

## Appendix B: Metal-removal fluids (MWFs)

In 1998, NIOSH published Criteria for a Recommended Standard: Occupational Exposure to Metalworking Fluids (DHHS [NIOSH] Publication No. 98-102).[8] This document explains in detail the health effects associated with MWFs, and I provided a copy to the Human Resources Manager during our site visit. Other copies may be ordered from NIOSH by calling 1-800-35NIOSH or downloaded off our website (www.cdc.gov/niosh/98-102.html). The following description is a brief summary of this document.

The term MWF aerosol refers to the mist generated during grinding and machining operations and the contaminants present in the mist. It may contain a variety of substances, including any component of the MWF, additives to the MWF, contaminants such as tramp oils or metals, and biological contaminants, such as bacteria and fungi, as well as their byproducts such as endotoxins, exotoxins, and mycotoxins.

There are four major classes of MWF:

1.Straight or neat oil MWFs are severely solvent–refined petroleum oils or other marine, vegetable, or synthetic oils used alone or in combination, with or without additives. They are not diluted with water.

2.Soluble or emulsifiable oil MWFs are composed of 30% to 85% severely solvent–refined petroleum oils and emulsifiers that are diluted with water, and may include performance additives.

3.Semisynthetic MWFs have 5% to 30% severely solvent–refined petroleum oils, a higher proportion of emulsifiers, and 30% to 50% water.

4.Synthetic MWFs contain no petroleum oils, and may be water soluble or water dispersable. They are diluted with water.

Workers are exposed to MWFs either through skin contact (splashes and aerosols, or handling equipment covered with MWF) or via inhalation of aerosols. The primary health effects are dermal (skin) and respiratory. Respiratory conditions associated with exposure to MWFs include asthma, hypersensitivity pneumonitis, hard metal disease if the MWF is contaminated with cobalt, acute irritation, chronic bronchitis, and rarely, lipid pneumonia and Legionellosis.

Straight oils can cause folliculitis (inflammation of the hair follicles), oil acne, oil keratosis, and squamous cell carcinoma on parts of the body contacting the MWF. The water–based oil emulsions and synthetic MWFs most commonly cause irritant contact dermatitis, and can occasionally cause allergic contact dermatitis. Dermatitis can continue despite removal from exposure.

To prevent or greatly reduce the risk of adverse health effects due to MWF, NIOSH recommended in the criteria document that airborne exposures to MWF aerosol be limited to 0.4 milligrams per cubic meter of air ($mg/m^3$) for thoracic particulate mass as a time-weighted average (TWA) for up to 10 hours per day during a 40-hour week. The 0.4 $mg/m^3$ concentration corresponds to approximately 0.5 $mg/m^3$ for total particulate mass in most workplaces. The NIOSH recommended exposure limit (REL) is based on evaluation of the health effects data, sampling and analytical feasibility, and technological feasibility. However, concentrations of MWFs should be kept below the REL where possible because some workers have developed work-related asthma, hypersensitivity pneumonitis, or other adverse respiratory health effects to MWFs when exposed at lower concentrations. There are no Occupational Safety and Health Administration (OSHA) or American Conference of Governmental Industrial Hygienists (ACGIH®) criteria for MWF aerosol.

## Appendix C: Medical Monitoring Program for Working with Metal-working fluids (MWFs)

Medical monitoring is secondary prevention. Primary preventive measures such as engineering controls are the most effective and important methods of preventing illness. However, medical monitoring does have a place in identifying workers who develop symptoms of MWF-related conditions such as asthma or dermatitis. All workers exposed to MWF above half of the REL should be included in the medical monitoring,[8] and all workers with exposure may benefit from medical monitoring. Supervision of the program should be done by a physician or other health professional who is knowledgeable about MWF-related respiratory conditions and skin diseases. Campbell Hausfeld should provide the medical director with current and previous job descriptions, hazardous exposures and their measurements, the type of PPE used, relevant Material Safety Data Sheets (MSDSs), and applicable safety and health standards.

A MWF monitoring program should include the following components:

- Initial or pre-placement exams should consist of a standardized symptom questionnaire, medical history, and skin exam, at a minimum. Spirometry would be useful to establish a baseline for future comparison.

- Periodic exams should include a brief standardized symptom questionnaire. Skin exam and spirometry may also be useful. The frequency of exams should be based on the frequency and severity of health effects at Campbell Hausfeld. If a worker does experience health effects possibly related to MWF exposure, they should be given more detailed exams.

- Following each exam, the physician should give the worker a written report that includes the results of any tests performed, the physician's opinion about any medical condition that may increase the risk of disease from exposures in the workplace, any recommended restrictions or accommodations, and recommendations for further evaluation or treatment. The physician should provide the employer with a written report that includes any recommended restrictions, a statement that the worker was informed of the results of the exam and of any medical condition that requires further evaluation or treatment. No information regarding specific findings or diagnoses should be released to the employer without a signed release of information from the worker.

- Workers should be encouraged to continue to report all potential work-related health problems to the plant medical department. These problems should be investigated on an individual basis by the company and consulting health care providers. Because the work-relatedness of health problems may be difficult to prove, each person with potentially work-related health problems should be evaluated by a physician, preferably one with expertise in occupational conditions. Individuals with definite or possible occupational diseases should be protected from exposures that may cause or exacerbate the disease. In some cases, workers may have to be reassigned to areas where exposure is minimized or nonexistent. Workers reassigned because of work-related health effects should retain seniority, wages, and other benefits to which they would be entitled had they not been reassigned.

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
www.cdc.gov/niosh

National Institute for Occupational Safety and Health
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