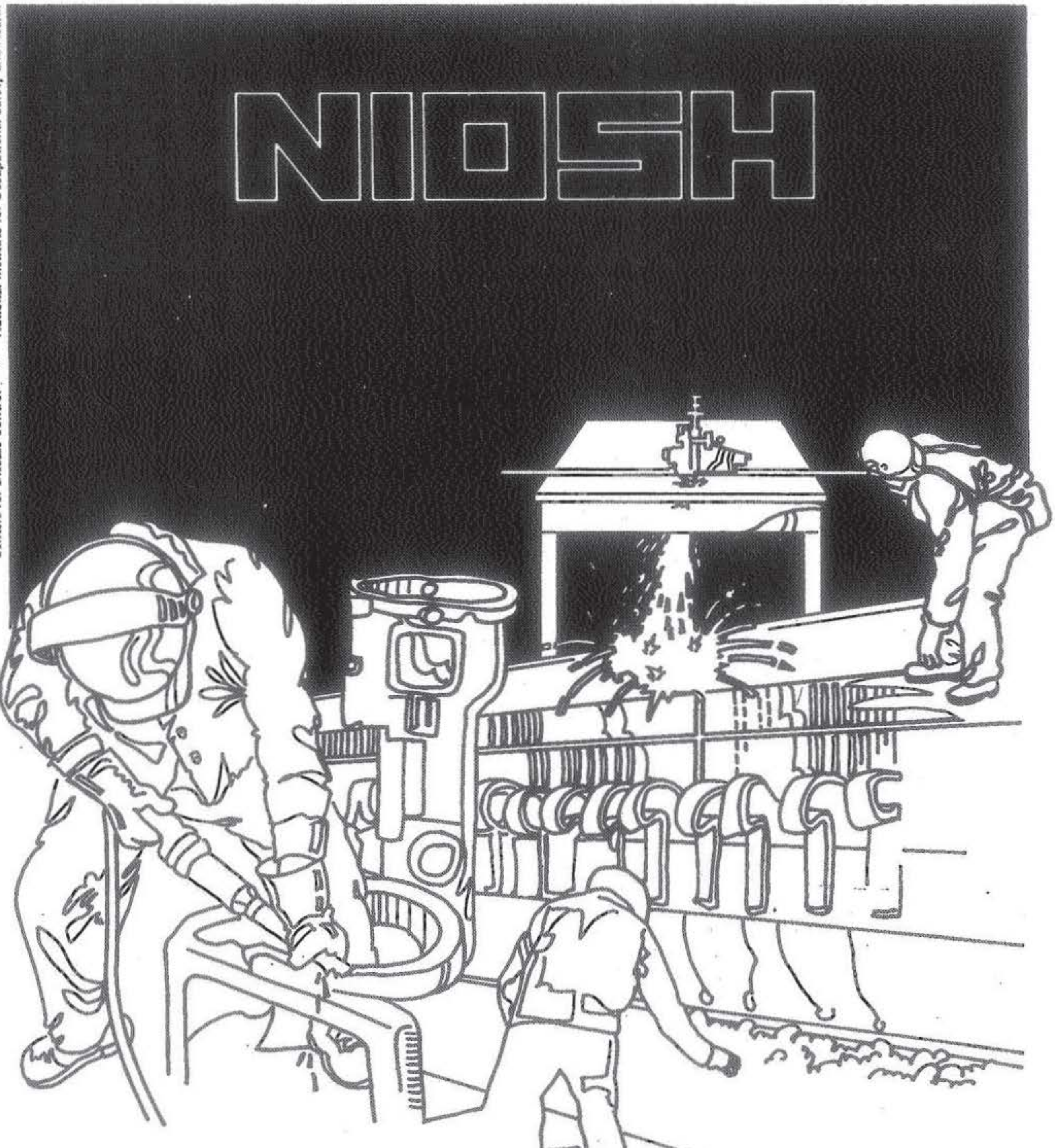
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health




# Health Hazard Evaluation Report

HETA 82-127-1370
HOOVER COMPANY, I P
NORTH CANTON, OHIO

## PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

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HOOVER COMPANY, I P
NORTH CANTON, OHIO

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## I. SUMMARY

On February 8, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate exposures to organic solvents and symptoms of eye and upper respiratory tract irritation among employees of the Hoover Company, located in North Canton, Ohio.

Environmental and medical monitoring of the Industrial Park facility of Hoover was conducted from June 5-8, 1982. Employee exposures to methyl ethyl ketone (MEK) in assembly areas were measured at levels from below the analytical limit of detection to 20.5 milligrams/cubic meter of air ($mg/m^3$), as compared to the NIOSH recommended standard of 590 $mg/m^3$. Employee exposures to solvents (MEK, butyl cellosolve, butyl acetate, petroleum naphtha, toluene, xylene, and perchloroethylene) in the Spray Painting Department were all within the recommended exposure criteria for the individual compounds, and for exposure to multiple substances with similar toxic effects. Employee exposures to vinyl chloride and di(2-ethylhexyl)phthalate (DEHP) in the vinyl blend and hose extruding area were either non-detectable (vinyl chloride) or within the OSHA standard (5 $mg/m^3$ - DEHP). Exposures to respirable particulates (polyvinyl chloride powder) in the Wire Coating Department were well within the criteria for inert dusts (5 $mg/m^3$). Concentrations of formaldehyde in the injection molding area ranged from 0.33 to 1.3 $mg/m^3$. Based on recent animal studies, NIOSH considers formaldehyde, butyl cellosolve, and perchloroethylene as potential occupational carcinogens, and recommends that exposures be maintained at the lowest feasible level.

The medical evaluation focused on exposure to three organic solvents (MEK, toluene, and xylene) and cadmium. MEK was present in six of 52 (12%) end-of-shift blood samples. The concentrations ranged from 0.03 to 3.3 ug/L (mean value = 1.2 ug/L; median = 1.0 ug/L). With one exception, all employees with exposures to less than 13.1 $mg/m^3$ of MEK had no detectable MEK in the blood.

Toluene-exposed workers had a greater pre- to post-shift increase in urinary hippuric acid concentration (mean = 0.31 mg/ml, range = -1.63 to + 4.67 mg/ml) than unexposed workers (mean = 0 mg/ml, range = - 0.26 to + 0.35 mg/ml). The difference between the post-shift urinary hippuric acid concentration for exposed workers compared to the unexposed workers was statistically significant ($t = -1.90$, $p < 0.05$). Urinary cadmium analysis of five workers with potential exposure showed no detectable cadmium (limit of detection = 2.5 parts per billion). Levels of urinary beta-2 microglobulins ranged from less than 15 ug/L to 292 ug/L (median = 18 ug/L), compared to the laboratory reference range of 4 - 370 ug/L.

Based on the environmental and medical data collected during the evaluation, it does not appear that under current conditions a health hazard exists from the use of solvents, metal pigments, vinyl chloride, or PVC powder. There is indication of systemic absorption of organic solvents in some of the exposed workers even at levels within current recommended standards. However, this does not correlate with symptoms experienced and the medical significance of continued systemic absorption at low exposure levels is unknown. Due to the potential carcinogenic nature of formaldehyde and DEHP, recommendations for controlling employee exposures to these substances are made in Section VII of this report.

KEYWORDS: SIC 3630 (Household Appliances), methyl ethyl ketone, butyl cellosolve, butyl acetate, petroleum naphtha, perchloroethylene, toluene, xylene, vinyl chloride, di(2-ethylhexyl)phthalate, barium, chromium, lead, cadmium, respirable particulates, formaldehyde, injection molding, spray painting, vinyl blending

## II. INTRODUCTION

On February 8, 1982, the International Brotherhood of Electrical Workers (IBEW) Local 1985 requested a health hazard evaluation of the Hoover Company located in North Canton, Ohio. The request expressed health concerns regarding several agents, including non-ionizing radiation, polyvinyl chloride, perchloroethylene, methyl ethyl ketone (MEK), nickel sulfate, nickel chloride, boric acid, sulfuric acid, and hydrochloric acid. The request noted complaints of adverse health effects among employees resulting from exposure to solvents (particularly MEK) and other substances used in the facility.

On April 7, 1982, a NIOSH industrial hygienist and medical officer conducted a walk-through survey of the Main Plant and Industrial Park locations of Hoover to develop an environmental and medical study protocol. At that time, as a result of employee interviews and discussions with IBEW and Hoover representatives, several other areas of the facility were included in the evaluation. Due to the size of the workforce and the number of manufacturing processes, the NIOSH officers elected to conduct two separate surveys, initially evaluating the Industrial Park facility and subsequently the Main Plant. This document is the final report for the industrial hygiene and medical survey conducted at the Industrial Park (IP) location from June 21 to June 25, 1982. The final report for the Main Plant facility will be presented separately.

The purpose of the evaluation was to determine the extent of employee exposure to several chemical substances through environmental monitoring and to identify any ill-health effects resulting from these exposures through biological monitoring and employee interviews. Methyl ethyl ketone (MEK) use at the glue lines was the main substance of concern as expressed by several employees during the initial walk-through survey on April 7, 1982. Also included in the evaluation were exposures to toluene, xylene, petroleum naphtha, butyl cellosolve, and butyl acetate (Spray Painting Department); metals, vinyl chloride, and di(2-ethylhexyl)phthalate (DEHP) (Vinyl Blend Department); particulates (Wire Coating Department); and vinyl chloride and DEHP (Hose Department).

## III. BACKGROUND

The Hoover Company produces vacuum sweepers of various sizes for commercial and home use. The North Canton, Ohio, plant employs approximately 3,000 workers. Essentially all of the component parts of the sweepers are manufactured and assembled on-site. This requires several industrial processes, including a foundry operation, injection molding, spray painting, degreasing, plating, extruding, and numerous assembly line operations. The Industrial Park (IP) facility of the Hoover Company was built in the mid-1970's and employs approximately 600 workers over three shifts. The primary operations at the IP include assembly, injection molding, plastic blending and pelletizing, painting, metal fabrication, and plastic extrusion. The building covers approximately 240,000 $ft^2$, with a mezzanine level of roughly 50,000 $ft^2$. General dilution ventilation is supplied via ten roof-mounted heating and ventilating units, each capable of supplying a maximum of 40,000 cubic feet/minute, in an "economizer" fashion. Also, numerous local exhaust systems are present, most notably in the Spray Painting Department. Following is a description of the manufacturing areas investigated during the NIOSH evaluation.

Slimline/Portable Assembly

The major concern expressed by employees during the walk-through survey was exposure to methyl ethyl ketone (MEK) at and near the hose assembly area for the Slimline/Portable vacuum sweepers. MEK is used to glue sweeper hoses to various plastic parts. At five workstations, the ends of the hoses are hand dipped into small containers of MEK and forced by hand into the plastic receptacles. The MEK containers are locally ventilated. Assembly of the Slimline and Portable vacuum sweeper units takes place in the area surrounding the glue line. Approximately 20 workers are employed in this area.

Injection Molding

Plastic vacuum sweeper parts are produced in a large open area of the building containing approximately 30 injection molders. Various types of plastics are utilized, including polyvinyl chloride, acrylonitrile-butadiene-styrene, acetal resin, polystyrene, and polycarbonate. In the area machine purges reportedly exposed the machine set-up operators to irritating odors and smoke. Three set-up operators normally work in the injection molding area.

PVC Blending and Pelletizing

Powdered PVC is blended and colored in this area. The PVC is blended with di(2-ethylhexyl)phthalate and pigments, heated, and the pelletized product is used at the injection molders. Commercial pellets are not used due to the variability in color. Two workers are normally employed in this area.

Enamel Painting

Metal sweeper parts are painted with enamel paint in one large spray booth. Also present is an automated electrostatic spray painting device. Adjacent to the spray-painting area is the paint mix room, where numerous types and colors of paints are prepared. Various plastic parts, particularly motor compartments and those parts surrounding wire harnesses are painted with a fire-proofing material in two smaller spray booths. Attempts are currently underway to change from solvent-based to water-based paints in order to comply with EPA emission guidelines. Currently, solvents used in the Spray Painting Department include petroleum naphtha, butyl cellosolve, butyl acetate, toluene, xylene, and methyl ethyl ketone. Spray painters normally wear organic filter respirators.

Quickbroom Assembly

This assembly area is located on the mezzanine level directly adjacent to and above the hose assembly area. This department was included in the survey for exposures to MEK, due to the effluents from the locally exhausted MEK containers in the Hose Assembly Department being released adjacent to the mezzanine level. The "Quickbrooms" are assembled in an assembly-line fashion. Seventeen employees were stationed on the line during the day of the evaluation.

Wire Coat

Located on the Mezzanine level, single strands of wire are coated with PVC plastic. One worker is normally stationed in this area. The concern was for airborne PVC dust, visible throughout the department.

Hose Extruding

Vacuum sweeper hoses are coated with PVC plastic at eight extruding machines. The hygienic concern was for irritating smoke generated from the process and the possibility of exposures to vinyl chloride.

## IV. METHODS AND MATERIALS

### A. Environmental

A walk-through survey of both the Main Plant and the Industrial Park facility was conducted on April 7, 1982. Environmental sampling at the IP facility was conducted June 21-25, 1982, under normal production conditions. Table I presents the sampling and analytical methodology used in collection and analysis of the environmental samples. For "breathing zone" samples, pre-calibrated personal sampling pumps attached to the employees' belts were connected to the sampling medium on the workers' collars. General area samples were collected in the general work area or near particular work stations. Process samples were collected directly adjacent to or directly upon a particular manufacturing process or device (which do not necessarily represent potential exposure levels). As indicated in Table I, most samples were collected for the duration of the shift. In some instances it was necessary to replace the sampling medium during the shift to prevent over-loading. Breathing zone samples were collected from employees in the Slimline/Portable and Quickbroom work areas for determination of exposures to MEK. In the Enamel Paint Department, breathing zone and general area environmental samples were collected for methyl ethyl ketone, petroleum naphtha, butyl cellosolve, butyl acetate, toluene, xylene, and perchloroethylene. At the vinyl blend and pelletizing work area, breathing zone and general area samples were collected for DEHP, vinyl chloride, and metals (pigments). General area and breathing zone samples were collected for formaldehyde in the injection molding area. Limited monitoring for vinyl chloride and DEHP was conducted in the Hose Extruding Department, and two samples for respirable particulates were collected in the Wire Coat Department.

B. Medical

The medical evaluation focussed on exposure to three organic solvents (methyl ethyl ketone, toluene, xylene) and to cadmium. MEK is the only solvent used in Department 918 (Slimline/Portable), and there is also potential exposure to this solvent alone on the mezzanine floor in Department 914 (Quickbroom Assembly). Twenty-seven out of 36 workers (75%) in Department 914, and 25 of 42 workers (60%) in Department 918 participated. Those who did not take part included those on vacation, other absentees, those who declined to provide a blood sample, or those who refused to participate for other reasons. All participants in these two departments were provided a self-administered questionnaire on symptoms of ill-health relevant to organic solvent exposure. Each worker also provided a beginning-of-shift and an end-of-shift blood sample for determination of MEK concentration. Detection of the presence of MEK in the blood indicates exposure to and systemic absorption of this solvent since is is not normally present in the body.

Administration of the questionnaire and collection of blood samples were also done in a comparison group of ten workers unexposed to chemicals, and geographically situated some distance away from Departments 918 and 914, though within the same building of the industrial park. The comparison group included ten workers which were randomly selected from a total of 58 individuals in Department 911. The characteristics of the MEK-exposed workers and the non-exposed comparison group are presented in Table II. The laboratory method used for determination of blood MEK levels was gas chromatography. The method involves initially heating a known volume of blood in a sealed container at a fixed temperature to equilibrate the volatile compounds. An aliquot of the vapour is then injected into a gas chromatograph equipped with a flame ionization detector.

Employees in the Spray Painting Department (dept. 961) are exposed to a number of organic solvents including toluene and xylene. Pre- and post-shift urine samples were collected for determination of concentrations of metabolites of toluene (hippuric acid) and xylene (methyl hippuric acid). Eighteen of 20 workers in this department (90%) participated. The ten workers from the comparison group from Department 911 also provided urine samples for analysis. The laboratory method used for determination of urinary hippuric and methyl hippuric acid levels was by high performance liquid chromatography.

Five employees whose work involves potential exposure to cadmium pigments provided spot urine samples for determination of urinary cadmium and beta-2 microglobulin levels. These indices are used to indicate cadmium absorption and its potential effect on the kidneys. The five workers include one person from the vinyl blend area, one from the paint mix area, and three from Department 961. Laboratory determination of urinary cadmium was by atomic absorption spectrophotometry, and determination of urinary beta-2 microglobulin was by radioimmunoassay.

## V. EVALUATION CRITERIA

### A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for 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 if 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 evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. In addition to their individual toxic action, substances with similar toxicities are also evaluated on their cummulative action, based on the following equation:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_n}{T_n}$$

Table III presents the evaluation criteria for sampled substances along with brief descriptions of their primary health effects.

## VI. RESULTS AND DISCUSSION

### A. Environmental

The environmental survey was designed to measure numerous exposure situations toward a general characterization of the plant environment, rather than focussing on a single process and extensive, repeated sampling. As a consequence, the survey results are only suggestive of potential problem areas and do not give definitive degrees of over-exposure or, conversely, an absolute index of safe exposure.

Slim Line/Portable - Quickbroom Assembly

Table IV presents results of environmental monitoring in the Slim Line/Portable Assembly Department for methyl ethyl ketone. The sampling media was replaced at approximately mid-shift, to prevent potential overloading or "breakthrough" of the solvent. Therefore, results are presented for the two samples collected from each employee for the shift, with a time-weighted average calculation representing a full-shift sample result. Time-weighted average exposures ranged from 0.93 to 20.5 mg/m$^3$, averaging 4.11 mg/m$^3$. The highest reported value, 20.5 mg/m$^3$ (approximately 4% of the exposure standard), was obtained from an employee engaged in dipping hoses in MEK. The second highest value, 16.4 mg/m$^3$, was from a small-tool operator located directly adjacent to the hose-cutting line. Although local exhaust ventilation is provided for the MEK containers, smoke tube testing demonstrated that capture velocities were inadequate at most locations. Also, numerous floor fans located throughout the area created cross-drafts which were counter-productive to the local exhaust system.

The effluent from the local exhaust system for the MEK containers was released approximately twelve feet overhead, directly adjacent to the mezzanine-level Quickbroom Assembly location. Complaints of obnoxious odors and irritation of the eyes, nose, and throat from employees in this area prompted environmental monitoring for MEK. Table V presents sampling results. Exposure concentrations ranged from below the analytical limit of detection (approximately 0.50 mg/m$^3$, air volume adjusted) to 13.1 mg/m$^3$, averaging 2.12, or approximately one-half the average exposure levels measured in the Portable/Slimline Department. Recirculation of locally exhausted air is not advisable, especially when the effluent is released near a work area. If the exhaust ports were positioned nearer the MEK vessels in the Slimline/Portable Department, and floor fans were positioned so as not to create cross drafts, airborne exposures at the hose-cutting stations should be reduced. Also, release of the exhausted air outside the building should eliminate exposures to MEK on the mezzanine level.

## Injection Molding

The health concerns in this area were associated with machine purges. Purges are required to cleanse the injection molders of all plastic material when color changes are made. The most notable incident occurred when an acrylic base clear material purger was used at temperatures in excess of the recommended temperature range. During this episode which occurred prior to the NIOSH evaluation, irritating smoke was released which caused concern among most employees in the injection mold area. Following this single incident, the acrylic purger was no longer used.

A more frequent concern among the set-up operators was the use of Delron™, an aldehyde-containing plastic material. Three automated injection molders normally use this material, and exposures occur when the set-up operators make color changes. Environmental monitoring was conducted for formaldehyde by obtaining breathing zone samples from two set-up operators for the duration of the shift, and during a purge cycle (15 minute cycle). Also, general area and process formaldehyde samples (sample aquisition directly adjacent to the injection molder using the Delron™ material) were collected, using both solid sorbent and liquid media sampling devices. All solid sorbent results were below the 5 microgram limit of detection (<0.23 - 0.44 mg/m$^3$ air volume adjusted). Two of the liquid media samples were positioned by the NIOSH investigators in the breathing zone of the two set-up operators while a Delron™ purge was being conducted. Analytical results indicated exposures to formaldehyde at 1.3 mg/m$^3$. An additional liquid media sample was placed near an injection molder during use of the Delron™ material. Results indicate average airborne formaldehyde levels of 0.33 mg/m$^3$ in the general area of the molder.

## Spray Painting

Tables VI, VII, and VIII present results of environmental sampling for toluene, xylene, perchloroethylene, methyl ethyl ketone, butyl cellosolve, butyl acetate, and petroleum naphtha in the Paint Department. All solvent exposures except perchloroethylene are a result of solvent use in the paints. Perchloroethylene exposures apparently result from an automated degreasing operation in the area of the Paint Department. A review of material safety data sheets and an inspection of solvent containers in the Paint Department did not indicate the presence of perchloroethylene. However, following gas chromatographic/mass spectrophotometric analysis of a randomly selected charcoal tube collected during the evaluation, significant quantities of perchloroethylene prompted its analytical determination on the remaining charcoal tubes collected in the spray painting department. Although relatively low, these exposures are important due to recently available information indicating perchloroethylene as a potential carcinogen.[5]

In general, solvent exposures generated from the painting operations were relatively low, with the exception of the sample collected from the paint mixer. During the evaluation, the exhaust system in the paint mix room malfunctioned, creating above normal exposure conditions. A calculation was made to determine if the cumulative effect of all exposures exceeded unity (prescribed for substances which have similar toxic actions). In no instance were exposure conditions excessive, as compared to the evaluation criteria.

PVC Blending and Pelletizing

Environmental samples were collected in the PVC and Pelletizing area for determination of exposures to vinyl chloride (PVC raw material), di(2-ethylhexyl)phthalate (plastisizer), and metals (pigments). Due to the low probability of exposures to the vinyl chloride monomer, only one process sample was collected (directly adjacent to the blending operation, in an area where highest airborne exposures were expected to occur). Results were reported as non-detectable (less than 0.02 $mg/m^3$, air volume adjusted). Two samples were collected for determination of DEHP exposures, one from the breathing zone of the operator for the duration of the shift, and one general area. The personal sample result was at 0.04 $mg/m^3$, while the area sample was below the limit of detection (<0.04 $mg/m^3$, air volume adjusted). Table IX presents results of all samples collected for DEHP. According to the material safety data sheets for materials used in the pelletizing area the pigments contained cadmium, barium, chromium, and lead. Two full-shift samples were obtained from the operator and two samples were obtained from the mixing room area and near the blending operation. Analytical results were all less than the detection limit for these metals (generally <0.001 $mg/m^3$, air volume adjusted).

Hose Extruding

Limited environmental monitoring was also conducted in the hose extruding area for determination of exposures to DEHP (Table IX) and vinyl chloride. Samples were obtained from the breathing zone of the operator, and directly above the extruder thermocouple (process samples). The inlets of these process samples were placed from MEK use, and he was not aware of any exposure to MEK. Since the likely cause of MEK in his blood was an MEK exposure of which the worker was not aware, his data was excluded from further epidemiologic analysis.

Environmental sampling for MEK was done using personal samplers for 20 workers in Department 918 and 19 workers in Department 914. MEK was detected in most environmental samples (from approximately 0.5 to 20.5 mg/m$^3$; the TLV being 590 mg/m$^3$). MEK was detected in the blood of only three of these 39 persons (8%). The person with the highest exposure to MEK during the work day also had the highest end-of-shift blood MEK level (Blood MEK = 3.3 ug/L; MEK-in-air = 20.5 mg/m$^3$). The person with the next highest MEK-in-air reading (16.4 mg/m$^3$) had close to the next highest blood MEK level (blood MEK of 1.8 ug/L compared to the next highest reading of 1.9 ug/L). The third person had a blood MEK level of 0.05 ug/L and an MEK-in-air reading of 0.54 mg/m$^3$. With the exception of this individual, all those with exposures to less than 13.09 mg/m$^3$ of MEK had no detectable MEK in the blood.

Of the six workers with MEK detected in the blood, two were symptom-free during the day of blood collection. The other four had headache (3 persons), dizziness (2), irritation of the nose (2) and/or sore throat (1).

The person with the highest blood MEK concentration of 3.3 ug/L had headache, dizziness, and irritation of the nose. Of the two with a blood MEK concentration of 1.8 and 1.9 ug/L, one had dizziness and irritation of the nose and the other had no symptoms.

In the comparison group of nine workers, four were symptom-free during the day of blood collection (44%). The other five reported headache (3 persons); irritation of the eyes (2); nose (2) and/or throat (2); drowsiness (2); and/or dizziness (1).

There appears to be no significant difference in symptoms between those with MEK in the blood and those in the comparison group with no exposure to chemicals at work.

2. Toluene and xylene exposure

The eighteen workers from Department 961 with exposure to toluene and xylene included 16 males and 2 females, aged 33 to 61 years (mean age = 41 years; median age = 39 years)

The hippuric acid levels in the urine samples for these 18 workers and for the 9 workers in the comparison group from Department 911 are presented in Table X.

The 18 toluene-exposed workers had greater urinary hippuric acid concentrations at the end of shift and greater pre- to post-shift increases than the nine unexposed workers (Table X). One-tailed t-tests were performed on log transformed data to see whether the differences are statistically significant between exposed and unexposed workers. The statistical analyses showed that the difference between the post-shift concentrations of urinary hippuric acid in the exposed and the unexposed group was statistically significant ($t = -1.90$, $p<0.05$).

Urinary hippuric acid levels in individuals not exposed to toluene range from 0.4 to 1.4 mg/ml (1). Two workers in the exposed group had post-shift urinary hippuric acid concentrations higher than 1.4 ug/ml. One at 6.66 ug/ml and another at 1.6 ug/ml. With the exception of these two values, the highest reading for the exposed group was 0.95 ug/ml, and for the comparison group is 0.77 ug/ml. Dietary sources contribute to the presence of this metabolite in persons not exposed to toluene (2). Canned and preserved foods and bottled drinks which contain benzoic acid as a preservative are sources for hippuric acid. However, the amount of hippuric acid from this source is usually not significant (3). NIOSH recommends that an end-of-shift level of more than 5 mg/ml urinary hippuric acid is unacceptable and indicative of excessive toluene exposure (4). Using this criterion, only one worker has an unacceptable level, and this is the individual in the exposed group with the highest post-shift reading.

Methyl hippuric acid was detected in only one of the 27 urine analyzed (18 exposed and 9 unexposed workers) samples. This was at a concentration of 0.18 mg/ml in a paint mixer. Urinary methyl hippuric acid is specific for xylene absorption, and dietary sources do not contribute to its presence in urine.

3. Cadmium exposure

The five workers with potential exposure to cadmium compounds include five white males aged 32 to 39 years No cadmium was detected in their urine samples (detection limit = 2.5 parts per billion). Concentrations of urinary beta-2 microglobulins were from less than 15 ug/L to 292 ug/L (median = 18 ug/L). The laboratory reference range is 4 to 370 ug/L. Hence, there is no laboratory indication of cadmium absorption or effect.

## VII. CONCLUSIONS AND RECOMMENDATIOMS

Exposures to MEK in the Slimline/Portable and Quickbroom assembley areas, were perceived by the workers as unacceptable, and concern was expressed for potential long-term consequences. Based on environmental and medical monitoring, exposures were such that no chronic health problems would be expected in this group of workers due to this substance under normal operating conditions. However, as a means of reducing exposures to airborne MEK toward reducing the irritant effects among employees, engineering controls are recommended in the form of improved local exhaust ventilation and release of the effluent outside the facility, rather than recirculation.

With the exception of one individual, biological and environmental monitoring for exposures to solvents and cadmium indicated that employee exposures were well within the relevant evaluation criteria. This was true even though the ventilation system was malfunctioning in the paint mix area, which created airborne solvent levels well above those normally present. Considering the use of respiratory protection and the fact that the company is anticipating a change to water-based paints, no medically significant exposures to solvents or metal pigments in the spray painting or vinyl blend areas are expected.

Due to the potential carcinogenicity nature of formaldehyde and DEHP, are of concern in the injection molding area (formaldehyde) and the vinyl blend and hose extruding areas (DEHP). Short-term monitoring for formaldehyde in the breathing zone of set-up operators indicated exposure levels of up to 1.3 mg/m$^3$. Because this operation is intermittent, and is conducted over a short period of time, respiratory protection is probably the most applicable means of exposure reduction.

Although the carcinogenic potential of DEHP is somewhat less defined (neither NIOSH, OSHA, or the ACGIH have officially labeled this substance a potential occupational carcinogen), recent animal studies have shown increased incidences of liver and testicular cancers following inhalation at various concentrations. Because employee exposures to DEHP in the vinyl blend area and the hose extruding area were relatively low (less than 0.06 mg/m$^3$ for the hose extruder, and 0.04 mg/m$^3$ for the vinyl blend operator, TWA) no recommendations for exposure reductions are made. However, the potential for relatively high airborne concentrations (21.9 mg/m$^3$ hose extrusion process sample) warrants continued surveillance of this work area to assure that employee exposures remain minimal.

The following recommendations are made based on the data collected and observations made during the evaluation:

1. Improve the local exhaust ventilation at the MEK containers for the hose line operation. Floor fans should be positioned so that cross drafts do not interfere with the collection efficiency, yet provide comfort in addition to maintaining air flow away from the MEK - covered hose the employee handles.

2. Exhaust the effluent from the local exhaust in "1" to the outside of the facility. Recirculation of exhaust air is not recommended.

3. Furnish respirators for the set-up operators for use when conducting purge operations. A chemical cartridge respirator with an organic vapor cartridge is recommended.

4. The company should continue environmental surveillance of perchloroethylene in the area of the degreaser. Employees should be aware of the potential carcinogenity of this substance.

5. Strict adherence to manufacturer's instructions is recommended for use of the injection mold purge material.

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## X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Hoover Company
2. IBEW, Local 1985
3. NIOSH, Region V
4. OSHA, Region V

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

TABLE I

Sampling and Analytical Methodology

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Substance | Collection Device | Flow Rate (lpm) | Duration (hrs) | Analysis | Detection Limit | Reference[6] |
|---|---|---|---|---|---|---|
| Methyl Ethyl Ketone | Ambersorb Tubes | 0.05 | 4 - 6 | Gas Chromatography | 0.01 mg/sample | NIOSH S-3 |
| Petroleum Naphtha | Charcoal Tubes | 0.05 | 1 | Gas Chromatography | 0.1 mg/sample | NIOSH P&CAM 127 |
| DEHP | AA Filter | 1.00 | 2 - 4 | Gas Chromatography | 0.01 mg/sample | NIOSH S-40 |
| Vinyl Chloride | dual series charcoal tubes | 0.20 | 6 | Gas Chromatography | 0.001 mg/sample | NIOSH P&CAM 178 |
| Formaldehyde | Chromosorb Tubes | 0.05 | 6 | Gas Chromatography | 5 ug/sample | NIOSH P&CAM 354 |
| Metals | AA Filters | 1.00 | 6 | ICP - AES | 0.5 ug/sample | NIOSH P&CAM 351 |
| Butyl Cellosolve | Charcoal Tubes | 0.20 | 1 | Gas Chromatography | 0.01 mg/sample | NIOSH S-76 |
| Butyl Acetate | Charcoal Tubes | 0.20 | 1 | Gas Chromatography | 0.01 mg/sample | NIOSH S-76 |
| Respirable Particulate | M5 filter | 1.70 | 6 | Electro Balance | 0.01 mg/sample | NIOSH 29.02 |
| Toluene - Xylene Perchloroethylene-MEK | Charcoal Tubes | 0.05 | 6 | Gas Chromatography | 0.01 mg/sample | NIOSH P&CAM 127 |

TABLE II

Characteristics of MEK-exposed Workers Versus Comparison Group

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Department | No. of Participants | Age | Sex |
|---|---|---|---|
| Department. 918 (MEK-exposed) | 25 | Range = 28 to 64 years<br>Mean = 44 years<br>Median= 47 years | 6 males<br>19 females |
| Department 914 (mezzanine fl.) (Potential MEK exp.) | 27 | Range = 24 to 51 years<br>Mean = 37 years<br>Median= 37 years | 6 males<br>21 females |
| Department 911 (comparison group) | 10 | Range = 27 to 41 years<br>Mean = 34 years<br>Median= 33 years | 4 males<br>6 females |

TABLE III

Evaluation Criteria

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Substance | Evaluation Criteria ($mg/m^3$) NIOSH | OSHA | ACGIH | Primary Health Effects |
|---|---|---|---|---|
| Butyl Acetate | - | 710 | 710 | At relatively high concentrations, may cause irritation to the mucous membranes, and prolonged exposure may irritate the skin. May also cause headache, drowsiness, and unconsciousness with sufficient concentration. |
| Butyl Cellosolve | - | 240 | 120 | Excessive exposure may cause conjunctivitis and upper respiratory tract irritations. Symptoms from repeated overexposure to vapors are fatigue, and lethargy, headache, nausea, anorexia, and tremor. Of particular concern are recent animal studies which suggest that exposure to derivaties of glycol ether are associated with skeltal malformations in the offspring of exposed female rats and testicular atrophy (dimishing size of organ) of exposed male rats. |
| Di(2-ethylhexyl)phthalate | - | 5 | 5 | Although little adverse human toxicity data is available, recent rat and mouse exposure studies have shown significantly higher incidences of liver and testicular carcinoma.[1] |
| Formaldehyde | lowest feasible | 3.7<br>5.1(c) | 3.0(c)* | In addition to being a potential carcinogen, formaldehyde is an irritant to the eyes and respiratory tract being capable of causing both primary irritation and sensitization. |

TABLE III
(Continued)

| Substance | Evaluation Criteria (mg/m$^3$) NIOSH | OSHA | ACGIH | Primary Health Effects |
|---|---|---|---|---|
| Methyl Ethyl Ketone | 590 | 590 | 590 | Eye, nose, and throat and skin irritations may result from exposure to MEK |
| Petroleum Naphtha | 350 | 2000 | - | Irritating to the skin, eyes, and the upper respiratory tract. Skin "chapping" and photo-sensitivity may develop after repeated contact with the liquid. |

Reference [1]: Carcinogenesis bioassay of di(2-ethylhexyl)phtalate in F344 rats and B6C3F, mice (Feed Study). Rockville, Md.: National Institute of Health, 1982. (National Toxicology Program, Technical Report Series No. 217) (NIOSH Publication No. 82-1773)

* (c) denotes ceiling concentration; a level which may not be exceeded.

TABLE IV

Methyl Ethyl Ketone Exposures: Hose Assembly Area

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Sample # | Duration | Operation | Concentration (mg/m$^3$) | TWA (mg/m$^3$) |
|---|---|---|---|---|
| 118 | 07:40 - 12:11 | Bench Assembler | 2.32 | 2.93 |
| 81 | 12:13 - 13:46 | Bench Assembler | 4.69 | |
| 73 | 07:41 - 11:38 | Packer | 1.81 | 1.81 |
| 112 | 11:38 - 13:45 | Packer | - Pump Malfunction - | |
| 67 | 07:43 - 12:10 | Bench Assembler | 3.09 | 3.41 |
| 50 | 12:10 - 13:47 | Bench Assembler | 4.30 | |
| 133 | 07:49 - 11:36 | Trucker | 1.74 | 2.26 |
| 126 | 11:36 - 13:51 | Trucker | 3.12 | |
| 138 | 07:53 - 11:37 | Trucker | 0.88 | 1.68 |
| 114 | 11:37 - 13:53 | Trucker | 2.99 | |
| 85 | 07:55 - 11:30 | Trucker | 4.55 | 4.43 |
| 104 | 11:31 - 13:53 | Trucker | 4.25 | |
| 94 | 07:59 - 11:48 | Machine Operator | 1.81 | 2.31 |
| 124 | 11:48 - 13:58 | Machine Operator | 3.20 | |

(Continued)

TABLE IV
(Continued)

| Sample # | Duration | Operation | Concentration (mg/m$^3$) | TWA (mg/m$^3$) |
|---|---|---|---|---|
| 91 | 08:00 - 11:29 | Machine Operator | 4.75 | 4.45 |
| 96 | 11:30 - 13:58 | Machine Operator | 4.03 | |
| 82 | 08:02 - 12:05 | Machine Operator | 1.74 | 1.79 |
| 103 | 12:05 - 14:00 | Machine Operator | 1.88 | |
| 53 | 08:09 - 11:32 | Hose Cutter | <0.99 | 20.0 - 20.5 |
| 106 | 11:34 - 14:01 | Hose Cutter | 47.6 | 20.5* |
| 51 | 08:10 - 11:50 | Salvage Operator | 1.87 | 2.31 |
| 100 | 11:50 - 14:02 | Salvage Operator | 3.05 | |
| 141 | 08:13 - 11:35 | Small Tool Operator | 13.0 | 16.41 |
| 56 | 11:35 - 14:02 | Small Tool Operator | 21.1 | |
| 79 | 08:17 - 12:03 | Pace Line | 3.83 | 3.13 |
| 130 | 12:03 - 14:07 | Pace Line | 1.83 | |
| 115 | 08:19 - 12:15 | Pace Line | 3.31 | 2.82 |
| 136 | 12:15 - 14:07 | Pace Line | 1.78 | |
| 144 | 08:21 - 12:00 | Pace Line | 3.52 | 2.80 |
| 129 | 12:00 - 14:08 | Pace Line | 1.56 | |

(Continued)

TABLE IV
(Continued)

| Sample # | Duration | Operation | Concentration (mg/m3) | TWA (mg/m3) |
|---|---|---|---|---|
| 88 | 08:28 - 11:52 | Supervisor | 1.92 | 2.31 |
| 58 | 11:52 - 14:08 | Supervisor | 2.89 | |
| 135 | 08:29 - 11:41 | Assembler | 2.09 | 2.37 |
| 132 | 11:41 - 14:08 | Assembler | 2.73 | |
| 97 | 08:31 - 11:40 | Supervisor | 2.14 | 1.81 |
| 32 | 11:40 - 14:09 | Supervisor | 1.39 | |
| 70 | 08:13 - 11:45 | Bench Assembler | 1.06 | 1.80 |
| 121 | 11:45 - 14:15 | Bench Assembler | 2.70 | |
| 52 | 08:38 - 11:51 | Hose Cutter | 9.03 | 0.93 |
| 117 | 11:51 - 14:16 | Hose Cutter | 11.1 | |

* TWA calculation based on assumption that 08:09-11:32 exposure was between 0 and 0.98 mg/m3.

TABLE V

MEK Exposures; Mezzanine Area

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Sample No. | Duration | Operation | Concentration ($mg/m^3$) |
|---|---|---|---|
| 86 | 07:08 - 13:44 | Packer | 1.48 |
| 98 | 07:09 - 13:42 | Packer | * |
| 75 | 07:10 - 13:46 | Repair | 1.03 |
| 119 | 07:17 - 13:54 | Inspection | 13.1 |
| 109 | 07:20 - 13:51 | Packer | 1.09 |
| 128 | 07:20 - 13:47 | Pace Line | 0.54 |
| 57 | 07:26 - 14:02 | Packer | 1.00 |
| 90 | 07:30 - 14:00 | Pace Line | 0.53 |
| 101 | 07:32 - 13:53 | Pace Line | 1.03 |
| 80 | 07:36 - 13:58 | Fan Housing | 0.56 |
| 95 | 07:40 - 14:03 | Electrical Testing | 0.52 |
| 120 | 07:48 - 14:12 | Pace Line | <0.55 |
| 66 | 07:51 - 14:15 | Pace Line | 0.52 |
| 76 | 07:53 - 14:16 | Bench Assembly | 8.24 |
| 71 | 07:54 - 14:13 | Pace Line | 0.54 |
| 145 | 08:02 - 14:34 | Machine Operator | 0.51 |
| 140 | 08:07 - 14:16 | Bench Assembler | 1.15 |
| 61 | 08:11 - 14:39 | Bench Assembler | <0.50 |
| 83 | 07:57 - 14:32 | Assembler | <0.50 |
| 65 | 07:46 - 14:34 | Sonic Welding | <0.48 |

* Sample tube broken in transit

TABLE VI

Toluene, Xylene, Perchlorethylene, & Methyl ethyl ketone
Exposure Concentrations

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| | | | Concentration (mg/m$^3$) | | | |
|---|---|---|---|---|---|---|
| Sample # | Duration | Operation | Toluene | Xylene | Perchlor. | MEK |
| 231 | 07:19 - 14:47 | Pace Line | <0.44 | <0.44 | 4.39 | <0.44 |
| 240 | 07:25 - 14:25 | Racker | <0.50 | <0.50 | 50.0 | <0.50 |
| 228 | 07:34 - 14:20 | Group Leader | <0.57 | <0.57 | 10.2 | <0.57 |
| 215 | 07:33 - 14:36 | Paint Stripper | 0.51 | <0.51 | 11.2 | 7.61 |
| 213 | 07:37 - 13:51 | Racker | <0.53 | <0.53 | 37.0 | 0.53 |
| 220 | 07:47 - 14:28 | Racker | <0.50 | <0.50 | 48.4 | 0.50 |
| 224 | 07:58 - 14:02 | Spray Painter | <0.52 | 1.04 | 8.85 | 13.0 |
| 233 | 08:20 - 14:01 | Paint Mixer | 2.65 | 9.54 | 7.95 | 190. |
| 232 | 08:57 - 14:00 | Spray Painter | <0.71 | <0.71 | 14.2 | 26. |

TABLE VII

Petroleum Naptha Exposure Concentrations

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Sample # | Duration | Operation | Concentration ($mg/m^3$) |
|---|---|---|---|
| 243 | 09:11 - 09:38 | Paint Mixer | 396. |
| 203 | 09:38 - 10:09 | Paint Mixer | 159. |
| 25 | 10:09 - 10:44 | Paint Mixer | 87.7 |
| 36 | 10:44 - 11:14 | Paint Mixer | 169. |
| 40 | 11:14 - 11:45 | Paint Mixer | 65.7 |
| 202 | 09:29 - 10:15 | Spray Painter #1 | 22.9 |
| 8 | 10:15 - 10:41 | Spray Painter #1 | 19.6 |
| 22 | 09:34 - 10:07 | Spray Painter #2 | <16.5 |
| 18 | 10:07 - 10:43 | Spray Painter #2 | 15.4 |

Paint Mixer TWA for Petroleum Naphtha = 167. $mg/m^3$ (09:11-11:45)

TABLE VIII

Butyl Cellosolve-Butyl Acetate Exposure Concentrations

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Sample # | Duration | Operation | Concentration ($mg/m^3$) | |
|---|---|---|---|---|
| | | | Butyl Cellosolve | Butyl Acetate |
| 214 | 08:21 - 09:14 | Paint Mixer | 16.50 | 17.4 |
| 219 | 09:14 - 10:10 | Paint Mixer | 14.53 | 16.3 |
| 21 | 10:10 - 11:15 | Paint Mixer | 8.59 | 10.9 |
| 218 | 11:15 - 12:37 | Paint Mixer | 7.54 | 5.65 |
| 204 | 12:37 - 14:01 | Paint Mixer | 7.53 | 6.28 |
| 222 | 12:35 - 14:02 | Spray Painter | 7.91 | 4.75 |
| 35 | 12:39 - 14:00 | Spray Painter | 4.71 | 2.02 |

Paint Mixer TWA for Butyl Cellosolve = 10.29 $mg/m^3$ (08:21 - 14:01)

Paint Mixer TWA for Butyl Acetate = 10.42 $mg/m^3$ (08:21 - 14:01)

TABLE IX

Di(2-Ethylhexyl)phthalate Airborne Concentrations

Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Sample # | Type | Duration | Operation | Concentration (mg/m$^3$) | TWA (mg/m$^3$) |
|---|---|---|---|---|---|
| 1 | BZ* | 08:36 - 11:50 | Hose Extruding | <0.05 | <0.06 |
| 3 | BZ | 11:50 - 14:44 | Hose Extruding | <0.06 | |
| 2 | Area | 08:35 - 11:49 | Hose Extruding ** | 14.9 | 21.8 |
| 4 | Area | 11:49 - 14:45 | Hose Extruding ** | 29.55 | |
| 21 | Area | 09:57 - 14:07 | Vinyl Blend | - | <0.04 |
| 22 | BZ | 09:53 - 14:06 | Vinyl Blend | - | 0.04 |

*BZ = Breathing zone sample

**Process Sample; obtained directly adjacent to the extending operation.

Table X

Urinary Hippuric Acid Levels
Hoover Company, I P
North Canton, Ohio
HETA 82-127

June 21-25, 1982

| Department | Urinary Hippuric Acid Levels (mg/ml) | | |
|---|---|---|---|
| | Pre-Shift | Post-Shift | Post-Shift - Pre-Shift |
| 961 (18 workers) | Mean = 0.53<br>Median = 0.30<br>Range = 0.07 to 2.24 | Mean = 0.83<br>Median = 0.44<br>Range = 0.13 to 6.66 | Mean = +0.32<br>Median = +0.04<br>Range = -1.63 to +4.67 |
| 911 (9 workers) | Mean = 0.30<br>Median = 0.28<br>Range = 0.10 to 0.58 | Mean = 0.30<br>Median = 0.29<br>Range = 0.02 to 0.77 | Mean = -0.00<br>Median = -0.02<br>Range = -0.26 to +0.35 |