U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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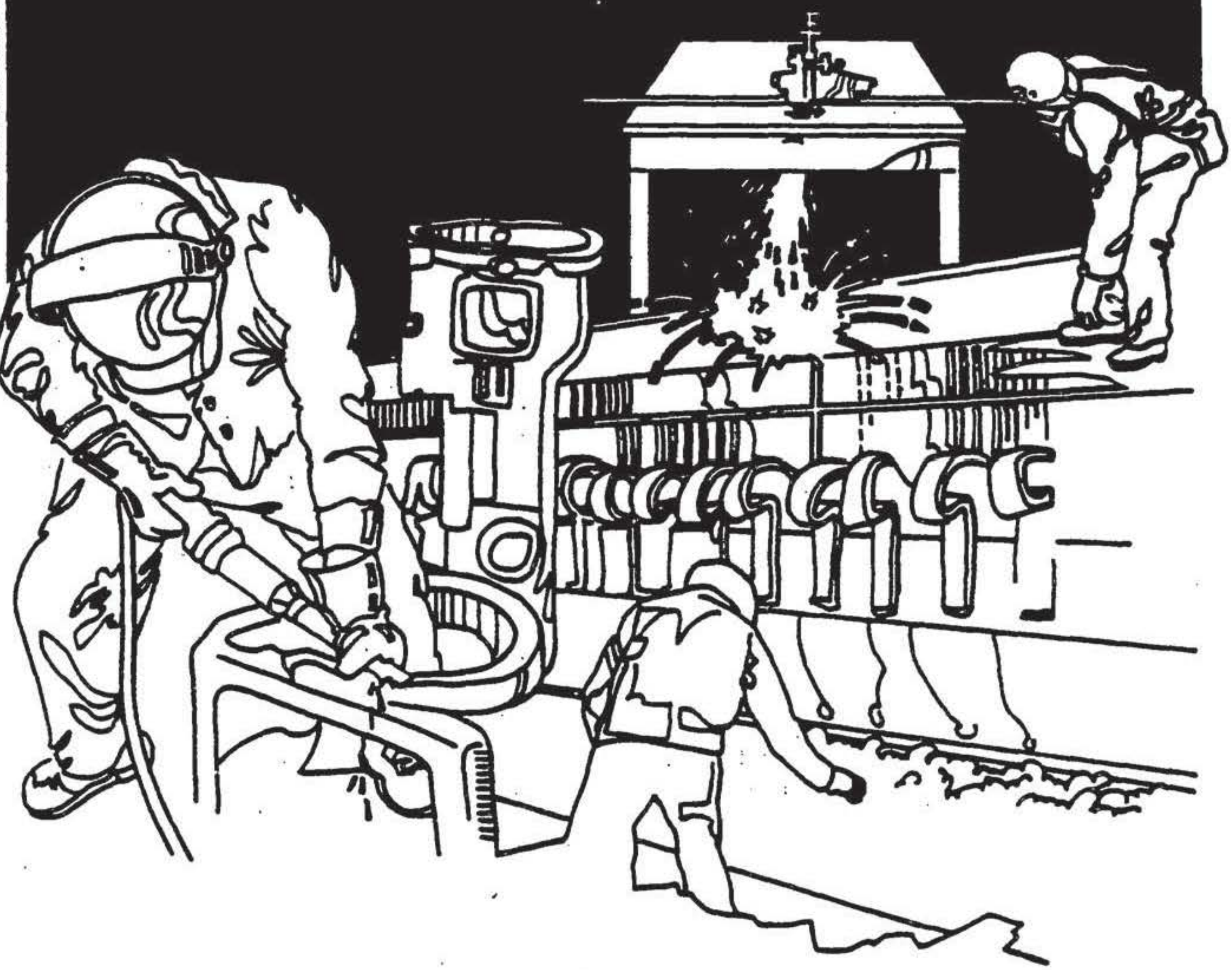

Health Hazard Evaluation Report

HETA 84-508-1626
STEINMETZ & SONS
MOSCOW, PENNSYLVANIA

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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STEINMETZ & SONS
MOSCOW, PENNSYLVANIA

NIOSH INVESTIGATORS:
David E. Clapp, PH.D., CIH
Mark Boeniger, MS, CIH
William Heitbrink, MS, PE
William Tolos, BS

I. SUMMARY

On August 10, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested by Steinmetz and Sons Machinery Co., Moscow, Pennsylvania, to evaluate the effectiveness of a procedure developed to reduce worker exposures to 4, 4'-methylenebis (2-chloroaniline)(MBOCA).

To evaluate worker exposures to MBOCA, NIOSH investigators conducted a site visit at the plant on September 10-12, 1984. NIOSH investigators obtained personal and area air samples, surface wipe samples, and hand contact monitors to estimate potential for exposure in the workplace. In addition, 24-hour urine samples were collected from each worker to evaluate actual absorbed dose.

During the visit, NIOSH investigators found no detectable air concentrations of MBOCA in the workplace in either personal or area samples. Limits of detection for air samples, wipe samples, and dermal monitors were 2.9 ug/m^3, 5.3 ug, and 5.3 ug respectively. MBOCA was detected on only two of eighteen surface wipe samples which were collected to identify contaminated surfaces. The two positive samples were collected on the surface of MBOCA pots where trace levels of MBOCA would normally be expected. None of the dermal dosimeters used to monitor MBOCA contamination on workers' hands revealed detectable MBOCA levels. Despite the negative results of the environmental sampling, all urine samples from six production workers, one maintenance worker, and one manager contained detectable concentrations of MBOCA. The day production workers', maintenance worker's, and manager's urine concentrations were below 5 ug/g creatinine, while the two night production workers and a day foreman were 4-5 times higher. The foreman was the only worker who actually was observed handling MBOCA and approximately 11 hours following his exposure his urine concentration peaked at 22 ug/g creatinine. The urine concentrations of two night production workers exceeded 20 ug/g creatinine for a few samples, but did not reflect the excretion pattern seen in the results for the foreman. All measured concentrations were well below the exposure standard for MBOCA in urine of 100 ug/L enforced by Cal/OSHA (the only existing standard).

Based on these results, it was concluded that exposures to MBOCA at the Steinmetz and Sons Machinery Co. are below prevailing standards. Since MBOCA is a suspect human carcinogen, however, it is advisable to attempt to further reduce concentrations of MBOCA in workers' urine. Suggested methods to accomplish this are found in the Recommendations Section of this report.

Keywords: SIC 2821 (Synthetic Rubber), MBOCA-cured urethane, 4, 4' -methylenebis (2-chloroaniline)(MBOCA), urethane molding.

II. INTRODUCTION

In August 1984, NIOSH received a request for a health hazard evaluation (HHE) at Steinmetz and Sons Machinery Co., Moscow, PA. The requestors asked NIOSH to evaluate exposures to 4,4'-methylenebis (2-chloroaniline)(MBOCA) in their workplace. This company has developed a proprietary method for transferring solid MBOCA from shipping containers to melting pots in their production process. The company contends that this method reduces (perhaps eliminates) worker exposure to MBOCA. The HHE was planned, using newly developed NIOSH exposure monitoring methods, to evaluate current exposure to MBOCA with the current MBOCA-handling process in place.

III. BACKGROUND

MBOCA cured urethane is a unique industrial product which has become essential in producing precision parts. The finished material has highly desirable qualities (durability, dimensional stability, etc.) and in addition allows relatively high production quantities with relatively low labor cost and equipment investment. Molded urethane products have become accepted as essential in products ranging from the common skateboard wheel to a component in an aircraft engine requiring dimensional precision and wearability.

The Steinmetz & Sons Machinery Co. has been in the urethane casting business for at least ten years in the State of Maryland. In 1981, the Company established a new corporate facility on a 20 acre suburban site near Moscow, Pa. Production operations are housed in an approximately 10,000 square foot steel building on the site.

The company employs six persons, mostly family members, in production operations. The process begins with the receipt of dry, prilled MBOCA(popcorn sized pellets) from the chemical manufacturer. Production of MBOCA has been voluntarily suspended in the United States for several years and most U.S. supplies are imported from Japan. At least one company has indicated an intention to again manufacture MBOCA in the U.S., and production in this country is expected to resume shortly.

At Steinmetz & Sons Machinery Co., dry MBOCA is melted to mix with an isocyanate prepolymer (e.g. Adiprene^{tm}) to form a moldable urethane. At Steinmetz, the dry MBOCA is melted and blended with prepolymer in an automatic machine (APC machine). The dry MBOCA is placed into a hot melting pot where it is melted and piped to the blending nozzle on the APC machine. The prepolymer is piped to this nozzle from a 55 gallon bulk storage barrel. The APC machine can be programmed to prepare a range of mixes of molten MBOCA and prepolymer depending upon the specifications of the finished product.

Precisely machined alloy metal molds are used to mold the finished part (e.g. a component of an aircraft engine). The blended urethane mix (prepolymer and MBOCA curative) is poured into a heated mold, placed in an oven to promote curing, and allowed to set. After a predetermined curing period, the mold is opened and the finished urethane part is removed. The finished part is inspected, trimmed, and prepared for shipment. The alloy metal molds are cleaned with methylene chloride and returned to storage for reuse.

IV. METHODS AND MATERIALS

A. Environmental

NIOSH investigators collected personal breathing zone, surface wipe samples, and hand monitor samples on September 10-12, 1984 to evaluate workers' exposures to MBOCA in the urethane molding operations at the Steinmetz Co. All of the methods employed in this survey are under development by NIOSH's Division of Physical Sciences and Engineering (DPSE) and were considered experimental in this HHE.

Air samples were collected in workers' breathing zone using Dupont P-2500 tm sampling pumps operating at 2 lpm. The pumps were placed on workers' belts and connected by tygon tubing to Millipore filter cassettes attached at the collar. The filter cassettes held 37-mm Gelman Type A/Etm acid coated glass fiber filters designed to collect and stabilize airborne MBOCA in either a particulate or vapor state. This method has recently received unofficial laboratory validation by the NIOSH Division of Physical Science and Engineering[1].

Each worker also wore a dermal monitor on one hand for a full workshift. Each dermal dosimeter was prepared by attaching elastic straps to two small (approximately 1" square) surgical cotton gauze pads (see diagram in Appendix 1). The gauze pads were moistened with gylcerine (trihydroxy propane) and attached to the hand which the worker used most frequently. This technique has been used with some success in assessment of exposures among pesticide workers[2]. At the end of the workshift, the dermal monitors were removed and stabilized in 4 ml. 0.02N sulfuric acid in 20 ml. scintillation vials for shipment to the analytical laboratory.

Wipe samples were collected on potentially contaminated surfaces in the plant using standard Whatman filter tabs. Samples were collected by wiping a 100 cm^2 area with dry tabs in a rectangular pattern. Sampling locations were selected from those surfaces where workers were deemed most likely to physically contact MBOCA dust if such dust was present. After wiping, tabs were stabilized in 4 ml. 0.02N sulfuric acid in 20 ml scintillation vials for shipment to the analytical laboratory.

As an additional, non-quantitative survey method, some wipe samples (collected as described above) were activated by spotting the wipe tabs with several drops of fluorescamine (Fluran) and visually observed under ultra violet light immediately after collection. Aromatic amines are known to fluoresce under UV light after activation[3], and experiments in the NIOSH laboratories prior to this survey indicated the feasibility of this method as a field technique. The goal of this technique was not the quantitation of levels of MBOCA contamination, but the relative grading of surface contamination using a simple, real-time field technique.

B. Biomonitoring

NIOSH collected all voids from four day production workers over a 24 hour period as an index of MBOCA exposure. Voids at the beginning and end of shift for two shifts were collected from two night production workers. For comparative purposes, a single void was collected from the office manager and a maintenance worker. Urinary monitoring for MBOCA exposure has become an accepted technique for assessing MBOCA exposure. NIOSH has developed a urine analysis method with a limit of detection 1 ug/liter [4]. Urinary monitoring represents the most likely method to detect exposure since significant exposure occurs via skin absorption and none of the environmental methods described above adequately assesses this route of exposure.

Individual urine voids were collected in 250 ml nalgene bottles. The total volume of each void was determined and 20 ml. aliquots of each sample were preserved in 3 ml. of 30% citric acid (w/w) and were retained, frozen, for later laboratory evaluation.

After the preservative was added, samples were frozen and shipped to the analytical laboratory. Urine specimens were analyzed by NIOSH Method 8302 [4] using certain modifications. MBOCA in the urine samples was derivatized using heptafluorobutyric anhydride instead of pentafluropropionic anhydride (PFPA) due to commercial unavailabilty of PFPA. Also, a fused silica capilary column (SE-54) was used instead of a glass packed column in hopes of obtaining better MBOCA separation.

V. EVALUATION CRITERIA

Toxic Effects of MBOCA

MBOCA has a chemical structure very similar to benzidene, a known bladder carcinogen. This structural similarity has led to considerable toxicological research into effects in animals. These studies have shown that MBOCA is carcinogenic in three animal species: rats[5], mice[6], and dogs[7]. This animal data, in addition to further evidence of the mutagenicity[8] and genotoxicity[9] found in recent studies, has led to the classification of MBOCA as a potential human carcinogen. There have been no medical or epidemiological studies demonstrating carcinogenicity in man, but since the average latency for bladder cancer is 20 years, insufficient time may have passed for observation of these findings.

Although the metabolism of MBOCA has been studied in rats [10], the metabolic fate of MBOCA in man is unknown. As with animals, a small percentage of parent MBOCA is excreted unchanged in the urine of exposed human workers. While the metabolites of MBOCA may prove in the future to be preferred indices of human exposure, parent MBOCA in urine has become a widespread and accepted index of exposure.

The State of California enforces exposure limits for air sampling, wipe sampling, and urinary monitoring. Under the California standard, airborne concentrations are limited to 10 ug/m^3 and surface contamination to 100 ug/ 100 cm^2 of surface area[11]. Michigan[12] enforced similar limits under an emergency temporary standard which expired. The American Conference of Governnmental Industrial Hygienists (ACGIH)[13] recommends a threshold limit value (TLV) of 220 ug/m^3 as an eight hour time weighted average (TWA). NIOSH[14] recommends that no worker be exposed to air concentrations exceeding 3 ug/m^3 as an time-weighted average for up to a 10-hour workshift. There are no current exposure standards promulgated by the Occupational Safety and Health Administration (OSHA).

For evaluating exposure by urinary monitoring, California enforces a standard of 100 ug/L in urine of exposed workers corrected to a specific gravity of 1.024. Michigan enforced a standard of 50 ug/L (with a similar correction for specific gravity) prior to expiration of the temporary standard. NIOSH, ACGIH, or OSHA do not currently recommend standards for urinary levels of MBOCA.

VI. RESULTS

A. Environmental

Area and personal air sampling using acid coated glass fiber filters revealed no quantifiable exposures above the limit of quantitation (LOQ) of 14.7 ug per sample established for the analytical procedure (Table 2). With the exception of two wipe samples, surface wipe tabs stabilized in sulfuric acid revealed no surface contamination above the LOQ of 26.4 ug per sample (Table 3). The two positive wipe samples were taken on the surface of the MBOCA melting pots which was assumed to be the site of highest exposure potential since MBOCA was added frequently to the pot as the supply of molten MBOCA dwindled. The two surface wipe results were 136 and 1490 ug, respectively which are well above the LOQ. Finally, all of the gauze pads used to monitor skin contamination were below the LOQ of 26.4 ug per sample (Table 4).

B. Biomonitoring

Urine samples were collected from two machine operators, a foreman and a supervisor as voided over a twenty four hour period starting at the beginning of the day shift and ending the following morning. Two second shift machine operators provided specimens at the start and end of the shift for two workshifts. One specimen each was obtained from a maintenance worker and the office manager.

As shown in Table 1, the results revealed very low MBOCA concentrations in the urine of all workers monitored both before and after creatinine adjustment. All urine samples contained detectable MBOCA concentrations (above the limit of detection of 1 ug/L), but most workers had concentrations below 10 ug/L. Three workers had urine concentrations substantially above trace levels, one was a foreman who directly handled MBOCA in recharging the MBOCA pot (average MBOCA level 22 ug/L, and 11 ug MBOCA/g creatinine), and the two night shift machine operators had similar levels as the foreman.

Table 1
MBOCA Concentrations in Urine of Monitored Employees

Worker	Date	Time	Free MBOCA ug/L	Creatinine mg/L	Corrected MBOCA ug/g Creatinine
Day	9/11	8:00 am	4	1600	3
Machine	9/11	11:00 am	5	1640	3
Operator	9/11	1:00 pm	5	2490	2
ID:1004	9/11	5:00 pm	5	2600	2
	9/11	10:30 pm	5	1660	3
	9/12	2:00 am	5	1380	4
	9/12	6:30 am	4	1240	3
	9/12	8:00 am	5	1490	3
Day	9/11	8:30 am	5	1910	3
Machine	9/11	11:00 am	4	2460	2
Operator	9/11	1:00 pm	6	2540	2
ID:1006	9/11	5:00 pm	6	3800	2
	9/11	8:00 pm	7	1850	4
	9/11	10:00 pm	7	1710	4
	9/12	6:20 am	4	1440	3
	9/12	9:00 am	7	2780	3
Day	9/11	8:00 am	8	2800	3
Machine	9/11	11:00 am	6	2410	2
Operator	9/11	1:00 pm	7	2520	3
ID:1003	9/11	5:00 pm	7	2090	3
	9/11	10:50 pm	7	3760	2
	9/12	6:35 am	5	3300	2
	9/12	9:00 am	7	2120	3
Foreman	9/11	8:00 am	8	1880	4
Day	9/11	11:00 am	11	2160	5
ID:1005	9/11	1:00 pm	16	2320	7
	9/11	5:00 pm	17	2640	6
	9/11	7:30 pm	37	1970	19
	9/11	11:00 pm	34	1520	22
	9/12	:00 am	23	1440	16
	9/12	9:00 am	16	1390	12
Night	9/10	4:30 pm	25	1580	16
Machine	9/11	12:30 am	23	2280	10
Operator	9/11	4:30 pm	32	1420	23
ID:1001	9/12	12:30 am	20	2220	9

Table 1 (Continued)
MBOCA Concentrations in Urine of Monitored Employees

Worker	Date	Time	Free MBOCA ug/L	Creatinine mg/L	Corrected MBOCA ug/g Creatinine
Night	9/10	4:30 pm	19	1460	13
Machine	9/11	12:30 am	sample lost	----	---
Operator	9/11	4:30 pm	36	2530	14
ID:1002	9/12	12:30 am	22	2250	10
Maintenance Worker ID:1007	9/12	11:15 am	6	1130	5
Manager ID:1008	9/12	12:00 pm	2	1230	2

Each of the urine specimens was adjusted for creatinine excretion to correct for differences in urine volume excreted by each individual. As shown in Table 1, the raw data for each specimen and each individual is tabulated both before and after creatinine adjustment. The creatinine correction reduced the numerical value of each sample, but did not change the relationship between the foreman and night machine operators and the day machine operators. Urines from the latter workers showed MBOCA levels 2 to 3 times greater than the former workers even after the creatinine correction.

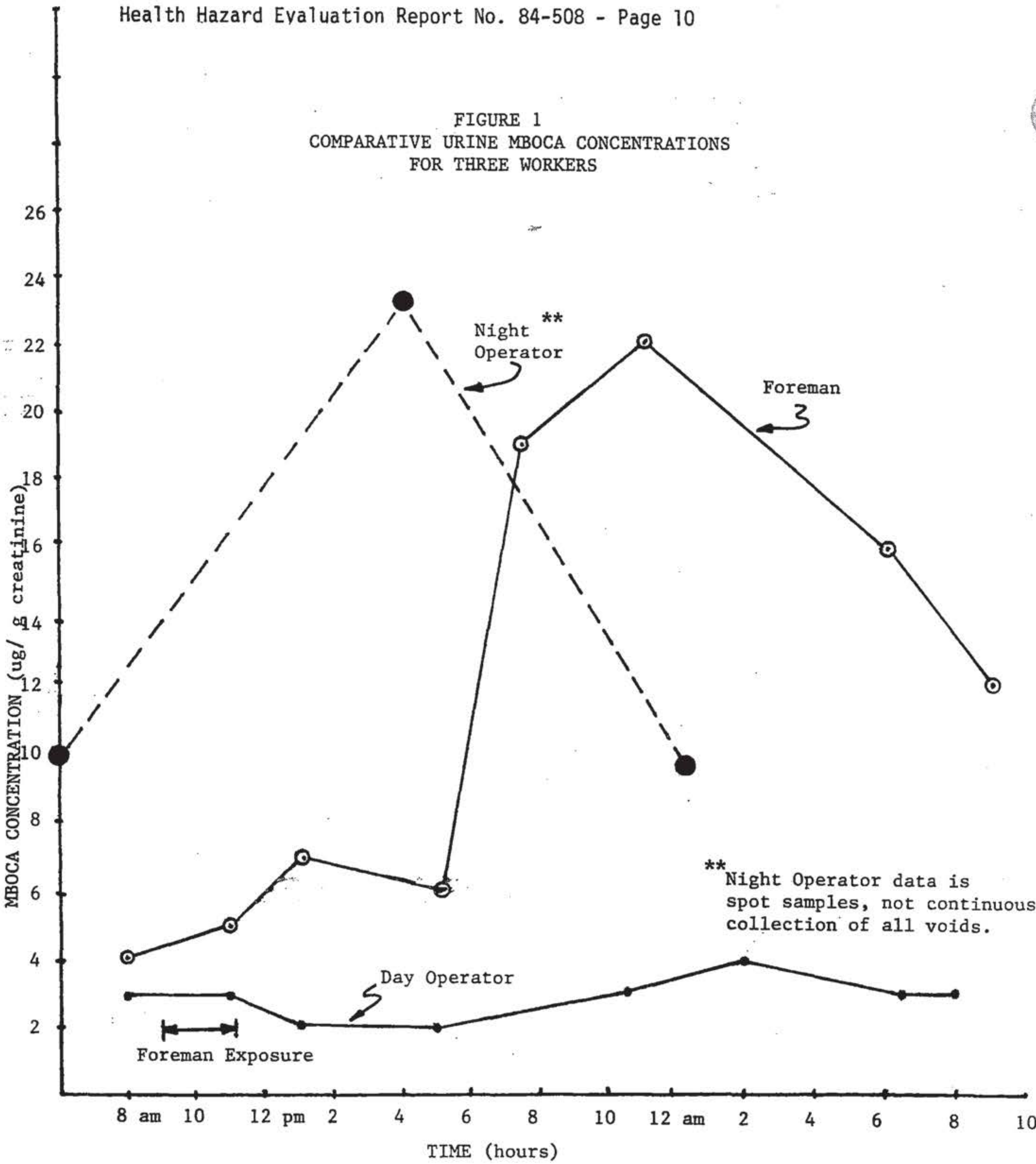
A plot of the results for the foreman, a day machine operator, and a night machine operator is shown in Figure 1. For the foreman, the most significant observation from these data is the very apparent peak in excretion eleven hours after an observed exposure. The foreman was observed to be working with MBOCA directly on Sept. 11 between 9 and 11 AM; however the peak excretion of parent MBOCA was not observed until 9 to 11 hours later. This result, while representing only a small amount of data, clearly shows a marked increase in excretion after an observed exposure, followed by a relatively rapid return to the pre-exposure level. For comparative purposes, the urine levels of two machine operators are also plotted on Figure 1. For the day machine operator, the biomonitoring results did not reflect any notable excursions in excretion pattern. This pattern was typical of all other day machine operators who did not directly contact MBOCA during their workshift. The night machine operator, on the other hand, did show levels well above the average of all day machine operators. The data for this worker is not continuous (hence a dotted line is used to join the points in Figure 1), since only spot urine samples were collected.

As an overall observation of biomonitoring data for all workers, it can be seen that the urinary MBOCA levels never declined to a theoretical zero or non-detectable level during the sampling period. It would be of interest, in a future study, to determine if urine levels fall below the analytical detection limit after several days without exposure (e.g. over a weekend).

VII. DISCUSSION AND CONCLUSIONS

Based upon the results of the environmental and biomonitoring evaluations, NIOSH has determined that MBOCA exposure at the Steinmetz & Sons Machinery Co. is below current exposure criteria. The results do suggest that levels can be further reduced, which is advisable with a suspect carcinogen as potent as MBOCA. The day shift machine operators showed urine levels comparable to the Plant Manager who did not work directly with the production process and only occasionally entered the production area. The higher exposures were apparently due to direct contact with MBOCA by the foreman in charging the MBOCA pot, and by night workers who may not have been as closely supervised as day workers.

FIGURE 1
COMPARATIVE URINE MBOCA CONCENTRATIONS
FOR THREE WORKERS



The negative environmental results confirm the visual observation that the plant was well maintained and very clean. The two positive wipe samples demonstrated that free MBOCA is released during pot charging operations; hence there is potential for exposure. The elevated MBOCA levels found for the foreman (with an obvious peak not seen in other workers) suggested that pot charging is the most likely exposure point in the process.

While no relationship between environmental and biomonitoring results could be demonstrated in this study, additional research is needed prior to reaching a definitive conclusion. In a larger, older plant, where greater quantities of MBOCA are in use, higher measurable environmental results are expected. This study demonstrated the extreme sensitivity of the urine monitoring method in an environment with minimal exposure. The results were especially remarkable for one individual with an observed exposure. While these biomonitoring results do not suggest a hazardous exposure, they nonetheless indicate measurable exposure which deserves management attention.

VIII. RECOMMENDATIONS

Recommendations 1-5 were presented to Steinmetz and Sons Machinery Co. by letter dated December 3, 1984. They will be repeated here for reference, along with two additional recommendations.

1. The company should issue clothing (including underwear) which is laundered daily and which is not worn home. Shoes and disposable shoe covers should be included.

2. Shower facilities should be installed and employees should be required to shower before leaving at the end of a work shift. Employees should be encouraged to wash their hands frequently during the day, particularly before meals.

3. The company should discontinue the use of empty MBOCA shipping containers for any purpose (either as storage or waste containers) and dispose of those containers in an evironmentally acceptable manner.

4. Improvements in the plant ventilation system should be investigated. The hood which is used to formulate small quantities of urethane does not appear to have adequate face velocity (100 feet per minute), and it currently exhausts to an existing vent in the roof (vs. extending through the roof proper). Since it is possible that small quantities of MBOCA vapor escape from the curing ovens, negative pressure in the ovens or exhaust hoods over the ovens may be advisable. The ACGIH "Industrial Ventilation, A Manual of Recommended Practice" [15] may be a useful reference for investigating these alternatives.

5. A regular biomonitoring program should be established. Since worker urines in the plant showed positive MBOCA levels, some exposure is occurring (albeit very low). With a urine monitoring program, work practices of certain workers could be investigated (e.g. the foreman and 2nd shift employees) as well as investigating results of control efforts suggested above. NIOSH can provide further information on how to establish such a program.

6. The foreman who recharges the MBOCA pot should be further protected from exposure. A disposable garment should be worn, along with a respirator, during charging operations. In addition, more durable gloves should be provided for these operations. The surgical type gloves currently issued may be adequate for working with urethane after blending the prepolymer and MBOCA, but not during charging operations. The foreman's gloves were observed to be torn at one point during our survey which would lead to obvious skin exposure. The delicate rubber used in surgical gloves is not adequate for some of the rough operations in the production process, particularly for the foreman whose hands may directly contact pure MBOCA.

7. The second shift employees should be further studied to determine why their exposure is elevated over day shift workers. One of these employees was observed not wearing gloves due to an acknowledged skin condition. This might explain the elevated exposure in one employee, but does not explain similar exposures in both. More rigid work rules may be required to insure the lowest possible exposure; a biomonitoring program (item 5 above), would provide a means to verify compliance.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	David E. Clapp Industrial Hygiene Engineer Industrial Hygiene Section
Originating Office:	Industrywide Studies Branch Division of Surveillance, Hazard Evaluations and Field Studies
Report Typed by:	Marianne E. Fleckinger Clerk-Typist Industrial Hygiene Section

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. Steinmetz & Sons Machinery Company
2. NIOSH,Region III
3. OSHA, Region III

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 2
Air Sampling Results

September 11, 1984

Sample No.	Worker ID.	Pump No.	Sample Vol (L)	Analytical Wt. (ug)	Concentration (ug/m^3)	Comments
1	M01	7197	998	ND*	§3	FS/personal
2	area	8144	1013	ND	§3	FS/near oven
3	area	7162	994	ND	§3	FS/near oven
4	M02	6246	1008	ND	§3	FS/personal
5	M03	8183	1003	ND	§3	FS/personal
6	FOR	7128	8	ND	§368	ST/MBOCA mixing
7	FOR	7128	52	ND	§56	ST/MBOCA mixing
8	M04	7101	998	ND	§3	FS/personal
9	area	7161	994	ND	§3	FS/on APC unit
10	area	8182	989	ND	§3	FS/on MBOCA pot
11	M05	8190	1013	ND	§3	FS/personal
12	M06	7215	998	ND	§3	FS/personal
13	FOR	8185	1008	ND	§3	FS/personal
16	BLANK	----	--	ND	--	BLANK

September 12, 1984

Sample No.	Worker ID.	Pump No.	Sample Vol (L)	Analytical Wt. (ug)	Concentration (ug/m^3)	Comments
14	M02	7161	994	ND	§3	FS/personal
15	M05	8190	1013	ND	§3	FS/personal
17	FOR	7215	998	ND	§3	FS/personal
18	area	8182	989	ND	§3	FS/on oven
19	area	8183	1003	ND	§3	FS/on MBOCA pot
20	area	7128	---	LOST	--	Sample Lost
21	M06	7162	994	ND	§3	FS/personal
22	M04	8144	1013	ND	§3	FS/personal
23	BLANK	----	--	ND	--	BLANK
24	area	7197	998	ND	§3	FS/on work table

Note: FS=full shift sample (8 hours)
ST=short term sample (less than one hour)
*LOD= 2.94 ug/sample, LOQ=14.7ug/sample

Table 3

FILTER WIPE RESULTS

Sample No.	Analytical Wt. (ug)	Location
1W	ND*	Inside coffin oven
3W	(79.6)	Top of melting pot, small hood
4W	ND	Surface of work bench
5W	ND	Interior of used drum
6W	136	Surface of MBOCA pot
8W	ND	Face of oven door (yellow stain)
9W	ND	Surface of refrigerator
10W	ND	Surface of work bench
11W	ND	Top of coffin oven--dust accumulation
12W	ND	Face of walk-in oven
13W	1490	Surface of older MBOCA pot
14W	(31.2)	Face of APC machine
15W	(9.78)	Floor in front of work bench
16W	ND	Yellow stain on oven door
17W	ND	Lab table top
18W	ND	BLANK

Note: values in parentheses represent values above the LOD but below the LOQ
*LOD=5.29, LOQ=26.4

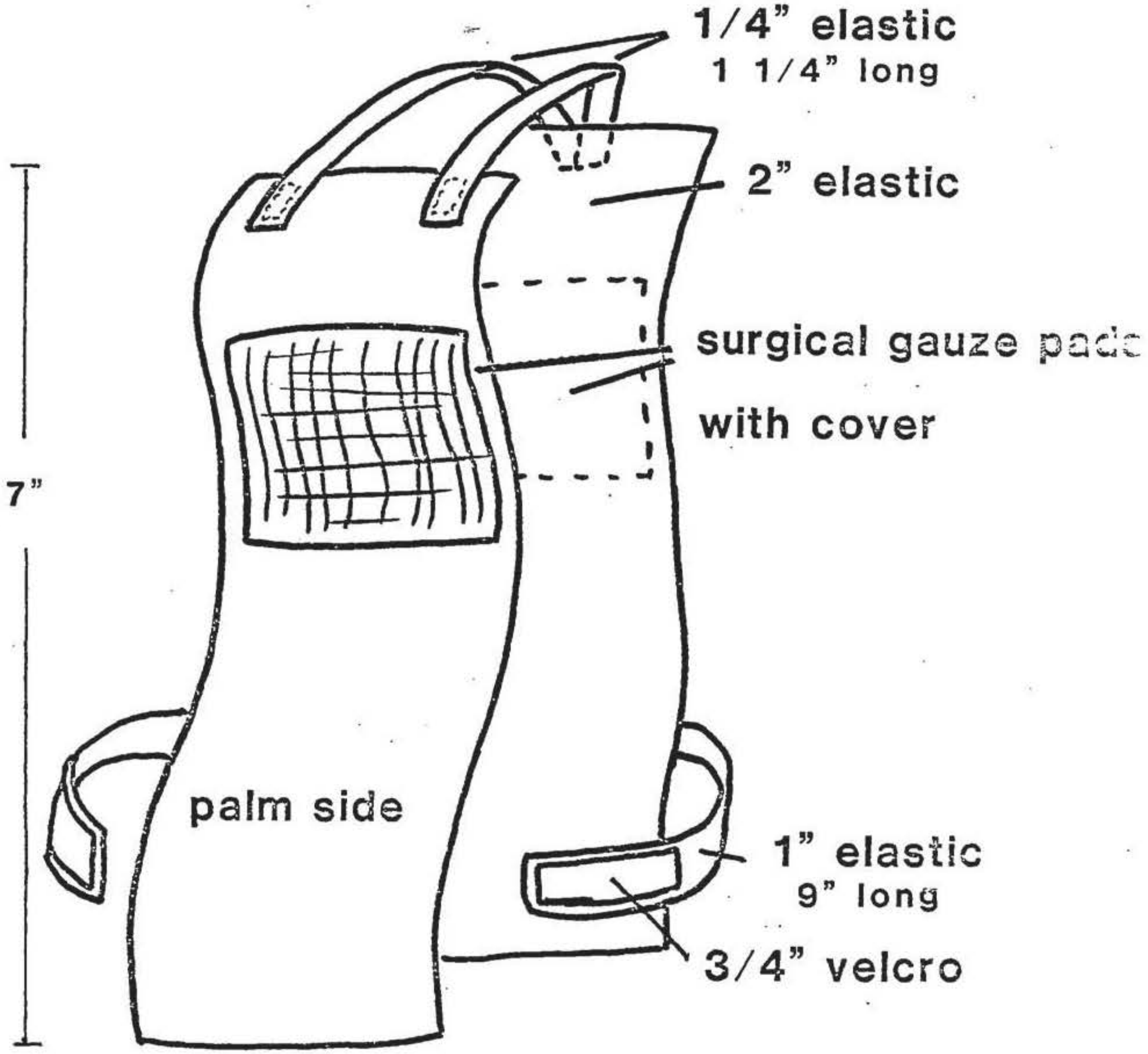
Table 4

HAND MONITOR RESULTS

Sample No.	Analytical Wt. (ug)	Worker ID./sample location
1P	(27.0)*	FOR/palm side of hand while mixing MBOCA
2P	ND	FOR/back side of hand while mixing MBOCA
3P	ND	M06/palm side of hand
4P	ND	M06/back side of hand
5P	ND	M05/palm side of hand
6P	ND	M05/back side of hand
7P	ND	M04/palm side of hand
8P	ND	M04/back side of hand
9P	ND	FOR/palm side of hand
10P	(10.0)	FOR/back side of hand
11P	ND	M01/palm side of hand
12P	(6.03)	M01/back side of hand
13P	ND	M03/palm side of hand
14P	ND	M03/back side of hand
15P	ND	FOR/palm side of hand
16P	ND	FOR/back side of hand
17P	ND	M04/palm side of hand
18P	ND	M04/back side of hand
19P	ND	M06/palm side of hand
20P	ND	M06/back side of hand
21P	ND	M05/back side of hand
22P	ND	M05/palm side of hand
23P	ND	M02/back side of hand
24P	ND	M02/palm side of hand

* LOD=5.29, LOQ=26.4 ug/sample

HAND CONTACT MONITOR



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PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
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