U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45202

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 73-142-213

W.S. DICKEY CLAY MANUFACTURING COMPANY
PITTSBURG, KANSAS 66762

JULY 1975

I. TOXICITY DETERMINATION

It has been determined that employees in Unit I were exposed to potentially toxic concentrations of carbon monoxide emanating from forklift truck exhaust. This is based upon environmental measurements made on November 18-19, 1974, for carbon monoxide which exceed the appropriate health standards for carbon monoxide exposure

It has been determined that employees in Units I and II were not exposed to toxic concentrations of toluene-2,4-diisocyanate (TDI) or polymethylsiloxanes. This is based upon the November 18-19, 1974, findings from: (1) medical interviews of employees; (2) medical testing of employees; and (3) environmental measurements for TDI and polymethylsiloxanes. However, it should be pointed out that minor acute irritative effects were present in employees exposed to each of the agents but no evidence of acute respiratory impairment was present in the exposed employees. The effect of chronic exposure to these agents could not be well defined from the evaluation. Two individuals no longer working in the areas of the Health Hazard Evaluation request were also evaluated. It was felt that both individuals had respiratory impairment resulting from either TDI hypersensitivity or TDI aggrevation of a pre-existing respiratory condition. It has been recommended that both men refrain from further isocyanate (TDI) exposure.

It has also been determined that employees in Units I and II were not exposed to toxic concentrations of methyl ethyl ketone (MEK), xylene, or toluene. Furthermore, employees in these areas as well as those in urethane mixing were not exposed to toxic concentrations of aryl phenyl mercury compound. This is based upon findings from: (1) medical interviews of employees; (2) medical examination of employees in some instances; and (3) appropriate environmental measurements.

Detailed information concerning the medical and environmental results of this determination are contained in the body of the report. Recommendations are included in this determination which are designed to keep employee exposure to these agents to a minimum.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of the Determination Report are available upon request from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a. W.S. Dickey Clay Mfg. Co., Pittsburg, Kansas
b. Authorized Representative of Employees
c. U.S. Department of Labor - Region VII
d. NIOSH - Region VII

For the purposes of informing the approximately 35 "affected employees," the employer will promptly "post" the Determination Report in a prominent place(s) near where exposed employees work for a period of 30 calendar days.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees to evaluate the exposure of employees to various airborne contaminants associated with operations involved with the fabrication or manufacturing of plastic collars around the female and male ends of clay pipe. The request was precipitated by employee concern regarding possible harmful effects from exposure to emissions present in the fabrication of plastic collars.

IV. HEALTH HAZARD EVALUATION

A. Description of Process - Conditions of Use

The company manufactures clay tile pipe of various lengths and diameters for use in the construction industry. In order to obtain a tight fitting for attaching one pipe to another, the company molds a polyurethane plastic collar on both ends of the pipe. This is accomplished in two separate areas of the plant. Unit I has a slow moving conveyor line for processing medium to large size pipe and has facilities for handling the larger size pipe on an individual basis. Unit II has a slow moving conveyor line for processing only the smaller pipes. Both unit processes are generally the same. An adhesive mixture is brushed on the ends of the pipe to bond the pipe to the plastic. The conveyor line with pipe then moves through a low temperature (150°F) preheat oven. A mold release solution (to assure little or no bonding between metal and plastic collar) is sprayed on the metal collar mold which is then placed on the top and bottom of the pipe. Products A (polymer polyol) and B (containing toluene diisocyanate - TDI) are pre-mixed on a continuous basis and the resulting viscous liquid is poured into the metal collar molds. The pipes then move through a low temperature (150°F) cure oven to form a solid plastic collar at both ends of the pipe. The metal molds are then knocked off for reuse and the pipe is taken off the conveyor for packaging and subsequent shipment to customers. There are 11 employees on day shift for Unit I and 24 employees (12 - day, 12 - swing) for Unit II.

B. Study Progress and Design

A summary of the procedures used to evaluate the areas of concern included: on-site interviews with representatives of union and management, a walk-through inspection of the workplace, contacting manufacturers of products used in the process to identify toxic substances, administering medical questionnaires to and examining workers potentially exposed to plant contaminants, and extensive air sampling to detect potential exposure to airborne contaminants.

On October 10-11, 1973, an initial environmental-medical evaluation of operations involving Units I and II was conducted by a NIOSH survey team. Initial environmental results showed that appropriate health standards (refer to following section IV D-1) were not exceeded for any airborne contaminants measured in this study. The pulmonary function test equipment was not operating satisfactorily during the initial visit and subsequent medical evaluation were conducted on November 26, 1973 and January 7, 1974. Definitive conclusions could not be reached in comparing the individuals' pre- and post-shift pulmonary function tests. For this reason, it was decided to carry out a more extensive medical and environmental study. Based upon the information from the initial studies, the final study involved the evaluation of employees exposed to the following chemicals:

(1) toluene 2,4-diisocyanate (TDI),
(2) an aryl phenyl mercury compound used in the plastic molding operation,
(3) polymethylsiloxanes used in the mold release solutions,
(4) organic solvents as methyl ethyl ketone, xylene, and toluene used in the adhesive or other solutions.

Exposure to carbon monoxide from forklift truck operations was also considered important. The final medical-environmental evaluation was carried out on November 18-19, 1974. The evaluation was carried out during normal plant operations.

C. Evaluation Methods

1. Environmental

Personal air samples were primarily used to evaluate the employees' exposure. The personal samplers were connected on or around the collar of the employees to collect a representative sample of air in the breathing zone of the workers. General area samples were collected in specific locations in the working environment. Charcoal tubes were used for collecting organic vapors and were analyzed by NIOSH Laboratories in Salt Lake City Utah, by the gas chromatographic method reported by W.D. White, et al.[1] Special impregnated charcoal tubes for mercury were used for mercury determinations. TDI was collected by bubbling the air samples through midget impingers with 15 ml. of absorbing solution. Reagents and analytical procedures were those of the modified "Marcali method" as reported by Grim and Linch.[2] Total mist and dust samples were collected with vinlymetracel filters and gravimetrically analyzed for total particulate by the NIOSH laboratory in Cincinnati. The filter samples were used primarily for the evaluation of polymethylsiloxane as there is no approved specific method of analysis for this compound.

Concentrations of carbon monoxide were measured using an MSA Universal Test Kit with direct reading detector tubes. Carbon monoxide measurements were also made with the Ecolyzer Model 2800 instrument with a graphic continuous recorder.

2. Medical

The medical methods used in the evaluation encompassed the following:

a. Evaluation for acute adverse effects developing over the shift.

Pre- and post-shift testing was carried out in non-exposed controls and in workers exposed to TDI, organic solvents, and/or polymethylsiloxanes. This included pre- and post-shift questionnaires, physical examinations (eyes/throat/chest), and Pulmonary Function Tests (PFT). Twenty-five exposed workers and 24 control workers were tested. The control workers were preselected, having been matched with the exposed workers for height, sex, age, and smoking history (see Table I). All controls denied ever working with TDI or polymethylsiloxanes.

b. Medical analytical methods for evaluation of acute adverse effects.

The development of signs and symptoms over the work shift was compared in the control and exposed groups. Tests of significance were calculated between pre- and post shift Pulmonary Function Test (PFT) mean values of control-smokers, exposed-smokers, control ex- and non-smokers, and exposed ex- and non-smokers. The following measurements were made: forced expiratory volume in one second (FEV_1), forced vital capacity (FVC), FEV_1/FVC, maximum mid-expiratory flow ($MMEF_{25-75}$), and forced expiratory flow from 0.2-1.2 liters ($FEF_{.2-1.2}$).

c. Evaluation for chronic adverse effects.

(1) A modified version of the Medical Research Council's Questionnaire on Respiratory Symptoms (MRCQ) was used to assess the prevalence of chronic respiratory disease. Twenty-five workers exposed to TDI, organic solvents, and/or polymethylsiloxanes, as well as 24 controls, were administered the detailed questionnaire. Additionally, pulmonary function test results ($FEV_{1.0}$, FVC) were analyzed, comparing the exposed and control groups.

(2) Questionnaire interviews, brief physical and neurologic examinations, and urine mercury determinations were carried out in controls and in individuals exposed to an aryl phenolic mercury compound. To assess the extent and effect of mercury exposure, four control and five exposed individuals were tested. Questionnaire interviews inquired about the individual's general state of health as well as asking about various systems known to be affected in chronic mercury intoxication (i.e., weight, sleep, appetite, mental outlook, bowel function, etc.). Physical and neurologic examination consisted of observation for tremors (eyes/fingers/tongue), evaluation of reflexes (biceps/triceps/jaw jerk/snout), Rhomberg position (with closed eyes), palpation of the thyroid gland, and looking at a sample of handwriting. Urine samples (collected for 16 hours) were taken for mercury determinations.

d. Medical analytical methods for evaluation of chronic adverse effects.

(1) Chronic Respiratory Effects
Responses to the MRCQ were compared in the control and exposed workers.

(2) Effects of Aryl Phenyl Mercury (APM) Exposure
Questionnaire interview and neurologic examination results were compared in the control and exposed workers. Urine samples were analyzed by the NIOSH Physical and Chemical Analysis Branch, using the "Standard Method for Total Mercury in Water" as described on page 118 of the 1974 EPA Methods for Chemical Analysis of Water and Wastes.[3]

D. Evaluation Criteria

1. Environmental Standards or Criteria

The three primary sources of environmental evaluation criteria considered in this report are: (1) NIOSH Criteria Documents recommending occupational standards, (2) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold

Limit Values (TLVs) with supporting documentation, and (3) federal occupational health standards as promulgated by the U.S. Department of Labor. For brevity, the recommended health standards or guides as used by the ACGIH are used as reference points in the following presentation of evaluation criteria. Use of the two other sources of criteria would not change any conclusions contained in this report.

The occupational health standard or guide promulgated by the ACGIH (1974) applicable to the principal individual substances of this evaluation are as follows:

	TLV 8-Hour Time-Weighted-Average (TWA) Exposure Standard or Guide	
Substance	ppm[a]	mg/M^{3} [b]
"C" Toluene diisocyanate (TDI)	0.02	0.14
"D" Mercury (all forms except alkyl)	--	0.05
"D" Oil mist	--	5.0[c]
Carbon Monoxide	50	55
"D" Methyl ethyl ketone (MEK)	200	590
"D" Xylene - skin	100	435
"D" Toluene - skin	100	375

a - Parts of vapor or gas per million parts of contaminated air by volume (ppm)
b - Approximate milligrams of substance per cubic meter of air (mg/M^3)
c - As sampled by a method that does not collect vapor
"C" - Denotes a ceiling limit of concentration for the substance which should not be exceeded
"D" - Denotes an excursion factor for all substances not bearing a "C" notation which are:

TLV = 0-1 (ppm or mg/m^3)	Excursion Factor = 3
TLV = 1-10 (ppm or mg/m^3)	Excursion Factor = 2
TLV = 10-100 (ppm or mg/m^3)	Excursion Factor = 1.5
TLV = 100-1000 (ppm or mg/m^3)	Excursion Factor = 1.25

The product of the TLV times the excursion factor represents a "ceiling value" which cannot be exceeded (i.e. "ceiling value" = TLV x Excursion Factor).

In reviewing the above table, it should be noted that there is no specific recommended health standard for polymethylsiloxanes. Polymethylsiloxanes are an oil-type viscous liquid substance used widely in the cosmetics industry as a base for many products such as creams, shaving lotions, etc. For purposes of this evaluation, the health standard which is used for the evaluation of this substance is that used for oil mists. It also should be noted that NIOSH recommends in two recent publications[4,5] that the health standards for TDI and Carbon Monxoide be lowered to the following levels: (1) Time weighted average(TWA) concentrations of TDI should not exceed 0.005 ppm (0.036 mg/M^3) and ceiling concentrations for any 20-minute period should not exceed 0.02 ppm (0.14 mg/M^3); and (2) TWA concentrations of carbon monoxide should not exceed 35 ppm and ceiling concentrations at no time should exceed 200 ppm (220 mg/M^3). Additionally, NIOSH recommends in "Criteria for a Recommended Standard...Occupational Exposure to Toluene" (1973) that ceiling concentrations of toluene for any 10-minute period should not exceed 200 ppm (750 mgm/M^3).

Occupational health standards or guides or ACGIH-TLVs (hereinafter referred to as health standard) for individual substances are generally established at levels designed to protect workers occupationally exposed on an 8-hour per day, 40-hour per week basis over a working lifetime.

2. Medical Standards or Criteria

a. Evaluation for Acute Adverse Effects

The medical criteria used to determine a toxic response to the substances under investigation consist of the symptoms and signs which each substance produces when toxic exposure occurs. A brief review of the substances of primary concern follows:

(1) Toluene 2,4-Diisocyanate (TDI)

TDI is a strong irritant, especially to the eyes and upper and lower respiratory tract. If TDI liquid comes into contact with the eyes, severe conjunctival irritation occurs. With exposure to lower concentrations of the vapor, burning or smarting of the eyes is noted. Headache as well as gastrointestinal complaints of nausea, vomiting, and abdominal pain have been reported following inhalation of the vapor or aerosol. Of all the adverse effects, the most notable are those involving the respiratory tract. The following two specific effects have been noted.

(a) Primary irritancy - at sufficient concentrations of TDI, all exposed individuals may have respiratory effects such as burning of the nose and throat, a choking sensation, dry or productive cough and general chest pain. These effects have sometimes been mistaken for a "cold" or upper respiratory tract infection. Exposure to higher concentrations of TDI can lead to severe irritation of the respiratory tract mimicking as an asthmatic attack. Additional symptoms include headache, sleeplessness, ataxia and euphoria.

(b) Allergic sensitization - when one has become "sensitized" to TDI, very small concentrations of TDI may elicit various symptoms. Nocturnal shortness of breath and cough as well as symptoms and signs of asthma may appear in sensitized individuals (such asthmatic reactions in a few instances have been fatal).

A third type of effect of TDI on the respiratory tract is under evaluation, i.e. the relationship of long term exposure to TDI and cummulative impairment of lung function. Although some studies suggest that long term exposure to non-irritating and non-sensitizing concentrations of TDI may impair lung function, further investigation is needed.

(2) Polymethylsiloxanes

Organosilicon compounds are felt to be relatively non-toxic, although relatively little is known about them. It is postulated that siloxanes may act as moisture suppressants or retardants and hence may inhibit mucous membrane secretion when applied topically.

(3) Aryl Phenyl Mercury (APM)

Because it is a non-alkyl organic mercurial, APM has a significantly less toxic effect than ethyl or methyl mercury compounds. Acute adverse effects may be quite diverse, including irritation and redness of the gingiva, excessive salvation, and tremor. With high levels of inhalation exposure, pneumonitis and shortness of breath as well as other respiratory symptoms may occur. Ingestion of high concentrations can bring about abdominal pain and bloody diarrhea.

Chronic excessive exposure affects primarily the nervous system. Such symptoms and signs as tremor, irritability, headache, excitability, shyness, constricted visual fields, abnormal reflexes, and weakness may occur.

(4) Organic Solvents (MEK, Toluene, Xylene)

The acute effects resulting from excessive exposure to these agents are generally the same with some minor differences noted. Toluene has been the most extensively studied, giving rise to mild fatigue, weakness, and paresthesias of the skin with early excessive exposure. At higher concentrations, confusion ensues, and nausea, headache, and dizziness appear. At very high concentrations, loss of coordination, extreme nervousness and finally unconsciousness may be present. Xylene is similar in its acute toxic effects but is noted to give rise to more pronounced gastrointestinal symptoms (nausea, vomiting, flatulence, etc.) MEK differs from toluene and xylene in giving rise to eye and mucous membrane irritation with early excessive exposure. Higher concentrations may produce effects similar to the other two agents.

Chronic effects of exposure to each agent range from weakness and fatigue (toluene) to dermatitis (MEK, toluene, xylene). Other chronic effects are less well defined; none of the agents by themselves have been noted to be toxic to the bone marrow.

(5) Carbon Monoxide (CO)

The acute effects resulting from exposure to increasing concentrations of CO are well defined. Because CO is an odorless gas, the sense of smell does not help in detecting its presence. Early symptoms include tightness across the forehead and slight headache. As the concentration increases, throbbing bitemporal headache ensues followed by weakness, dizziness, dimness of vision, nausea and vomiting.

Finally, collapse, coma and death may occur if high levels of exposure continue. Also the effect of chronic low level exposure has been associated with deleterious effects on the heart circulation and mild adverse behavioral effects as noted by psychological testing.

A statistically significant difference between pre- and post-shift PFT results was recorded if the mean difference for FEV_1, FVC, FEV_1/FVC, $MMEF_{25-75}$, or $FEF_{.2-1.2}$ exceeded the change one would expect on the basis of chance or randomness. The probability that such significant findings could have developed by chance over the shift was 5% or less (i.e. $p \leq 0.05$).

b. Evaluation for Chronic Adverse Effects

(1) Chronic Respiratory Effects

Work exposure is only one of many factors which can significantly influence an individual's respiratory health. Other factors such as infection, smoking history, family history, air pollution, etc., may play major roles as well. Recognizing the presence of these factors, the MRCQ results were compared in the control and exposed workers. Individuals in the exposed and control groups who had worked five or more years in a dusty trade (i.e. foundry, mine, quarry, pottery, flax or hemp mill, asbestos production) were eliminated from the comparison.

(2) Effects of Aryl Phenyl Mercury Exposure

The criteria set forth in publication #985 published by the Commonwealth of Massachusetts[6] were used for assessing the degree of exposure. They are as follows:

URINARY MERCURY (mg/l)	CONDITION
0.00 - 0.15	No or safe exposure
0.15 - 0.30	Undesirable exposure
0.30 - 0.60	Significant exposure
0.60 - 1.0	Definitively harmful exposure
Over 1.0	Hazardous condition

E. Environmental and Medical Results, Discussion and Conclusions

The environmental survey accomplished during the initial visit of October 10-11, 1973, was not as extensive (e.g. no CO measurements were made, etc.) as the second survey on November 18-19, 1974, although the results of the first survey are in complete agreement with the results of the second survey. Conditions were similar during both surveys. Hence, for the sake of brevity, the results of the first survey have not been included.

1. Environmental Results and Discussion

a. Toluene Diisocyanate (TDI) - Table IIA shows the results of 34 short-term personal air samples and 3 general area samples, all varying from levels of 0.001 to a maximum concentration of 0.066 mg/M^3 of TDI. None of these sample results exceeded the ACGIH health standard or NIOSH's recommended short term standard of 0.14 mg/M^3. Table IIB shows the maximum estimated 8 hour TWA results (based on Table IIA) which varied from .001 to .029 mg/M^3 of TDI.

Although none of the current or recommended standards have been exceeded, the results show the presence of TDI with the higher concentrations near the pour operator as expected. The general ventilation was good with most of the side doors being open during the survey. In view of this fact, TDI levels may increase under conditions in which most of the doors are closed.

Several other observations are noteworthy. The NIOSH study did not include any air measurement during accidental spills of solutions nor during the changing of TDI or "B" solution. The changing of the TDI supply should not significantly increase the TWA exposure of employees, for the operation occurs only infrequently for a short period of time. However to insure that short-term excursions of TDI during these times do not exceed the NIOSH recommended ceiling value, environmental measurements should be carried out. It was also noted that (1) no local exhaust ventilation is provided at the point of operation nor very near to the pouring operation, and (2) the liquid viscous plastic material is poured into an open cardboard box when the conveyor line is not moving or production is shut down.

b. Aryl Phenyl Mercury Compound (Hg) - Table III shows the results of the estimated TWA concentrations from 4 personal and general air samples to be at less than detectable levels. Two personal samples gave detectable readings of 0.004 and 0.005 mg/M^3. These latter results were less than eleven percent of the TWA health standard of 0.05 mg/M^3 of Hg. Such low results were expected because the mercury compound is in solution at a concentration of less than one percent. The urethane operator makes up the Project "A" polyol solution and hence should receive the maximum exposure to the mercury compound as he handles it in the purest form. The urethane operator visits the production lines only occasionally and wears a respirator while mixing and/or handling a wide variety of dry chemicals during mix operations.

C. Polymethylsiloxanes (Oil Mists) - Table IV shows the estimated TWA concentrations from 10 personal air samples in Units I and II, all varying from 017 to 2.1 mg/M^3 for total oil mists. All of these results were less than fifty percent of the TWA health standard of 5.0 mg/M^3 of oil mists. They may be somewhat lower in reality for the recorded weight also included any airborne particulate matter. Also obtained was an air sample from the operator of Press No. 14. Although this operation was not considered a part of this request or survey, he appeared to receive a considerable exposure to oil mists containing polymethylsiloxanes. The results of the Press operator's sample was 4.5 mg/M^3 of oil mist which, although 90 percent of the TWA health standard, is considered as elevated and indicates a need to evaluate further other spray operations involving mold release solutions.

d. Carbon Monoxide (CO) - Direct reading detector tubes around all area operations involving Unit II were all less than 20 ppm which is considerably less than the federal or ACGIH health standard, as well as NIOSH's recommended standard of 35 ppm for CO. Readings were taken in the morning and afternoon. However, similar readings around Unit I showed to be about 90 ppm. These are in excess of the TWA health standard. In order to confirm these findings, CO levels were measured on a continuous basis (Ecolyzer Model 2800 Meter) for about four hours. These results show concentrations varying from 40 ppm to greater than 100 ppm over the four hour time period. The average results from Ecolyzer Model 2800 Meter are conservatively estimated as 65 ppm which are somewhat lower than those obtained with the detector tubes. Although these (tubes and Ecolyzer) results are area samples, they are indicative and probably represent a realistic estimate of a TWA exposure of personnel to CO concentrations in excess of any recommended health standard. It is felt that the excessive carbon monoxide exposure was due to the exhaust fumes of forklift trucks in that area. The CO concentrations probably vary considerably in the area of Units I and II depending on the frequency of use and maintenance of forklift trucks as well as the amount of general ventilation (doors open vs. closed) provided the areas.

e. Organic Solvents (MEK, Xylene, Toluene) - Table V shows the estimated TWA results from 4 personal air samples and 2 general area samples which varied from less than detectable amounts to a maximum of 8 ppm. These are considerably less than the appropriate health standards (varying from 100 to 200 ppm) for MEK, Xylene and Toluene. Even if one considers the effects of each substance as additive, the maximum effect would only be about ten percent of the combined health standard. Hence, exposure to organic solvents in this operation appears minimal and well under control.

In summary, the sample data shows that the carbon monoxide concentrations around Unit I exceeded the health standard for CO and are thus considered toxic. Although all the other sample data for other substances evaluated show that the levels do not exceed appropriate health standards and are not considered toxic at the concentrations found, the levels of exposure for some substances under certain conditions may be excessive. This indicates a need for further evaluation under different survey conditions (e.g. winter time when more doors may be closed, etc.) than were present during the NIOSH survey.

2. Medical Results

a. Evaluation of Acute Adverse Effects

The symptoms developing over the shift in the exposed and control workers were compared. The exposed workers were divided into three groups for comparison -

i.e. those exposed primarily to TDI, those exposed primarily to polymethylsiloxanes, and those exposed to both agents to a similar degree. The division of the exposed workers was based upon the industrial hygienist's judgment regarding employee exposures. The results are found in Table VI.

The physical signs (e.g. reddened eyes, reddened throat, etc.) developing over the shift in the exposed and control workers were also compared. The findings were felt to be unreliable and hence are not included.

Pulmonary function testing (PFT) was compared in the exposed and control groups. These findings are shown in Table VII and Table VIII.

b. Evaluation of Chronic Adverse Effects

(1) Chronic Respiratory Effects

The control and exposed workers were divided into two groups for comparison - i.e. (1) smokers and (2) ex- and non-smokers. The questionnaire findings are found in Table IX.

(2) Effects of Aryl Phenyl Mercury (APM)

Table X shows the urine mercury results for the exposed and control workers. Additionally, neurologic examinations of the exposed and control workers showed no abnormalities in either group.

3. Discussion of Medical Evaluation

Regarding TDI and polymethylsiloxanes exposure, the principal acute effect noted in employees exposed to these agents was eye irritation. Nose and throat irritation was also found in some exposed individuals but to a lesser degree. No significant change in pre- and post-shift pulmonary function testing was noted in either the exposed or control groups. One exception was present however. As noted in Table VII, exposed smokers showed a statistically significant change in $MMEF_{25-75}$ (i.e. 220 ml. drop over the shift). Although this decrease was statistically significant, it was not clinically significant since it was less than a 10% drop. A drop in $MMEF_{25-75}$ suggests some degree of small airway obstruction developing over the work shift. However, when this decrement was compared to the change in $MMEF_{25-75}$ in the control smokers, no significant difference was noted between the exposed and control smokers (See Table IX). Hence no additional factors (e.g. work exposure) appear to be bringing about the drop in $MMEF_{25-75}$ other than what might be expected from smoking alone. Furthermore, all differences between mean pre- and post-shift PFT results showed less than a 10% decreas and none of the individuals exposed to TDI or polymethylsiloxanes and tested by pre- and post-shift testing showed a significant individual drop in pulmonary function testing. These findings suggest that minor irritative effects were present in workers exposed to TDI and/or polymethylsiloxanes and that no significant degree of acute respiratory impairment was found in these employees. No evidence was present that any of the employees tested pre- and post-shift were "sensitized (i.e. hypersensitive) to TDI at the concentrations found on the day of the medica and environmental evaluation. However, it is important to point out that individuals who have previously been sensitized to TDI are at risk in an environment where any airborne concentration of TDI is present. For this reason, individuals who are suspected to be hypersensitive to TDI should be evaluated medically and removed from any further potential exposure to TDI if found to be so affected.

At the request of the union, the medical histories and respiratory findings of two specific individuals were reviewed. Both men were on medical disability and no longer working in the areas of the Health Hazard Evaluation. For that reason, pre- and post-shift evaluation of respiratory function could not be carried out. After a review of their findings, it was felt that both men had respiratory impairment resulting from either TDI hypersensitivity or TDI aggrevation of a pre-existing respiratory condition. The exact cause could not be determined. It has been recommended to both men that they should permanently refrain from any isocyanate exposure at work or elsewhere. With their permission, appropriate company and union officials have been told their names and the NIOSH recommendations regarding them.

With regard to chronic respiratory effects, it is difficult to draw any conclusions. The respiratory questionnaire results found in Table IX indicate that smokers in Units I and II have more symptoms of chronic expectoration, wheezing, and nasal catarrh than do smokers in the control group. Ex- and non-smokers in Units I and II appear to have more chronic expectoration than their counterparts in the control group. To attempt to draw conclusions from questionnaire results at a single point in time is often fraught with error. For this reason the PFT results of individuals in these groups were compared with predicted values.[7,8] Specifically, the differences between observed and predicted values for FVC and $FEV_{1.0}$ were compared. The "mean differences" for exposed smokers vs. control smokers and exposed ex- and non-smokers vs. control ex- and non-smokers were compared. The results are shown below:

MEAN AGE (Years)

	EXPOSED	CONTROL	PROBABILITY	
Smokers	42.1	42.4	0.9595	Not Significant
Ex- and Non-smokers	43.9	47.7	0.345	Not Significant

MEAN DIFFERENCES, OBSERVED PRE-SHIFT FUNCTION AND PREDICTED VALUE (Liters)

	EXPOSED	CONTROL	PROBABILITY	
Smokers				
$FEV_{1.0}$	0.241	0.474	0.2765	Not Significant
FVC	0.545	0.649	0.6004	Not Significant
Ex- and Non-smokers				
$FEV_{1.0}$	0.563	0.642	0.7872	Not Significant
FVC	0.760	1.081	0.2740	Not Significant

In all cases the "mean difference" was positive indicating the average observed value was greater than the average predicted value. If the probability were 0.05 or less, the difference between the two "mean differences" would be considered significant. None were considered significant. Hence, although exposed employees were noted to have more symptomatology than their counterpart controls there were no significant differences in $FEV_{1.0}$ and FVC between the two groups as noted above. While no statistically significant differences were found, it must be pointed out that further evaluation in both groups (exposed and control) of symptoms and measurements of pulmonary function over a period of years is really needed to clarify the matter. This is because determinations of $FEV_{1.0}$ and FVC are generally abnormal only after significant airways disease has taken place. More refined measurements ($MMEF_{25-75}$ and $FEF_{.2-1.2}$) could be followed over a several year period to see how each group's PFT changes, comparing one to the other. Further evaluation in this matter seems warranted but lies outside the scope of the Health Hazard Evaluation.

As noted in Table X, the urine mercury determinations in the five exposed employees were all well within the "no or safe exposure" range of exposure. Employee #6, whose urine mercury concentrations was the highest (0.077 mgm-Hg/L), workes in urethane mixing where highest exposure to APM presumably occurs. Questionnaire interviews and neurologic examinations of all employees (exposed and control) were felt to be normal. Based upon these findings there appears to be no significant exposure to APM in the urethane mixing operation or Units I and II.

Finally, no apparent chronic symptomatology was attributed by the employees in Units I and II to organic solvent exposure.

F. Conclusions and Recommendations

To summarize, evidence of minor acute irritative effects was present in some individuals exposed to TDI and polymethysiloxanes. However, no significant effects of acute respiratory impairment were noted. The effect of chronic exposure to these agents could not be well defined from the evaluation. No evidence of acute or chronic toxicity was noted in the employees evaluated for exposure to aryl phenolic mercury compound or organic solvents. With the exception of carbon monoxide, all environmental sampling results for TDI, polymethylsiloxanes, mercury, MEK, xylene and toluene were below the appropriate health standards for these substances. Although the health standards were not exceeded, the results, particularly for TDI, are indicative of a need for monitoring and evaluation during different conditions of use (changing of product "B" barrels) and environmental conditions (winter - doors closed) than occurred during this survey. It has been determined that employees working around Unit I are exposed to potentially toxic concentrations of carbon monoxide fumes exceeding the health standard.

In view of the above medical and environmental evaluation determination, the following recommendations are made to ameliorate existing or potential hazard(s), and to provide a better environment for the employees covered by this determination.

1. It is recommended that immediate action be taken to lower the carbon monoxide concentrations in the Unit I area to acceptable levels. For immediate steps to lower the carbon monoxide levels, forklifts currently in use around Unit I should be in good operating condition (e.g., recent maintenance, tune up, etc.) and should not be producing excessive amounts of carbon monoxide. It may be necessary or preferred to utilize propane or battery propelled forklift trucks for control of carbon monoxide exposure. Other administrative controls such as turning the motor off when not in use should also be considered. Continued monitoring of the carbon monoxide concentrations around Unit I (as well as other confined areas not covered by this evaluation) should take place until it can be assured that the exposure of employees is within acceptable standards.

2. Particular environmental and medical recommendations contained in NIOSH's publication entitled "Criteria for a Recommended Standard...Occupational Exposure to Toluene Diisocyanate" should be followed. The more salient recommendations include:

a. periodic environmental monitoring of TDI concentrations to assure that that ceiling concentrations do not exceed 0.02 ppm (0.14 mgm/M^3) and 8-hour time weighted average concentrations do not exceed 0.005 ppm (0.036 mgm/M^3),

b. suitable protective measures and clean up policies when a TDI spill occurs as well as adequate work and control procedures, and

c. appropriate medical screening of new employees and periodic medical monitoring of present employees. The details concerning each of these measures are discussed in the NIOSH document "Occupational Exposure to Toluene Diisocyanate."

3. It is further recommended that local exhaust ventilation be provided at "point of operation" for the pouring operations, and that a tight container be used in lieu of the current use of an open cardboard box for the pour gun when not in use

4. The use of a different type of spray gun which would significantly reduce (factor of 5 or more) the amount of overspray should improve the environment of the mold release operation.

V. REFERENCES

1. White, W.D., et al. "A Convenient Method for the Analysis of Selected Solvent Vapors in the Industrial Atmosphere," Am. Ind. Hyg. Assoc. J. 31:225 (1970).

2. Grim, E.K. and A.L. Linch. "Recent Isocyanate in Air Analysis Studies," Am. Ind. Hyg. Assoc. J. Vol. 25, May-June, 1964.

3. Elkins, et al. "Concentration Adjustment in Urinalysis," Am. Ind. Hyg. Assoc. J., 599, Sept. 1974.

4. "Criteria for a Recommended Standard...Occupational Exposure to Toluene Diisocyanate." U.S. Dept. of Health, Education, & Welfare, PHS, NIOSH, 1973.

5. "Criteria for a Recommended Standard...Occupational Exposure to Carbon Monoxide," U.S. Dept. of Health, Education, & Welfare, PHS, NIOSH, 1972.

6. Commonwealth of Massachusetts, Department of Labor and Industries, Division of Occupational Hygiene, Publication #985: "Significance of Urinary Mercury Concentration in Light of Change in MAC(TLV) for Mercury Vapor."

7. (For White Males) Kory, R.C., Callahan, R., Hollis, G.B. and Syner, J.C. "The Veterans Administration-Army Cooperative Study of Pulmonary Function. I. Clinical Spirometry in Normal Men" Am. J. Med. 30:243-258 (1961).

8. (For Black Males) Lapp, N.L., Amandus, H.E., Hall, R. and Morgan, W.K.C. "Lung Volumes and Flow Rates in Black and White Subjects." Thorax 29:185-188 (1974).

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