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ADI Systems, Inc.
Salina, Kansas

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PREFACE

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

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

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Daniel J. Hewett, CIH, of the Respiratory Disease Hazard Evaluations and Technical Assistance Program, Division of Respiratory Disease Studies (DRDS) and Charity Camaddo, MS, Clinical Investigations Branch, DRDS. Field assistance was provided by Charity Camaddo, Michael Bergman, and Angela Shen. Desktop publishing by Terry Stewart. Review and preparation for printing was performed by Penny Arthur.

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ADI Systems, Inc.
Salina, Kansas
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SUMMARY

In February 1997, the National Institute for Occupational Safety and Health (NIOSH) received a confidential health hazard evaluation (HHE) request from employees in the laser printer cartridge recycling area of ADI Systems, Inc. The requesters asked NIOSH to evaluate workers' exposures to dusts and vapors during cartridge recycling and printer ribbon re-inking. Workers reported cough, headache, dizziness, side ache, and blurred vision associated with exposures to toner dust or solvents.

On April 25 and 26, 1997, NIOSH investigators performed a walkthrough survey of the worksite. Material safety data sheets (MSDSs) of products used in the cartridge recycling area were reviewed. Potential chemical exposures to toner components include styrene acrylate copolymer, iron oxide, and polypropylene, with less dominant carbon black, "dyestuff", and amorphous silica components. Potential solvent exposures, mostly associated with the use of a solvent mixture (trade name Fedron®) were alcohols, alicyclic / aromatic hydrocarbons, ketones, esters, and naphthas.

On June 24 to 26, 1997, NIOSH investigators returned to ADI Systems to perform quantitative personal and area air sampling for dusts and chemical vapors during cartridge recycling, ribbon re-inking, and re-ink equipment cleaning. A local exhaust hood had been installed after the walkthrough survey to control solvent vapor exposures during re-ink equipment cleaning. Air velocity measurements were conducted to help determine the effectiveness of dust collector hoods and a local exhaust hood.

Personal interviews of current and former employees were conducted by NIOSH investigators on April 25 and 26 and June 24 and 26, 1997. Work and medical histories were discussed during the interviews.

A total of 11 time-weighted average (TWA) personal breathing zone (PBZ) samples were collected and analyzed for total dust, and 11 for respirable dust. A total of 2 PBZ and 3 area samples were collected and analyzed for xylene, ethyl acetate, and naphtha. Four PBZ and 6 area samples were collected and analyzed for methyl isobutyl ketone (MIBK). Two PBZ and 21 area samples were collected and analyzed for isopropanol and ethanol. Short term detector tube samples were collected for xylene, ethanol, ethyl acetate, isopropanol, and MIBK.

No PBZ and no area dust or solvent exposures exceeded full-shift TWA exposure limits or short-term exposure limits (STELs) as enforced by the Occupational Safety and Health Administration (OSHA) or recommended by NIOSH or the American Conference of Governmental Industrial Hygienists (ACGIH).

Short-term detector tubes measured exposures to isopropanol in the 800 to 1200 parts per million (ppm) range. However, longer term, task-length TWA isopropanol concentrations ranged from 0.30 to 5.1 ppm, well below TWA STELs for isopropanol.

Toner cartridge recycling workers were not exposed to concentrations of toner dusts or solvent vapors which exceeded exposure limits. If properly maintained, the half-facepiece respirator with organic vapor cartridges (OVCs) worn when cleaning re-inking equipment and refilling bottles with Fedron® should provide adequate respiratory protection from intermittently high breathing zone concentrations of isopropanol. If local exhaust capture velocities for solvent vapors are increased, the need for respiratory protection may be eliminated.

Recommendations were made to modify the function of local exhaust to increase solvent vapor capture velocities and to periodically remove toner build-up from within dust collectors to maximize the capture of toner dust by dust collectors.

Keywords: SIC 3861 (Photographic Equipment and Supplies), Toner, Styrene-acrylate Polymer, Re-inking, PNOC, Carbon Black, Solvents, Recycling.

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INTRODUCTION

In March, 1997, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from toner cartridge recycling workers for a safety and health hazard evaluation at ADI Systems, Inc. ADI Systems, Inc., in Salina, Kansas, recycles laser printer toner cartridges and printer ribbons.

The request was initiated by reports of cough, headache, dizziness, side ache, and blurred vision among cartridge recycling workers. The workers associate the symptoms with cleaning toner dust from used cartridges, re-filling cartridges, and the use of solvents to clean ink and toner residues. Some employees were concerned about exposures emitted from the use of Fedron® solvent. Others were concerned about the long term health effects of toner dust inhalation. One former worker was concerned that asthma could be triggered by vapors emitted by Fedron®, and that asthma could be induced by toner dust.

In response to this request, NIOSH investigators performed a walkthrough survey on April 25 and 26, 1997. Material safety data sheets (MSDSs) of products used by cartridge recycling workers were reviewed, toner dust filtration units were inspected, occupational safety and health program records were reviewed, and personal interviews of current and former employees were conducted.

On June 24 to 26, 1997, NIOSH investigators returned to ADI Systems, Inc. to perform an environmental survey which included quantitative air sampling for airborne dusts, and six classes of chemicals (alcohols, alicyclic/aromatic hydrocarbons, ketones, esters, and naphthas). In addition further personal interviews were conducted.

The purpose of this report is to provide observations from the two surveys, report the results of air velocity measurements and air sampling, and offer conclusions and recommendations based on observations, worker interviews, and measurement results. This is the final report of this NIOSH safety and health evaluation.

BACKGROUND

Laser printers, fax machines, and photocopiers have become commonplace in offices today. An essential component of these machines is the toner cartridge which contains the printing mechanisms and powdered black toner needed to produce printouts and photocopies. In 1991, greater than 15.2 million toner cartridges were used in the United States. Of these, 70 to 80 percent were discarded. The toner cartridge recycling and ribbon re-inking industry is part of an office supply recycling industry which emerged in response to environmental concerns about the increasing amounts of office waste.[1] The industry developed in the mid-1980's and has grown to include more than 4,000 small businesses. Between 1990 and 1992, the market for recycled toner cartridges grew by 133 percent. The number of recycled cartridges jumped from 0.78 million in 1990 to 4.23 million in 1992.[2]

ADI Systems, Inc., in Salina, Kansas, is a small company in the office supply recycling industry that services a four state area in the midwest. The company re-inks ribbons and cartridges for dot-matrix and ink-jet printers, recycles toner cartridges for laser printers, services printers in the field, and provides computer consulting services. An average of 685 cartridges are recycled or re-inked per month.

Four to six workers are assigned to the cartridge recycling area; two supervisory technicians and four cartridge recycling technicians (hereafter referred to as "recyclers"). Two managers and two office workers are positioned outside of the recycling area; seven workers are assigned to the field in computer support, sales, or service positions.

The ADI Systems Inc. building has been occupied by the company since September 1995. The building is constructed of cinder block with one main entrance. Offices are located in a third of the building. The toner cartridge recycling area is located in the rear third of the building. A small room called the breakdown room, workbenches in the main workroom, and a small area in a storage room comprise the recycling area. Disassembly and toner refilling take place in the breakdown room. Disassembly, assembly, testing, packaging, ribbon re-inking, and ink jet cartridge filling take place in the main workroom. Cleaning of ribbon re-inking and ink jet cartridge equipment is performed near a restroom in a rear storage area. Bottles of toner are shelved in the breakdown room. Fedron® solvent is stored in the rear storage area next to the restroom, along with boxes of recycled and new toner cartridges. The main workroom contains printers used to test the recycled cartridges and provides storage for additional supplies. There are door exits in the breakdown and main workrooms. These doors remain closed, as the building is air conditioned.

Four to five recyclers work from 8:00 a.m. to 5:00 p.m., five days per week. One to two recyclers are assigned to the breakdown room, where cartridges are disassembled, refilled with toner, and partially reassembled. One to two workers complete the reassembly and test cartridge print quality. One supervisor is solely responsible for re-inking ribbons and cartridges, cleaning re-inking equipment with Fedron®, and refilling plastic bottles with Fedron®, in addition to helping other workers. Another supervisor disassembles, re-fills, reassembles, and tests certain cartridges that are less often recycled, referred to as "specialty" cartridges. All recycling department employees are responsible for clean-up duties on Fridays.

The recycling area ventilation system is general exhaust by a kitchen-type exhaust fan positioned in the breakdown room, and supply air provided by a rooftop package-type heating, ventilating, and air conditioning (HVAC) system that services the entire building. Two filtered dust collection devices are used to capture toner dust. One dust collector is positioned in the breakdown room. An identical unit, which is generally not operated, is positioned in the main workroom. The dust collector hoods are four-sided, square inlets with four square foot faces. Toner enters the dust collector, where it is prefiltered by two fiberglass mesh filters and a final bag-type cloth collector. The two prefilters in the dust collectors are changed twice per month, the final filter is changed once per month. Cleaned air enters a centrifugal fan, then exhausts from the rear of the unit through a grill near the floor. Other toner dust collection devices in the breakdown room include two high efficiency particulate arrestance (HEPA) filtered vacuum cleaners. A local exhaust canopy type hood was installed in the period between the walkthrough and environmental surveys. This hood helps capture solvent vapors produced during equipment cleaning. A humidifier in the main workroom maintains the relative humidity above 50% to prevent uncontrolled discharge of the corona wire on test laser printers.

The toner cartridge recycling process is similar for each cartridge type that is recycled. Used cartridges are disassembled with a screwdriver at a workbench in the breakdown room. After disassembly, residual toner inside the cartridge is removed by shaking the toner from the cartridge into a slot in the dust collector hood. The slot empties into a trash can; toner is dumped into the slot if possible, to avoid collection by the filters. Compressed air is used to blow toner out of the cartridge and off of surfaces while the worker holds the cartridge in front of the dust collector hood. At the workbench, the cartridge is partially reassembled and toner caps are inserted into the cartridge. The cartridge is refilled with toner outside of the dust collector hood. New toner is forced into the cartridge from a plastic squeeze bottle. A HEPA vacuum is used to remove loose toner from the cartridge and toner caps. Workers use also use cotton swabs and isopropanol to clean certain areas of the cartridge. The cartridge is carried to the reassembly workbench in the main workroom, where assembly is completed. Lubricants are applied to the movable parts of the cartridge. The cartridge is inserted into a laser printer for testing, then weighed, placed into a plastic bag and heat sealed, then boxed. Occasionally, all recyclers help disassemble and assemble SX type cartridges in batches. Work activities vary significantly depending upon the number of recycle orders. Typically, about 4 to 6 cartridges are disassembled, cleaned, filled, and reassembled per worker per hour; several workers can clean up to 72 SX type cartridges in about 1 hour; batches are done on Mondays for four to six hours. Specialty cartridges are recycled three days per week for a total of about three hours. Cartridges other than specialty or SX types are recycled as needed.

Ink jet cartridges are refilled by forcing ink into the cartridges with a syringe. The ink used in the ink jet cartridges is water soluble; cleanup of these cartridges and the syringe is performed in the bathroom sink. The re-inking process for dot matrix printer ribbons involves positioning used ribbons on small machines that rotate the ribbons slowly, uniformly distributing ink from an ink reservoir or "ink bucket" onto the ribbons. A worker monitors the machines when they are in use, refilling the ink reservoirs as needed. Most re-inking processes require little contact with the ribbon and ink except to refill the ink reservoirs. However, some re-inking processes require more handling. For example, some dot matrix printers have very large spools of ribbon which must be wound tightly after being re-inked. This requires that the worker apply pressure to the re-inked spool as it is being rewound. Ink buckets are emptied into a trash can under a local exhaust hood in a storage area, where Fedron® is used to remove ink residue from the buckets. Up to 20 ribbons are re-inked on Mondays or Wednesdays for about one to three hours; about 10 ink buckets are cleaned 3 to 4 times per week, taking 30 to 40 minutes. About four to five ink jet cartridges are refilled per day at two minutes per filling.

Workers have vinyl gloves, dust / mist respirators, and cloth aprons available for use. One worker who cleans equipment with Fedron® solvent began to wear a half-mask respirator equipped with an organic vapor cartridge (OVC) during the period between the walkthrough and environmental surveys. Workers do not typically wear respiratory protection against toner exposures unless a particular type of toner is perceived to be especially prone to aerosolization. Gloves are typically worn by a worker who fills ink jet cartridges and cleans ink buckets. Paper towels are used to reduce skin contact with the inks. Cloth aprons are typically worn by workers.

METHODS

Personal interviews of current and former employees were conducted by NIOSH investigators on April 25 and 26 and June 24 and 26, 1997. Work and medical histories were discussed during the interviews.

During the April 25 and 26 walkthrough survey, dust collector hoods were modified with cardboard to determine if capture velocities could be improved. Air velocity measurements at dust collector hoods were performed with an Airflow TA-2 thermal anemometer with a range of 0 to 6000 feet per minute (fpm). Air velocity at a local exhaust hood was measured by timing the movement of smoke.

A list of chemicals in products used at ADI Systems, Inc. during cartridge and ribbon recycling was compiled. The chemical information was obtained from MSDSs.

The following 7 chemicals or mixtures were selected for environmental air sampling at ADI Systems, Inc. during the June 24 and 26, 1997, survey: ethanol, ethyl acetate, isopropanol, methyl isobutyl ketone (MIBK), naphtha, toner, and xylene.

Two types of air samples were collected to determine worker exposures: personal breathing zone (PBZ) samples and area samples. Sampling periods were full-shift, and partial-shift (task length or less). Sampling periods did not include lunch or break periods; these breaks were taken outside of the recycling area.

Full-shift PBZ toner dust and chemical vapor samples were collected from four recycle workers (workers #1 through #4). Partial-shift and detector tube PBZ chemical vapor samples were collected from worker #2 while the worker cleaned ink buckets with Fedron®.

A total of 11 PBZ samples were collected and analyzed for total dust, and 11 for respirable dust. A total of 2 PBZ and 3 area samples were collected and analyzed for xylene, ethyl acetate, and naphtha. Four PBZ and 6 area samples were collected and analyzed for MIBK. Two PBZ and 21 area samples were collected and analyzed for isopropanol and ethanol. Short term detector tube PBZ samples were collected for xylene, ethanol, ethyl acetate, isopropanol, and MIBK. See Figure 1 for the locations of the area samples (locations #1 through #4) in relation to work areas. Area samples were collected at a height of approximately five feet.

Chemicals collected on the charcoal tubes were quantitatively analyzed by gas chromatography using a modified combination of NIOSH Analytical Methods 1457, 1501, and 1550 for ethyl acetate, naphtha, and xylene. Method 1400 was used for ethanol and isopropanol, 2500 for MIBK, and 0500/0600 for toner dust.[3] Table 1 describes in more detail the sampling methods used during the survey.

In addition to environmental air sampling and air velocity measurements, the hazard communication program was reviewed and processes/work practices were observed to identify potential workplace hazards.

EVALUATION CRITERIA

Chemical Exposures

Table 2 lists the chemicals that were selected for sampling and specific health effects associated with the chemicals.[4]

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[4], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs™)[5], and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[6]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations (CFR). The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELS included in this report reflect the 1971 values.

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

Table 3 lists the chemicals sampled and the NIOSH, ACGIH, and OSHA exposure criteria for each chemical. These exposure criteria have been derived from human and animal toxicological data and from industrial experience. The objective of these criteria is to establish levels of exposure to which most workers may be exposed, from 8 to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. Differences between the NIOSH RELs, OSHA PELs, and ACGIH TLVs® may exist because of different philosophies and interpretations of technical information.

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. Some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase overall exposures. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

Capture Velocities

Measurements of linear air velocities at local exhaust and dust collector hoods were compared to recommended linear air velocities for the capture of smoke, gases, and vapors.[7] Linear air velocities inside hoods that are recommended for capture of vapor, gas, or smoke dispersions with practically no velocity into quiet air range from 50 to 100 feet per minute (fpm). For active generation of particulates in a zone of rapid air motion, recommended linear air velocities range from 200 to 500 fpm. Higher velocities (500 to 2000 fpm) are recommended if particulate is released at high initial velocity into a zone of rapid air motion.

RESULTS

Air Samples

Results of the environmental air sampling are listed in Tables 5 through 11 in the Appendix. Minimum quantifiable concentrations (MQC) or minimum detectable concentrations (MDC) are noted in the tables. The MQC and MDC are based on the limit of quantification or detection, which are the smallest quantity of analyte that can be quantified or detected with an acceptable level of precision. The MQCs and MDCs are calculated by dividing limits of quantification or detection by the sampling volume of each sample. All samples were collected from June 24 to 26, 1997.

Full-shift Area Samples

All full-shift area solvent vapor samples (see Appendix Tables 5-7) were above quantifiable concentrations. Concentrations of these chemicals were well below full-shift TWA exposure limits. Concentrations of isopropanol ranged from 1.3 to 5.0 ppm; ethanol from 0.030 to 0.85 ppm; xylene from 0.22 to 0.61 ppm; ethyl acetate from 0.029 to 0.047 ppm; naphtha from 0.68 to 1.6 ppm; and MIBK from 0.006 to 0.024 ppm.

Full-shift Personal Samples

All full-shift personal total toner dust samples (see Appendix Tables 8-9) were above quantifiable concentrations. About half of the respirable dust concentrations were above MDCs. All toner dust concentrations were well below applicable full-shift TWA exposure limits. Total dust concentrations ranged from 0.091 to 1.6 mg/m^3; quantifiable respirable toner dust concentrations ranged from 0.025 to 0.076 mg/m^3.

Partial-shift Personal Samples

Eight partial-shift personal solvent vapor samples were collected during ink bucket cleaning and Fedron® bottle filling (see Appendix Tables 10-11). Concentrations of these chemicals were well below TWA STELs. Concentrations of isopropanol ranged from 0.3 to 5.1 ppm; ethanol from 2.3 to 47 ppm; xylene from 4.0 to 8.5 ppm; ethyl acetate from 0.29 to 0.56 ppm; naphtha from 4.0 to 6.9 ppm; and MIBK from below the MQC (0.040) to 0.70 ppm.

Short-term Detector Tube PBZ Samples

Twelve short-term PBZ solvent vapor samples were collected during ink bucket cleaning and Fedron® bottle filling (see Appendix Table 12). Concentrations could not be directly compared to STELs, which are TWAs of 15-minute sampling periods; detector tube samples are five minute samples. Concentrations of isopropanol (800 and 1200 ppm) could be characterized as intermittently high in comparison to the 15 minute TWA NIOSH and ACGIH STEL of 500 ppm.

Air Velocity Measurements

Local Exhaust

Smoke movement underneath the canopy from the trash can to the fan was measured at 15 feet per minute (fpm).

Dust Collectors

Use of compressed air inside dust collector hoods causes air velocities in excess of 300 fpm to push toner out of the hood. During the walkthrough survey, the dust collector in the breakdown room (with clogged filters) had an average capture velocity at the face of 34 fpm. The dust collector in the breakdown area was modified with cardboard to improve average capture velocity. After adding a 2" baffle, lowering the top front 6", making a 14" sash opening, and narrowing the slot in the bottom of the hood to 4", average velocity increased to 90 fpm. New filters increased velocity to 108 fpm. Cleaning excess toner from interior surfaces increased velocity to 190 fpm. During the environmental survey, the unmodified dust collector in the breakdown room, with clean filters, had an average capture velocity of 90 fpm.

Recycle Worker Interviews

Personal interviews were conducted with six workers during April 25 and 26, 1997. Five of the six had been employed at ADI Systems, Inc. as recycle workers for one month or less. Workers were curious as to the long term effects of toner inhalation. Workers reported toner dust in the nose. One worker experienced dizziness, lack of coordination, and lightheadedness experienced about once per month during Fedron® use. Workers reported watery eyes (1) and hay fever (1).

Interviews were conducted with four workers on June 25, 1997. Three of the four had been employed with ADI Systems, Inc. for less than three months. One reported childhood and adult asthma; no asthma attacks were experienced at work. Two were former smokers, one a current smoker. Workers reported hay fever (3), cough (1), chest tightness (2), itchy eyes (3), wheezing (1), and phlegm (1).

Interviews with two former ADI Systems, Inc. workers were conducted on June 26, 1997. One worked as a recycle worker (2 years) and another worked in service (3 years). One reported adult asthma with onset during work at ADI Systems, Inc. Both are former smokers. Both workers reported cough, phlegm, shortness of breath, chest tightness, wheezing, and itchy eyes during work at ADI Systems, Inc. Both reported relief from symptoms after leaving employment with ADI Systems, Inc.

DISCUSSION

Isopropanol concentrations measured with detector tubes during ink bucket cleaning ranged from 800 to 1200 ppm. However, partial period personal samples of isopropanol during cleaning indicate that 7 to 10 minute TWA concentrations of isopropanol are well below NIOSH and ACGIH STELs. Therefore, the canopy type local exhaust ventilation is not effective in controlling intermittently high PBZ exposures to isopropanol. Capture velocity measurements of 15 fpm were well below the 50 fpm recommended capture velocity for gases and vapors recommended in the ACGIH Industrial Ventilation Manual.

According to the ACGIH Industrial Ventilation Manual, capture velocities as high as 500 fpm or more may be required to capture toner dust effectively when compressed air is used in the hood of the dust collector. Capture velocities (90 to 190 fpm) at dust collector hoods were too low to be completely effective at capturing toner dust. Even with less than effective capture of toner, exposures to toner dust were well below applicable exposure limits. Capture velocity measurements of the dust collector in the breakdown room indicate that changing filters and cleaning the build-up of the strongly electrostatic toner from the interior of the dust collectors can help increase capture velocities.

A variety of toner MSDSs and toner labels for toner refills in use at ADI Systems, Inc. were reviewed, including those for Sharp®, Minolta®, Okidata®, IBM®, Xerox®, Brother®, Hewlett Packard®, Fuji®, and Epson® toners. Commonly listed toner ingredients include a variety of styrene acrylate copolymers, iron oxide, and polypropylene. Less frequently listed were carbon black, varieties of "dyestuff", and amorphous silica. Quaternary ammonium salts and styrene acrylic resin were also listed. Table 4 lists similar chemical compounds or trade names listed within MSDSs at ADI Systems, Inc., and the percent of the chemical as an ingredient in 28 different toner products. A review of the scientific literature indicates that toner can contain; charge control agents (alkylchlorosilane [silanol ester][8], fumed silica[8], quaternary anilunium and ammonium salts[9], polyvinylidene fluoride[10], polymethylmethacrylate[10]), binders (styrene-n-butyl methacrylate[11], n-butyl acrylate[11], vinyltoluene-butadiene copolymer[12], styrene allyl alcohol copolymer[12], acrylic and polyamide resins[12]), small-particle additive (polytetrafluoroethylene[13]), pigments (carbon black), and release agents (polydimethylsiloxane oil[14], polyethylene wax[14]). MSDSs and the literature indicate that toner is a complex, often proprietary mixture. Toner particles vary in size and shape from product to product because image quality depends on particle size and shape.[15] In turn, particle size affects the ability of a particle to reach the deep lung tissue; therefore adverse effects are dependent, in part, upon size.[16] Toner MSDSs are not very revealing in terms of specific chemical names and toxicological data. MSDSs for toners that were reviewed cite the OSHA PNOR standards of 15 mg/m^3 total and 5 mg/m^3 respirable toner dust as applicable exposure limits. Some cite the ACGIH PNOC standard of 10 mg/m^3 total dust. Others cite the NIOSH, OSHA and ACGIH 3.5 mg/m^3 total dust exposure limit for carbon black.

When workers were asked if they felt that they had developed health problems as a result of their work at ADI Systems, Inc., some symptoms were reported. The symptoms of dizziness, lack of coordination, and lightheadedness experienced about once per month during Fedron® use were consistent with solvent exposure.[17,18,19,20] One former worker reported adult asthma with onset during work at ADI Systems, Inc. that the employee attributed to inhalation of toner dust. A review of the scientific literature indicates that toner exposure is not implicated in inducing asthma, nor are ingredients of toners identified by this investigation.[21,22,23] Further reviews did not identify any components of toner as carcinogens.[19,24,25]

Since two of the activities of this business is blowing toner dust out of cartridges with compressed air and solvent use, without proper engineering controls or personal protective equipment, the potential exists for exposure to dust and solvent odors. Although toner is not implicated as an asthma inducer, exposures to toner dust and solvent odors can be implicated as asthma triggers.[23]

Animal exposure studies involving rats show that toner exposures can result in impaired but reversible alveolar clearance, toner deposition in the lung, and mild fibrosis. Exposure to toner at high concentrations exceeding 40 mg/m^3 resulted in irreversible impairment of alveolar clearance, excessive deposition of toner in the lung tissue, and fibrosis. The respiratory effects observed at higher toner exposures are likely attributed to excessive lung particulate burden and lung overloading. Animal exposure studies also suggest that toners are not carcinogenic since formulations were developed with high purity carbon black[37,26,27,28,29, 30] Experimental results from one human inhalation study showed that brief exposures to toner dust concentrations at 2 mg/m^3, 10 mg/m^3, and 25 mg/m^3 did not affect mucocilliary clearance or lung function among study participants.[31] Siderosilicosis has been diagnosed in a woman who worked for six years in a photocopy shop. Lung biopsy showed iron in macrophages and mild interstitial fibrosis. Both the photocopier dusts she was exposed to and her lung biopsy cells contained iron and silicon.[32] Granulomatous pneumonitis and mediastinal lymphadenopathy was diagnosed in a man whose only exposure to photocopier toner was described as "changing toner". Toner dust and lung cells contained various quantities of iron, copper, aluminum and silicon; few particles (silicon and copper) were found in lymph nodes.[33] The authors explained that exposure to metals in the toner may have induced a specific cellular immune response, which is not completely understood.[34,35,36]

The OSHA criteria for classification of a substance as a PNOR is that it is an "inert" substance or nuisance dust. The PNOR standard does not apply to toner; this dust cannot be considered inert because two components of the toner (carbon black and iron oxide) are listed as having exposure limits. In addition, incomplete ingredient identification and toxicological information in toner MSDSs make it difficult to ascertain whether or not a particular toner is inert.

Bellman et. al. suggest that toner can be categorized as a "nuisance dust", therefore the ACGIH PNOC criteria are applicable.[37] The criteria for the classification of a substance as a PNOC would include the following: 1) the architecture of the air spaces remains intact; 2) collagen (scar tissue) is not formed to a significant extent; and 3) the tissue reaction is potentially reversible.[38] A basis for limiting exposure to "toner dust" is impeded by the variability of the fraction of components in toner products. Because toner products vary so widely in chemical composition, the ACGIH PNOC standard cannot be applied with certainty to all types of toner dusts.

The 29 Code of Federal Regulations (CFR) 1910.1200 (d)(5)(ii)[6] states that mixtures that have not been tested as a whole to determine whether the mixture is a health hazard shall be assumed to present the same health hazards as do [non carcinogenic] components which comprise one percent or greater of the mixture. The mixture is assumed to carcinogenic if carcinogenic components comprise one tenth percent or greater of the mixture. The components of toner that clearly limit exposure to toner mixtures are carbon black and iron oxide. Exposures to carbon black containing toners should be limited to no more than the OSHA TWA carbon black standard; 3.5 mg/m^3 total dust. If iron oxide is present without carbon black, the exposure limit is the OSHA TWA iron oxide standard; 10 mg/m^3, or the lower NIOSH and ACGIH standard; 5 mg/m^3.

CONCLUSIONS

No exposures to toner or solvents were above applicable exposure limits. Exposure measurements indicate that the local exhaust capture velocity is not effective in controlling intermittently high isopropanol solvent vapor concentrations.

Capture velocities of dust collectors were improved by about 75% when toner build-up was removed from the interior surfaces of the dust collector. Toner dust probably creates a rough surface which impedes the flow of air inside the dust collector.

RECOMMENDATIONS

The use of an OVC equipped half mask respirator during Fedron® solvent use should be continued to control intermittently high isopropanol exposures; the need for respiratory protection could be eliminated by increasing the capture velocity of the local exhaust such that solvent vapors are effectively pushed from the breathing zone of the worker into the hood. This can be accomplished by increasing the horsepower of the exhaust fan in the existing canopy type hood. However, this canopy hood design is not recommended since the worker must bend over the source of the isopropanol. A better hood design would be one that is closer and more able to surround the area of solvent use (see Figure 2). Fan capacity should allow capture velocities in the area of solvent use to be in the range of 50 to 100 fpm in order for vapors and gases to be effectively captured and pulled away from the breathing zone.

Due to the adhesion of the electrostatically charged toner on interior surfaces, the cleaning schedule for air cleaners should be evaluated to ensure that filters are replaced and the dust collector is cleaned before capture velocities are significantly reduced at dust collector hoods. To help maintain the effectiveness of the dust collectors, periodically remove toner from interior surfaces by removing the pre-filters and blowing toner from the inside walls of the dust collector with compressed air. Operate the dust collector during this procedure so that the final filter can collect the toner.

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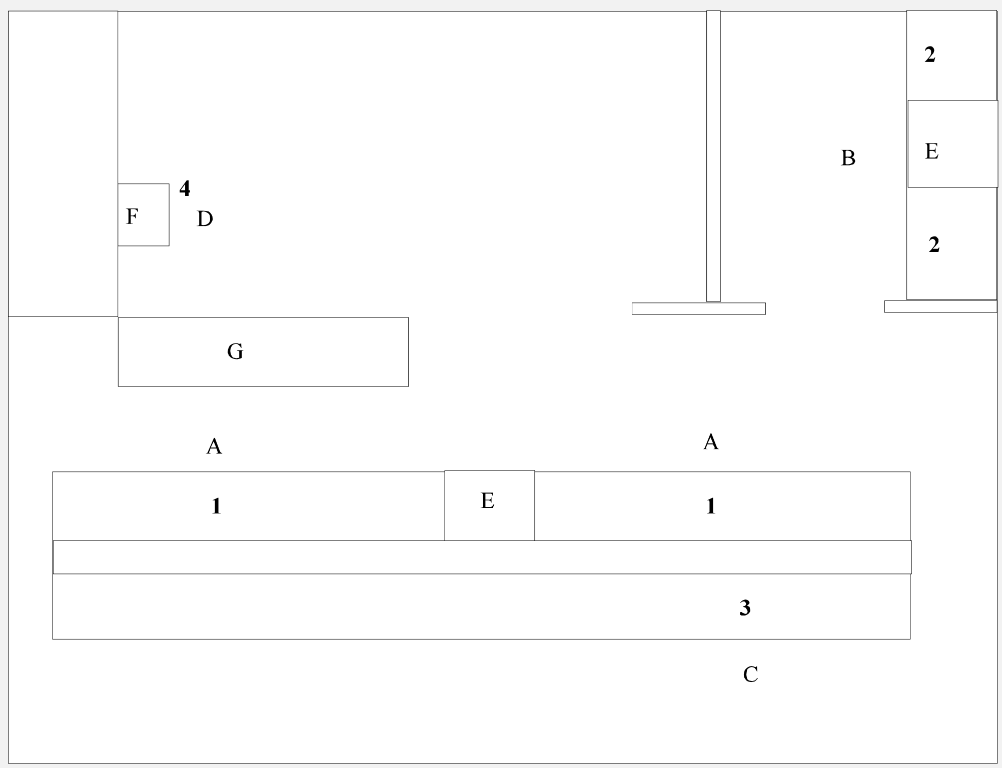
FIGURE 1

Cartridge Recycling Area
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107



Numbers are Area Sample locations

A = assembly / disassembly area and bench

B = breakdown / cleaning area and bench

C = specialty area and bench

D = ink bucket cleaning area and trash can

E = dust collector

F = canopy local exhaust hood

G = ribbon re-inking area and bench

FIGURE 2

Local Exhaust Hood Design

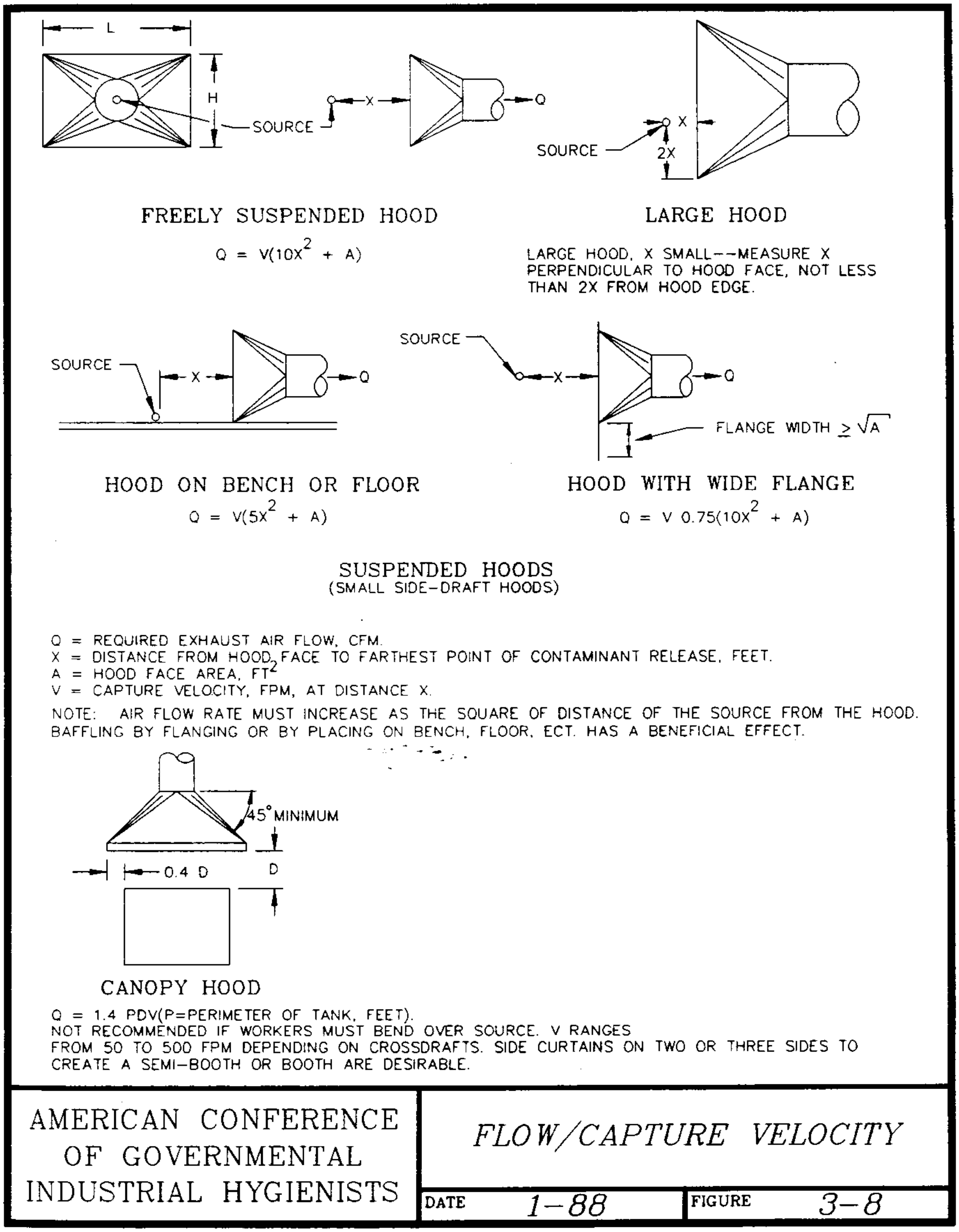


TABLE 1

Environmental Sampling Methods
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Analyte	**Sampler**	**Media**	**Air Sampling Rate**	**Approximate Sampling Time**	**Sample Analyses**
Total dust	Total dust cassette	PVC filter (37mm)	2.0 liters per minute (lpm)	7 hours	Gravimetric [3]
Respirable dust	Respirable cyclone	PVC filter (37mm)	1.7 lpm	7 hours	Gravimetric[3]
Organic compounds / Hydrocarbons	Solid sorbent tube	Activated charcoal	0.75 lpm	7 hours	Gas chromatography[3]
Gases / Vapors: ethanol ethyl acetate isopropanol MIBK xylene	Direct reading indicator tubes	Various sorbents	—	5 minutes	Colorimetric: Length of stain in sample tube proportional to air concentration of contaminant. A direct measure.

TABLE 2

Chemicals / Compounds Selected for Sampling and Associated Health Effects
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Chemical / Compound	Health Effects[1]
ethanol	Eye, respiratory, and skin irritation; teratogenic and reproductive effects
ethyl acetate	Eye and respiratory irritation
isopropanol	Mucous membrane irritation; possible carcinogenic effects
methyl isobutyl ketone (hexone) *Class: ketones*	Irritation; liver, kidney, and nervous system effects
naphtha (coal tar)	Narcosis; liver and kidney damage in animals
toner	Not listed
xylene, all isomers (dimethylbenzene)	Central nervous system depression; respiratory and eye irritation

1 = NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements.

TABLE 3

Chemicals / Compounds Sampled and Occupational Exposure Limits
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Chemical	Occupational Exposure Limits (ppm unless designated in milligrams per cubic meter, mg/m^3)		
	NIOSH REL[1]	ACGIH TLV®[2]	OSHA PEL[3]
ethanol	1000-TWA	1000-TWA	1000-TWA
ethyl acetate	400-TWA	400-TWA	400-TWA
isopropanol	400-TWA 500-STEL	400-TWA 500-STEL 200-TWA[4] 400-STEL[4]	400-TWA
methyl isobutyl ketone (hexone) *Class: ketones*	50-TWA 75-STEL	50-TWA 75-STEL	100-TWA
naphtha (coal tar or rubber solvent)	100-TWA	400-TWA	100-TWA
toner (PNOR[5] / C[6] exposure criteria)	NONE	10 mg/m^3 [7] 3 mg/m^3 [8]	15 mg/m^3 [9] 5 mg/m^3 [10]
toner (carbon black exposure criteria)	3.5 mg/m^3	3.5 mg/m^3	3.5 mg/m^3
toner (iron oxide exposure criteria)	5 mg/m^3 [11]	5 mg/m^3 [11]	10 mg/m^3 [12]
xylene, all isomers (dimethylbenzene)	100-TWA 150-STEL	100-TWA 150-STEL	100-TWA

1 = NIOSH Recommended Exposure Limit
2 = ACGIH Threshold Limit Value
3 = OSHA Permissible Exposure Limit
4 = Proposed changes to existing TLVs® as noted in the ACGIH Notice of Intended Changes for 1998
5 = Particulates Not Otherwise Regulated under OSHA
6 = Particulates Not Otherwise Classified under ACGIH
7 = Inhalable fraction
8 = Respirable fraction
9 = Total Dust
10 = Respirable Dust
11 = iron oxide dust
12 = iron oxide fume

TABLE 4

Similar Chemical Compounds or Trade Names Listed Within MSDSs, and the Percent of the Chemical as an Ingredient in 28 Different Toner Products

June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Chemical or Trade Name	Percent Range	Average Percent
styrene acrylate copolymer	43 - 85%	65%
magnetite, iron oxide, iron powder	2 - 50%	33%
carbon black, solvent black	1 - 10%	7%
propene polymers, polyolefin, polypropylene wax, polypropylene	1 - 10%	5%
dye, dyestuff, metal complex azo dye	1 - 5%	3%
silica, silicone dioxide, amorphous silica (SiO_2)	1 - 2%	2%
quaternary ammonium salt	none listed	not applicable
styrene acrylic resin	none listed	not applicable

APPENDIX

TABLE 5

Area Sample Full-Shift Time-Weighted Average (TWA) Concentrations
for Comparison to Full-Shift Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Location # (see Figure 1) / Area description / Volatile chemicals used in proximity of sample	Sampling Period		Sample Number	Sample Volume (liters)	TWA Concentration (ppm)			
	Time 1	Time 2			Isopropanol	MQC[1]	Ethanol	MQC
#1 / Assembly / Disassembly / Isopropanol, ethanol	0838 - 1702		C1	377	1.8	0.007	0.058	0.021
#1 / Assembly / Disassembly / "	0839 - 1702		C5	379	1.7	0.007	0.060	0.021
#1 / Assembly / Disassembly / "	0819 - 1201	1310 - 1647	C57	328	4.7	0.008	0.13	0.024
#1 / Assembly / Disassembly / "	0818 - 1201	1310 - 1644	C61	323	3.9	0.008	0.14	0.025
#1 / Assembly / Disassembly / "	0823 - 1204	1311 - 1649	C2	331	2.6	0.008	0.12	0.024
#1 / Assembly / Disassembly / "	0824 - 1204	1311 - 1650	C6	331	3.4	0.008	0.12	0.024
#2 / Breakdown / Cleaning / "	0842 - 1704		C9	377	3.6	0.007	0.030	0.021
#2 / Breakdown / Cleaning / "	0844 - 1704		C13	370	2.9	0.007	0.032	0.022
#2 / Breakdown / Cleaning / "	0820 - 1201	1309 - 1644	C65	327	4.8	0.008	0.057	0.024
#2 / Breakdown / Cleaning / "	0820 - 1201	1309 - 1646	C69	326	5.0	0.008	0.059	0.024
#2 / Breakdown / Cleaning / "	0828 - 1204	1311 - 1652	C38	325	4.9	0.008	0.069	0.024
#2 / Breakdown / Cleaning / "	0828 - 1204	1311 - 1652	C34	328	3.7	0.008	0.053	0.024
Full-Shift TWA Occupational Exposure Standards								
NIOSH REL					400 -TWA		1000 -TWA	
ACGIH TLV®					400 -TWA		1000 -TWA	
OSHA PEL					100 -TWA		1000 -TWA	

1 = Minimum Quantifiable Concentration

TABLE 6

Area Sample Full-Shift Time-Weighted Average (TWA) Concentrations
for Comparison to Full-Shift Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Location # (see Figure 1) / Area description / Volatile chemicals used in proximity of sample	Sampling Period		Sample Number	Sample Volume (liters)	TWA Concentration (ppm)			
	Time 1	Time 2			Isopropanol	MQC[1]	Ethanol	MQC
#3 / Specialty / Isopropanol, turpentine	0847 - 1202	1336 - 1703	C21	302	2.0	0.009	0.082	0.026
#3 / Specialty / Isopropanol, turpentine	0847 - 1202	1336 - 1704	C17	295	2.2	0.009	0.085	0.027
#3 / Specialty / Isopropanol, turpentine	0813 - 1201	1311 - 1645	C45	330	4.2	0.008	0.12	0.024
#3 / Specialty / Isopropanol, turpentine	0814 - 1201	1311 - 1646	C41	333	4.0	0.008	0.14	0.024
#3 / Specialty / Isopropanol, turpentine	0825 - 1205	1312 - 1651	C30	330	2.5	0.008	0.13	0.024
#3 / Specialty / Isopropanol, turpentine	0826 - 1205	1312 - 1651	C18	331	2.5	0.008	0.13	0.024
#4 / Ink Bucket Cleaning / Fedron®	0904 - 1202	1324 - 1659	C29	298	1.3	0.009	0.45	0.027
#4 / Ink Bucket Cleaning / Fedron®	0819 - 1200	1313 - 1647	C53	326	3.2	0.008	0.60	0.024
#4 / Ink Bucket Cleaning / Fedron®	0820 - 1203	1310 - 1653	C10	336	2.5	0.008	0.85	0.024
Full-Shift TWA Occupational Exposure Standards								
NIOSH REL					400 -TWA		1000 -TWA	
ACGIH TLV®					400 -TWA		1000 -TWA	
OSHA PEL					100 -TWA		1000 -TWA	

1 = Minimum Quantifiable Concentration

TABLE 7

Area Sample Full-Shift Time-Weighted Average (TWA) Concentrations
for Comparison to Full-Shift Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Location # (see Figure 1) / Area description / Volatile chemicals used in proximity of sample	Sampling Period		Sample Number	Sample Volume (liters)	TWA Concentration (ppm)							
	Time 1	Time 2			Xylene	MQC[1]	Ethyl acetate	MQC	Naphtha	MQC	MIBK[2]	MQC
#4 / Ink Bucket Cleaning / Fedron®	0906 - 1202	1324 - 1659	C25	289	0.22	0.003	0.029	0.003	0.68	0.009		
#4 / Ink Bucket Cleaning / Fedron®	0818 - 1200	1313 - 1647	C49	327	0.28	0.003	0.047	0.003	1.5	0.025		
#4 / Ink Bucket Cleaning / Fedron®	0819 - 1203	1310 - 1653	C14	337	0.61	0.003	0.040	0.003	1.6	0.024		
#4 / Ink Bucket Cleaning / Fedron®	0906 - 1202	1324 - 1659	O1	294							0.006	0.003
#4 / Ink Bucket Cleaning / Fedron®	0904 - 1202	1324 - 1659	O5	292							0.015	0.003
#4 / Ink Bucket Cleaning / Fedron®	0818 - 1200	1313 - 1647	O17	321							0.012	0.003
#4 / Ink Bucket Cleaning / Fedron®	0819 - 1200	1313 - 1647	O21	326							0.016	0.002
#4 / Ink Bucket Cleaning / Fedron®	0820 - 1203	1310 - 1653	O37	336							0.020	0.002
#4 / Ink Bucket Cleaning / Fedron®	0819 - 1203	1310 - 1653	O33	337							0.024	0.002
Full-Shift TWA Occupational Exposure Standards												
NIOSH REL					100 - TWA		400 - TWA		100 - TWA		50 - TWA	
ACGIH TLV®					100 - TWA		400 - TWA		400 - TWA		50 - TWA	
OSHA PEL					100 - TWA		400 - TWA		100 -TWA		100 - TWA	

1 = Minimum Quantifiable Concentration
2 = methyl isobutyl ketone

TABLE 8

Personal Sample Full-Shift Time-Weighted Average (TWA) Concentrations
for Comparison to Full-Shift Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Worker # / Task Description / Particulate Exposures	Sampling Period		Sample Number	Sample Volume (liters)	TWA Concentration (mg/m^3)			
	Time 1	Time 2			Toner dust (Total / Inhalable)	MDC[1]	Toner dust (Respirable)	MDC
# 1 / Specialty cartridge assembly and disassembly, refilling / toner, dry lube powder	0815 - 1156	1331 - 1757	1357	974	0.16	0.021		
#1 / See above	0802 - 1156	1302 - 1659	1398	928	0.15	0.023		
#1 / See above	0800 - 1158	1305 - 1653	1371	932	0.23	0.021		
#1 / See above	0815 - 1156	1331 - 1757	1404	828			(0.0)[2]	0.024
#1 / See above	0802 - 1156	1302 - 1659	1369	796			(0.013)	0.025
#1 / See above	0800 - 1158	1305 - 1653	1405	797			(0.013)	0.025
#2 / Cartridge assembly and disassembly, refilling / toner, dry lube powder	0805 - 1200	1307 - 1655	1391	921	0.14	0.022		
# 2 / See above	0815 - 1156	1331 - 1757	1384	951	0.21	0.021		
# 2 / See above	0802 - 1156	1325 - 1659	1370	883	0.091	0.023		
# 2 / See above	0815 - 1155	1331 - 1756	1359	825			(0.012)	0.024
# 2 / See above	0802 - 1156	1325 - 1659	1352	753			0.066	0.027
# 2 / See above	0805 - 1200	1307 - 1655	1386	792			0.025	0.025
Full-Shift TWA Occupational Exposure Standards								
NIOSH REL					None		None	
ACGIH TLV®					10 -TWA		3 -TWA	
OSHA PEL					3.5 -TWA		None	

1 = Minimum Detectable Concentration
2 = ( ) Concentration is below the MDC

TABLE 9

Personal Sample Full-Shift Time-Weighted Average (TWA) Concentrations
for Comparison to Full-Shift Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Worker # / Task Description / Particulate Exposures	Sampling Period		Sample Number(s)	Sample Volume (liters)	TWA Concentration (mg/m^3)			
	Time 1 Time 2	Time 2 or 3			Toner dust (Total / Inhalable)	MDC[1]	Toner dust (Respirable)	MDC
#3 / Cartridge assembly and disassembly, refilling / toner, dry lube powder	0801 - 1158	1305 - 1657	1410	929	0.29	0.022		
#3 / See above	0803 - 1026 1030 - 1157	1305 - 1649	1365	908	0.33	0.022		
#3 / See above	0801 - 1158	1305 - 1657	1344	793			0.076	0.025
#3 / See above	0803 - 1026 1030 - 1157	1305 - 1649	1411	772			(0.013)[2]	0.026
#4 / Cartridge assembly and disassembly, refilling / toner, dry lube powder	0806 - 1157	1308 - 1700	1372	926	0.25	0.022		
# 4 / See above	0807 - 1202	1308 - 1654	1348	899	0.40	0.022		
# 4 / See above	0815 - 1248	1404 - 1754	1367	855			0.070	0.023
# 4 / See above	0806 - 1157	1308 - 1700	1395	778			(0.013)	0.026
# 4 / See above	0807 - 1202	1308 - 1654	1403	788			0.025	0.025
# 4 / See above	0815 - 1248		1400	996	1.6	0.042		

Worker # / Task Description / Particulate Exposures	Sampling Period		Sample Number(s)	Sample Volume (liters)	TWA Concentration (mg/m^3)			
	1404 - 1754		1392					
Full-Shift TWA Occupational Exposure Standards								
NIOSH REL					None		None	
ACGIH TLV®					10 -TWA		3 -TWA	
OSHA PEL					3.5 -TWA		None	

1 = Minimum Detectable Concentration 2 = (   ) Concentration is below the MDC

TABLE 10

Personal Sample Partial-Period Time-Weighted Average (TWA) Concentrations
for Comparison to Short-term TWA Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Worker # / Task description / Volatile chemicals in use	Sampling Period	Sample Number	Sample Volume (liters)	TWA Concentration (ppm)			
				Isopropanol	MQC[1]	Ethanol	MQC
#2 / Cleaning 4 ink buckets, exhaust fan on, trash can lid raised / Fedron®	1611 - 1618	C73	5.21	5.1	0.51	47	1.5
#2 / Ink bucket cleaning and bottle filling, exhaust fan on, trash can lid raised / Fedron®	1630 - 1640	C42	20.4	0.30	0.13	2.3	0.39
Short-Term Exposure Limit (STEL) TWA Occupational Exposure Standards							
NIOSH REL				500 -STEL		none	
ACGIH TLV®				500 -STEL		3000 - Excursion[2]	
OSHA PEL				None		none	

1 = Minimum Quantifiable Concentration
2 = ACGIH Excursion Limit of 3 times the TLV

TABLE 11

Personal Sample Partial-Period Time-Weighted Average (TWA) Concentrations
for Comparison to Short-term TWA Occupational Exposure Standards
June 24 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Worker # / Task description / Volatile chemicals in use	Sampling Period	Sample Number	Sample Volume (liters)	TWA Concentration (ppm)							
				Xylene	MQC[1]	Ethyl acetate	MQC	Naphtha	MQC	MIBK[2]	MQC
#2 / Cleaning 5 ink buckets, exhaust fan on, using empty trash bag, can lid raised / Fedron®	1532 - 1540	C33	6.0	8.5	0.15	0.56	0.15	6.9	1.4		
#2 / Same as above	1532 - 1540	O13	6.0							0.22	0.14
#2 / Cleaning 4 ink buckets, exhaust fan on, using empty trash bag, can lid raised / Fedron®	1611 - 1618	O25	5.2							0.70	0.16
#2 / Ink bucket cleaning and bottle filling / Fedron®	1622 - 1629	C22	14.3	4.0	0.061	0.29	0.064	4.0	0.58		
#2 / Ink bucket cleaning and bottle filling / Fedron®	1622 - 1629	O41	14							(0.0)[3]	0.058
#2 / Same as above	1630 - 1640	O45	20							(0.020)	0.040
Short-Term Exposure Limit (STEL) TWA Occupational Exposure Standards											
NIOSH REL				150 - STEL		None		None		75 - STEL	
ACGIH TLV®				150 - STEL		1200 - Excursion[4]		1200 - Excursion[4]		75 - STEL	
OSHA PEL				None		None		None		None	

1 = Minimum Quantifiable Concentration
2 = methyl isobutyl ketone
3 = ( ) Concentration is below the MQC
4 = ACGIH Excursion Limit of 3 times the TLV

TABLE 12

Short-term Detector Tube Breathing Zone Concentrations
for Comparison to Short-term TWA Occupational Exposure Standards
June 25 - 26, 1997

ADI Systems, Inc., Salina, Kansas HETA 97-0107

Worker # / Task description / Volatile chemicals in use	TWA Concentration (ppm)				
	Xylene	Ethanol (methanol tube)	Ethyl acetate	Isopropanol	MIBK (Acetone tube)[1]
#2 / Ink Bucket Cleaning / Fedron®	10	500			ND[2]
#2 / Same as above	10, 30	200	75	800	ND
#2 / Bottle Filling / Fedron®		400	50	1200	

1 = methyl isobutyl ketone
2 = Not Detected