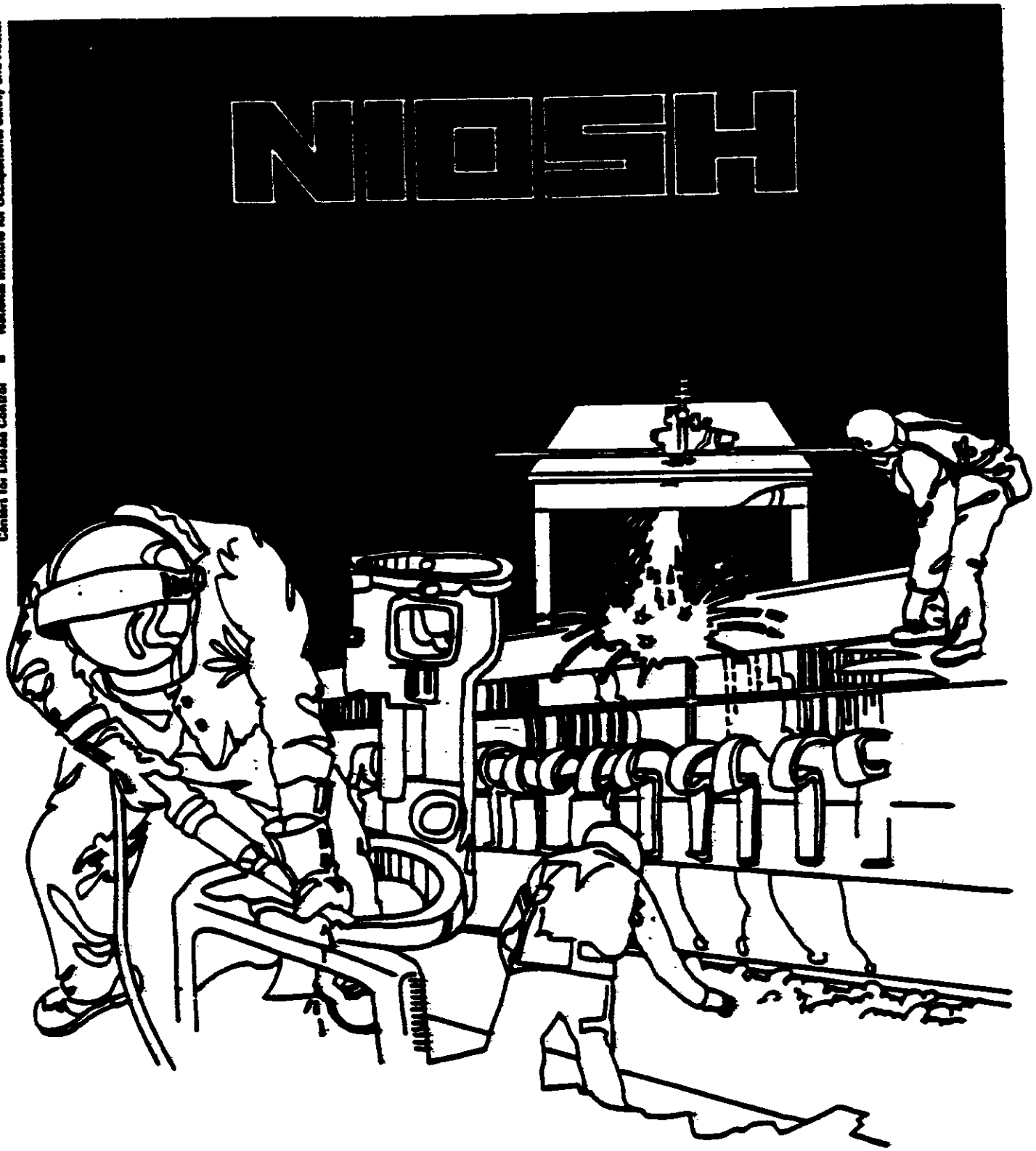
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 86-004-1740
INDUSTRIAL PRECISION, INC.
WESTFIELD, MASSACHUSETTS

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.

HETA 86-004-1740
October 1986
INDUSTRIAL PRECISION, INC.
WESTFIELD, MASSACHUSETTS

NIOSH INVESTIGATOR:
Kevin P. McManus, I.H.

I. SUMMARY

On October 3, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from officials of Industrial Precision, Inc., Westfield, Massachusetts. This request was precipitated by incidents in 1983 during which at least four employees experienced varying degrees of sensorimotor neuropathy, believed to be associated with exposure in the lapping room to n-hexane (a known neurotoxin). As a result, remedial measures were instituted by the company to eliminate exposure to hexane which included substitution with another solvent (Lacolene™) and engineering modifications of the ventilation system. The company was concerned about the potential for n-hexane exposure as a result of these changes.

An initial site visit and walkthrough was conducted on January 31, 1986. A solvent bulk sample collected during this visit was shown to contain primarily C5 - C8 aliphatic hydrocarbons, with only a small amount of n-hexane. On April 8-10 1986, an industrial hygiene survey was conducted. Personal and area air samples were collected to determine employee exposure to n-hexane and total C5 - C8 alkanes.

The results of the NIOSH air sampling indicate minimal exposure to n-hexane (around 1 ppm) at the time of this survey. However, exposure to total alkanes was routinely above the "action Level" of 200 mg/M^3, but below the recommended exposure limit of 350 mg/M^3.

Based on the results of this survey, it was determined that a health hazard from exposure to solvents used at this facility (alkanes) did not exist at this time. However, the information contained herein suggests that employee exposure to n-hexane was the most likely cause of polyneuropathy in at least four employees in late 1983 and early 1984. Recommendations are found in the body of this report to minimize employee exposure to solvents, and establish good work practices.

KEYWORDS: SIC 3599, n-Hexane, Alkanes, Neuropathy, Lapping, Grinding, Neurotoxicity

II. INTRODUCTION

On October 3, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from officials of Industrial Precision, Inc., 1014 Southampton Road, Westfield, Massachusetts. The request concerned potential employee exposure to cleaning solvents in the lapping room. Of special concern was the potential for n-hexane exposure as a result of the lapping operation using Lacolene™.

An initial site visit and walkthrough was conducted on January 31, 1986 by an industrial hygienist. On April 8-10, 1986 a more comprehensive industrial hygiene survey was conducted.

III. BACKGROUND

Industrial Precision, Inc. is a machine shop located in an eight year old, one story, concrete block building. The company machines parts to close tolerances for aerospace, oil drilling, and defense contractors. This evaluation addresses solvent exposure in the lapping room and was requested as a result of the information described below.

The lapping operations use a fine diamond powder dispersed in a hydrocarbon solvent. Job tasks involve the manual removal of stock from metal parts by rubbing the diamond paste between the metal and a rubbing block. For example, the diamond dispersion is sprayed on the rubbing block, and vanes, rotors or cams are rubbed in a circular motion on the block with the diamond acting as the abrasive. The parts are cleaned with the solvent by immersing them into a bucket, and then the parts are checked by an electronic calibrator. The operation is repeated until the parts are within the tolerance specifications. The rotors contain grooves for the vanes to fit in and these must also be lapped. A rotor is placed in a vice and diamond compound applied. A piece of carbide flat-stock is rubbed into the groove to remove stock.

The hydrocarbon solvent has historically been an aliphatic mixture of C5-C8 alkanes (pentanes through octanes). Shell Sol B™ was the solvent of choice for the first four or five years of lapping operations. This solvent reportedly contained 90% paraffins (alkanes) of which up to 25% could be hexane. In early 1983, the solvent was changed to Hexasol™ which was reported to contain 2-5% n-hexane. The reason for the change was a change in a supplier. Employees reported no problems working with either of these solvents. In June 1983, a drum was received labeled n-hexane. Upon checking with the distributer, (Ashland Chemical), the employer was assured that n-hexane was essentially similar to the solvent they had been using, and would give the desired properties. The lapping room used the n-hexane from June through December, 1983 at a rate of approximately 55 gallons per month. Employees reported that unusual symptoms began sometime in November, 1983. The first abnormality reported by employees was an inability to put pressure on the fingers. Reportedly, their fingers would give out when holding a part and the employees started to push on the part. The effect that they said finally convinced them to seek

medical attention was an inability to walk properly. These employees found they could not roll off the ball of the foot to the toes. They said they could not stand on their toes either. They began to walk flat-footed with a noticeable limp.

Between November, 1983 and January, 1984, four of the nine employees of the lapping room left work because of neurological symptoms. Two of these four had worked here for one year or less; one for three years and one for six years. All four sought medical attention from a neurologist. Polyneuropathy was confirmed in all four cases. Subsequently, in June, 1984 a fifth employee (with only one year of work experience at IPI) left work alleging symptoms associated with hexane exposure. There was no documentation regarding this employee's health characterization.

Lacolene(TM) was substituted for hexane in January, 1984 and is still used in the lapping operations. Lacolene's major components are heptane and methylcyclohexane. The manufacturer reports that there is a trace amount of n-hexane in Lacolene.

In addition to its use in lapping, the solvent was also used to clean parts. After lapping, employees would dip the parts in a 1 or 2 gallon can containing the solvent. Gloves were seldom used while dipping. Employees' hands were often covered with the solvent.

The lapping room measures 34' X 24' X 8'. Prior to 1984 there was no mechanical ventilation in this room. The room has always been air conditioned to maintain 68 degree temperature. Subsequent to the hexane incident, in February, 1984, a recirculating air cleaning system was installed. Room air is now drawn through a charcoal filter before being dumped back into the room.

In December, 1983, while n-hexane was in use, air samples were collected by Arnold Green Testing Labs. The air sampling pump was located in an area approximately 12 feet from the main dipping container, which was near the center of the room. The analysis reported 195 ppm (687 mg/M^3) n-hexane and 374 ppm (1,316 mg/M^3) total organics. In February, 1984, after installation of the air filtering system and substitution of the solvent with Lacolene, the air sampling was repeated. Results indicated 3 ppm n-hexane, 31 ppm 1,1,1-trichloroethane, 8.8 ppm methyl iso-butyl ketone, and 20 ppm heptane.

Two of the affected employees have returned to work and report that their neurologic symptoms have reversed significantly, although their symptoms may not have completely resolved.

IV. EVALUATION DESIGN AND METHODS

This evaluation was designed to characterize current conditions at this facility. In addition work and process histories were collected to put together a retrospective chronology of events leading up to the manifestation of neurological symptoms in the workers.

A walkthrough of the facility was conducted and employees were interviewed as to their work practices and health status. A bulk sample of Lacolene™ solvent was obtained for qualitative analysis, to be used also in the analysis of subsequent air samples.

Sixteen (16) air samples were collected on activated charcoal, at 50 cc/min flow rate. Samples were analyzed according to NIOSH Method 1500.[1] Both personal and area samples were collected in order to characterize exposure to alkanes and especially n-hexane within the lapping room. Four of the sixteen samples were collected from workers outside the lapping room in the machine shop to be used for comparison.

V. EVALUATION 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 of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition and/or by 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 considered for this study were: 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) federal 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 exposure limits, by contrast, are based primarily 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 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 8-10 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.

Alkanes

Alkanes irritate the skin and depress the central nervous system. Chronic exposures to certain alkanes, such as hexane, can result in persistent symptoms of numbness, muscular weakness. and other nervous system disorders known as polyneuropathy.[2]

In 1977 NIOSH issued a Criteria Document on Alkanes which recommended a standard based on the belief that polyneuropathy, usually attributed to n-hexane, can be caused by other alkanes and their isomers as well. The reasoning behind this recommendation was that historical reports of neuropathy have been the result of exposure to alkane mixtures containing varying amounts of n-hexane, but exposures to n-hexane alone have not been described in any of the reports.

Considerable evidence has been presented to indicate that n-hexane and not other isomeric forms of hexane or other alkanes, is responsible for neurotoxicity. The theory that n-hexane metabolizes to 2,5-hexanedione, a known neurotoxin, has been supported by many research experiments.[3,4,5] The metabolic pathway is similar to that of methyl butyl ketone (MBK).

The ACGIH TLV Committee reported in the Documentation of TLV's, "the evidence seems fairly convincing that the neurotoxicity of n-hexane is not possessed by the other hexane isomers"[6]. As for the other alkanes, metabolism research is still needed. It has been shown that 2,5-heptanedione and 3,6-octanedione produce neuropathy in animals, but the extent of metabolism of the respective alkanes to these compounds is not known.

Other factors that seem to contribute to the neurotoxicity of n-hexane include concurrent exposure to methyl ethyl ketone and certain drugs which boost liver oxidative mechanisms.

The criteria judged most appropriate for this study are as follows:

Substance	NIOSH Recommended Exposure Limit	ACGIH TLV	OSHA Standard
n-Hexane	100 ppm (350 mg/M^3) 510 ppm (ceiling)	50 ppm	500 ppm
Total Alkanes	350 mg/M^3 1800 mg/M^3 (ceiling)		

VI. RESULTS

The following Table presents the results of the environmental air sampling during the week of April 8-10, 1986.

Sample No.	Volume (liters)	Time (min)	Hexane (mg/M^3)	Alkanes (mg/M^3)
4811	28.2	556	1.4	29.1
4812	35.3	551	1.1	13.6
4813	24.0	498	1.3	246.7
4814	44.3	523	***	***
4911	30.4	595	1.3	177.0
4912	27.6	565	1.1	146.7
4913	37.7	590	1.1	114.9
4914(A)	50.8	585	1.4	187.8
4915	27.4	581	***	***
4916(A)	49.3	519	1.2	213.0
41011	27.0	545	1.1	260.7
41012	42.0	493	0.0	163.3
41013	30.0	582	1.3	242.6
41014	25.2	539	***	***
41015(A)	46.2	533	1.3	296.5
41016	35.3	555	1.1	204.0
Criteria			350	350

(A) denotes Area sample
*** Samples indicated breakthrough on backup tube

Samples 4814, 4915, and 41014 were all personal samples from three consecutive days of sampling the same employee outside the lapping room in the machine shop, where solvent exposure would be expected to be lower. The fact that the collection media showed breakthrough on these samples invalidates the result. It was not deemed necessary to resample outside the lapping room for the purposes of this evaluation.

No adverse health effects were reported by employees relative to current conditions at the plant. The walkthrough did not reveal any obvious hazards, unusual odors or recognizable air contaminants.

A review of the material safety data sheet on lacolene, and previous air sample data collected during its use, produced an unexplained inconsistency. The data sheet indicated the composition of lacolene as aliphatic petroleum distillates, without naming the components. The regulatory criteria cited on the data sheet for exposure levels references the NIOSH criteria for alkanes (C_5 to C_8 aliphatic hydrocarbons: pentane, hexane, heptane and octane). Air sample data obtained by Arnold Greene Testing Laboratories, Inc., while lacolene was the only solvent in use, reported the presence of trichloroethane, and methyl iso-butyl ketone in addition to heptane and a trace of hexane. NIOSH analyzed a bulk sample of the lacolene and found its composition to be as stated on the data sheet. It contained C_5-C_8 aliphatic hydrocarbons, primarily methyl cyclohexane and heptane. No trichloroethane or methyl iso-butyl ketone was found.

The sample results indicate that current exposures in the lapping room are within the reference criteria.

VII. DISCUSSION

Although employees reported that no adverse health effects are currently being experienced, this negative response, in conjunction with the history of no adverse health effects for years prior to the introduction of n-hexane, provides substantial evidence as to the etiology of polyneuropathy at this facility.

Industrial Precision, Inc. has an eight year history of lapping operations including the use of aliphatic hydrocarbon solvents. At least three employees had five years experience conducting lapping operations with Shell Sol B™ and Hexasol™ solvents under conditions of little or no ventilation. Skin contact with these solvents was commonplace. However, no adverse health effects were reported during those five years. Using the sampling results from December, 1983 (before ventilation was installed) it could be estimated that individual exposure to total alkanes exceeded the 1,316 mg/M^3 reported because that result was generated from an area 12 feet away from the operations. Although absorption through intact skin is slow, additional exposure was achieved through this route of entry.

Historically, it is conceivable that employees routinely received exposures to total alkanes in excess of the NIOSH recommended exposure limit of 350 mg/M^3, but below the ACGIH TLV of 1,800 mg/M^3. It is not likely that the OSHA standards (1,800 mg/M^3 hexane, 2,000 mg/M^3 heptane, 2,350 mg/M^3 octane, 2,950 mg/M^3 pentane) were exceeded.

It was not until 5 months after the introduction of n-hexane as the solvent that any employees began to experience adverse health effects. Four of the nine lapping room employees experienced neurological symptoms. Two of these four had extensive experience working with the other solvents, and two were relatively new to the lapping room (one year or less). One additional employee with 1 year experience left work six months later.

It is interesting to note that the 4 employees who were not affected in the lapping room were the only employees who did not work on rotors or vanes during the period when n-hexane was used. Two worked on cams, upstream from the path of vapor travel, and two worked on frames in the test area (also upstream from the path of vapor travel). Of the five who were affected, three worked on rotors, one on vanes, and one on cams, using the Lapmaster machine which was in the path of vapor travel. This last employee also worked on rotors and vanes as needed, as he was familiar with all jobs.

Subsequent to the substitution of n-hexane with Lacolene™, and the installation of the new air filtration system no employees have reported any adverse health effects. In fact, two of the five employees who left are back working in the lapping room. At the time of this survey, they have been back for approximately six months.

The results of the NIOSH air sampling indicate minimal exposure to n-hexane at the time of this survey. However, exposure to total alkanes was routinely above the "action level" of 200 mg/M^3 but below the recommended standard of 350 mg/M^3.

VIII. CONCLUSIONS

Based on the results of this survey it was determined that a health hazard from exposure to solvents used at this facility (alkanes) did not exist at this time. However, the information contained herein indicates that employee exposure to n-hexane was the most likely cause of polyneuropathy in at least four employees in late 1983 and early 1984.

IX. RECOMMENDATIONS

NIOSH recommends that the use of n-hexane free materials continue, as well as the use of impervious gloves while immersing parts in the solvent.

Employee exposure to alkanes would be further reduced with the installation of an exhaust hood, under which all parts cleaning should take place. A laboratory type exhausted enclosure would be ideal for this purpose, since the majority of the parts are small in size.

Although none of the environmental air samples exceeded the evaluation criteria, several employees were exposed to total alkanes above the "action level" of 200 mg/M^3. NIOSH recommends that employees exposed above the action level have medical surveillance made available to them. NIOSH recommends preplacement and periodic (annual) examinations, which give particular attention to general tests of nervous system function and evidence of skin condition.

X. REFERENCES

1. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods, Volume 1, Third Edition. Cincinnati, Ohio. DHEW (NIOSH) Publication No. 84-100, Jan. 1984.

2. Criteria for a Recommended Standard, Occupational Exposure to Alkanes. DHEW (NIOSH) Publication No. 77-151, Cincinnati, Ohio: NIOSH; 1977.

3. Spencer, P.S., Couri, D., Schaumburg, H.H.: n-Hexane and Methyl n-butyl Ketone. In: Experimental and Clinical Neurotoxicology, Chapter 32, pp. 456-475, 1980.

4. Spencer, P.S. et al: The enlarging View of Hexacarbon Neurotoxicity. To be published in CRC Critical Reviews in Toxicology.

5. Griffin, J.W.: Hexacarbon Neurotoxicity. Neurobehavioral Toxicology and Teratology, Vol. 3, pp. 437-44, 1981

6. American Conference of Governmental Industrial Hygienists. Documentation of the threshold limit values. 4th ed. Cincinnati, Ohio: ACGIH, 1980.

7. Occupational Diseases, A Guide to Their Recognition, Revised Edition, DHEW (NIOSH) Publication No. 77-181, June 1977.

8. Proctor, N.H., J.P. Hughes, "Chemical Hazards of the Work Place" J.P. Lippincott Co., New York, 1978.

9. Occupational Safety and Health Administration "General Industry Standards" (29 CFR 1910)

10. "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1986", American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, Ohio, 1986.

XI. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Kevin P. McManus, I.H.
Regional Industrial Hygienist
Region I
JFK Federal Building
Boston, Massachusetts

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

XII. 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. Industrial Precision, Inc.
2. NIOSH, Region I
3. OSHA, Region I

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.