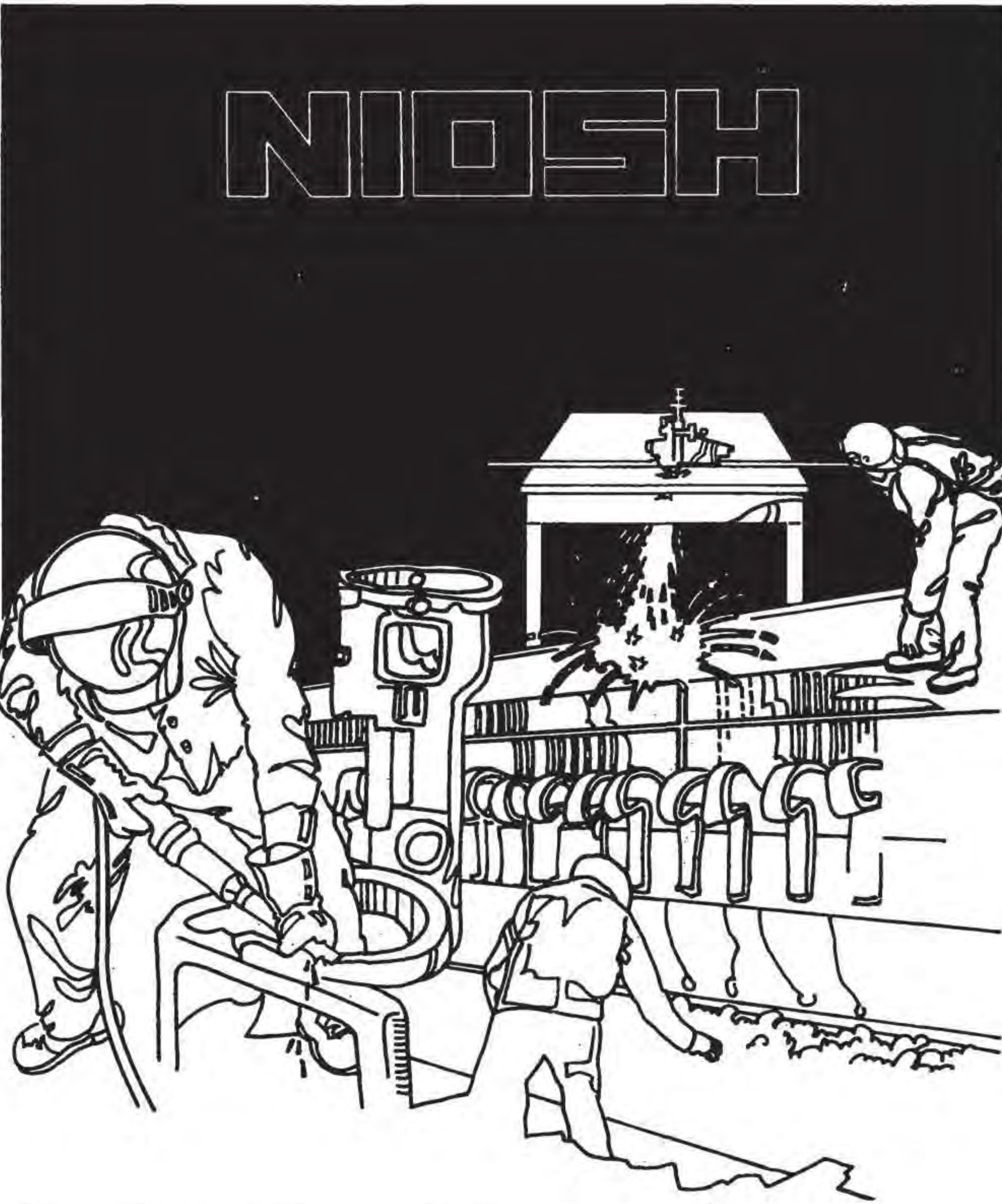
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-269-1167
FMC CORPORATION
TIPTON, INDIANA

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 81-269-1167
AUGUST 1982
FMC CORPORATION
TIPTON, INDIANA

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I. SUMMARY

In April 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steel Workers of America, Local 2166, to evaluate exposures to paints and solvents at the FMC Fire Apparatus Facility in Tipton, Indiana. The exhaust ventilation system in the fire truck spray paint booths was reported to be ineffective.

NIOSH conducted surveys at the plant on May 18-21, 1981, and September 28 - October 1, 1981. Personal breathing zone and area air samples were collected for measurement of exposure to cellosolve acetate, ethyl acetate, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), naphtha, toluene and xylene as well as to chromium, lead, hexamethylene diisocyanate (HMDI), a biuret compound of HMDI [a tri-molecular structure of 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B)] and nuisance (mist) particulates. Analysis of the environmental samples produced the following ranges of concentrations which are compared with their respective environmental criteria (EC): ethyl acetate, nondetectable (N.D.) - 111 mg/m^3 (EC-1400 mg/m^3); cellosolve acetate 2.2-172 mg/m^3 (EC-270 mg/m^3); methyl ethyl ketone, N.D. - 17.8 mg/m^3 (EC-590 mg/m^3); methyl isobutyl ketone, N.D. (EC-200 mg/m^3); aromatic naphtha, 231.5 mg/m^3 (EC-350 mg/m^3); total naphtha N.D. - 297.1 mg/m^3 (EC-350 mg/m^3); toluene 3.0-58.7 mg/m^3 (EC-375 mg/m^3); xylene N.D. - 22.1 mg/m^3 (EC - 434 mg/m^3); chromium N.D. - 0.31 mg/m^3 (EC-0.50 mg/m^3); HMDI (initial survey) N.D. - 180 ug/m^3 (EC-35 ug/m^3); HMDI-Biuret (follow-up survey: on glass fiber fiter) 13.1-111 ug/m^3; lead 0.01-1.54 mg/m^3 (EC - 0.05 mg/m^3); and nuisance (mist) particulates 19.8-35.4 mg/m^3 (EC-10 mg/m^3). No detectable hexavalent chromium was found. Measured concentrations of exposures to individual solvents were within NIOSH recommended levels and OSHA standards. However, workers were overexposed based on the additive effect of the solvent vapor mixtures. Although the spray paint employees did wear respirators, the protection afforded the painters using the respirators was inadequate as noted by the inefficient operating conditions of respiratory use as well as the types and concentrations of contaminants measured.

Five current and two former spray painters had medical assessments regarding their exposure to lead, chromium, HMDI and various organic solvents. These seven workers examined consisted of six men and one woman, aged 27-47 years (mean age - 34 years). None of these five present and two former spray painters medically evaluated showed any evidence of excessive absorption of lead, chromium or organic solvents. There was also no evidence of isocyanate hypersensitivity.

On the basis of the data obtained during this investigation NIOSH has determined that a health hazard due to overexposures to various organic solvents, hexamethylene diisocyanate, lead and nuisance (mist) particulates existed at the FMC Corporation. To improve worker safety and health, recommendations to reduce exposures are included in Section VII of this report.

KEYWORDS: SIC 7535 (Paint Shops), 3711 (Motor Vehicles), chromium, lead, hexamethylene diisocyanate, hexamethylene diisocyanate biuret-TICH B, nuisance (mist) particulates, organic solvents, spray painting

II. INTRODUCTION

On April 15, 1981 the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Steel Workers of America, Local 2166, to evaluate chemical exposures in the truck masking, primer, and finish truck spray painting areas, of the FMC Corporation, Tipton, Indiana. At this plant polyurethane enamel paints, an alkyd acrylic enamel paint, an alkyd primer-sealer, and lacquer and solvent thinners are used to paint tire trucks. The request was prompted because the exhaust ventilation system in the primer and finish truck spray paint booths was reported to be ineffective.

NIOSH investigators conducted an initial environmental survey at the FMC plant on May 18-21, 1981. A follow-up environmental/medical survey was performed from September 28 - October 1, 1981. Interim Report #1 was distributed prior to the follow-up survey and Interim Report #2 was distributed after the completion of the second NIOSH survey.

III. BACKGROUND

The FMC Fire Apparatus Facility has been involved in manufacturing fire trucks since 1965, and in spray painting fire vehicles since 1966. During the initial NIOSH survey, the spray painting processes operated on a one shift, 5-day, 13-hour per-day schedule, whereas on the follow-up evaluation, painting operations occurred on a 9-hour or less daily routine.

The primer and finish truck spray paint booth is a Bink's Manufacturing Company "drive-through" booth, about 70 feet long and 16 feet wide. The two booths share an 8-foot center exhaust plenum with a rated exhaust volume of 35,000 cubic feet per minute (cfm). Adjacent to the plenum and in the center of the booth, are bi-fold filter doors used to separate the booth into two separate chambers. The exhaust plenum itself contains paint arrestor dry filters. Each end of the booth is also equipped with bi-fold filter (inlet) doors.

The finish parts spray paint booth (a Bink's booth), situated next to the finish truck booth, is 34 feet long and 16 feet wide. The plenum chamber is located at the opposite end from the bi-fold inlet filter doors. In place of the paint arrestor filters, a perforated paper filter bed is used.

The spray painting equipment consists of Bink's hand-held compressed air paint atomizing guns fed from paint reservoir pressure pots of either 5- or 10-gallon capacities.

Various colors of polyurethane enamel paints and lacquer and solvent thinners are used in all three spray paint booths. In addition, an alkyd acrylic enamel paint and an alkyd primer-sealer are used in the primer truck paint booth.

IV. EVALUATION DESIGN AND METHODS

A. Environmental: Initial Survey

During the initial survey on May 18-21, 1981, long-term personal breathing-zone and area environmental samples were collected for measurement of exposure to hexamethylene diisocyanate (HMDI), lead, total chromium, hexavalent chromium, nuisance (mist) particulates, cellosolve acetate, methyl ethyl ketone, ethyl acetate, methyl isobutyl ketone, naphtha, toluene and xylene. The air sampling and analysis methodology for these substances are presented in Table I.

On May 19, 1981, ventilation measurements were made in the primer spray-paint booth using smoke tubes and an Alnor Sr. Velometer (in feet per minute, FPM). All exhaust systems and the make-up air unit were operating while air tests were made. Although no spray-painting was performed during the air-tests, a fire truck was parked in the booth.

All five employees working in the spray painting areas evaluated were interviewed on May 21, 1981, by the NIOSH industrial hygienist. Each spray painter reported experiencing eye irritation. A more comprehensive medical evaluation of these painters was planned for and obtained on the follow-up survey.

The results of the environmental air samples collected on the initial survey were presented in Interim Report #1 which was distributed prior to the follow-up survey. Employee overexposures were documented for nuisance (mist) particulates, lead and HMDI. Worker overexposures to solvents (based on the additive effects of the solvent vapor mixtures) were also found and presented in Interim Report #2. After receiving the data collected on the initial site visit NIOSH determined that further environmental/medical assessments were necessary and a follow-up survey was scheduled.

B. Environmental: Follow-Up Survey

Personal breathing-zone and area environmental air sampling was conducted in all three spray paint booths on the follow-up survey, September 28-October 1, 1981, with a two fold purpose: (1) to evaluate employee exposure to a biuret compound of HMDI, namely a tri-molecular structure of 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B), and; (2) to field test the newly proposed NIOSH air sampling/collection method for HMDI (13-mm glass fiber filter impregnated with *N*-*p*-nitrobenzyl-*N*-propylamine, "nitro-reagent") and compare these resulting values with those of the traditional midget impinger method using 10-15 milliliters (ml) of nitro-reagent (see Table I for air sampling and analysis methodology).

A NIOSH control technology program specialist made an assessment of all the paint booths on September 30, 1981. The results of these studies are presented in Section VI (Results and Discussion) of this report. All air sampling and analysis methodologys including substances, collection devices, flow rates and analytical procedures are presented in Table I.

C. Medical

On the follow-up survey seven workers had medical assessments regarding their exposure to lead, chromium, hexamethylene diisocyanate (HMDI), and organic solvents including methyl ethyl ketone (MEK), cellosolve acetate, and ethyl acetate. This group included all five workers currently employed in the spray painting department who had all the tests mentioned below, and two workers who had previously worked in that section but have since left to work in other areas of the same factory. These two only had the questionnaire, physical examination and pulmonary function tests. Ten workers from other departments provided urine samples for comparison of urinary chromium levels.

The full medical assessment included a brief questionnaire covering symptoms, chemical exposure, past medical problems, and an occupational history: physical examination was limited to the respiratory system and determination of signs relevant to the exposure to chemicals mentioned.

Blood samples were analyzed for blood lead and MEK levels, free erythrocyte protoporphyrin (FEP) level, hemoglobin and hematocrit, and renal function tests (serum creatinine and blood urea nitrogen) and liver function tests (serum aspartate aminotransaminase (SGPT), alanine aminotransaminase (SGOT), and gamma glutamyltranspeptidase (GGTP)).[1]

Blood MEK was determined by a gas chromatographic method using the headspace technique. Standard laboratory methods were used for the other analyses. Urinary chromium content was determined by graphite furnace atomic absorption spectrophotometry.

Serial pulmonary function tests (pre-shift, immediate post-shift, and 4-6 hours post-shift) included forced expiratory volume in 1 sec. (FEV1) and forced vital capacity (FVC). FEV1 is the volume of air expelled in the first second of a maximal forced expiration from full inspiration. FVC is obtained by continuing the forced expiration until no more air can be expelled. FEV1 is significantly reduced (<80% of predicted) when there is airways obstruction, as occurs in HDI-induced asthma. The FEV1/FVC ratio is also reduced (<70%) in this condition.[2] These pulmonary function tests were done using a Spirotech (Ohio Medical Products 822) dry rolling seal spirometer with computer linkage which records the flow curves and analyses them, as well as calculating expected values based on age, height, sex, and race. A test was considered adequate for interpretation and use in the study only if there were three acceptable trials and the two best curves differed by no more than 5% with respect to FVC and FEV1. The

FEV1/FVC ratio was calculated using the best reading available for FEV1 and FVC accordingly, regardless of whether they occurred on the same tracing. Predicted normal values were based on data from Morris et al, 1971.[3]

V. EVALUATION CRITERIA

A. Environmental Standards

A number of sources recommend airborne levels of substances below which it is believed that nearly all workers may be repeatedly exposed 8-10 hours per day, 40-hours per week, over a working lifetime, without suffering adverse health effects. Such airborne levels are referred to as permissible exposure limits or threshold limit values (TLV's). However, due to variations in individual susceptability, a small percentage of workers may experience effects at levels at or below the TLV; a smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by a hypersensitivity reaction.

The environmental evaluation criteria utilized in this study are presented in Table II. Listed for each substance are three primary sources of exposure criteria: (1) NIOSH recommended standards for occupational exposure to substances (Criteria Documents); (2) recommended TLV's[R] and their supporting documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH) (1981);[4] and (3) occupational health standards as promulgated by the U.S. Department of Labor (29 CFR 1910.1000).[5]

B. Physiological Effects

1. Lead

Lead - Inhalation of lead dust and fumes is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion of lead dust contamination on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. The absorbed lead can damage the kidneys, peripheral and central nervous system and the bone marrow. These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/100 ml whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/100 ml. Lead levels between 40-60 ug/100 ml in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/100 ml represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/100 ml are considered dangerous and often require hospitalization and medical treatment.

FEP reflects the average lead effect over a period of about 120 days (Eisinger et al, 1978).[6] The Centers of Disease Control (1978)[7] consider an FEP level equal to or more than 50 ug/100 ml of whole blood as an indication of undue lead absorption. Hemoglobin and hematocrit can indicate an effect on the red blood cells by lead. Normal values differ for males and females, and are as indicated in Section VI Results and Discussion (D. Medical: 2. Lead Exposure).

Portions of the OSHA lead standard have been stayed by the courts. However, the current OSHA standard for airborne exposure to lead is 50 ug/m^3 on an 8-hour time-weighted average (TWA) basis. For this particular industrial operation (FMC's), the current "feasible" standard is 200 ug/m^3 with the use of engineering controls and 50 ug/m^3 using the appropriate respiratory protection equipment. If an employee is exposed to lead levels greater than OSHA's present action level of 30 ug/m^3, the standard dictates that the employer must develop and implement: (1) a semi-annual blood lead monitoring program; (2) annual physical examinations; and (3) training employees regarding the signs and symptoms of overexposure to lead. Also, a stayed portion of the standard indicates that in four years, workers with blood lead levels greater than 50 micrograms of lead per 100 grams of blood (40 ug/100 g) must be immediately removed from further lead exposure and in some circumstances workers with lead levels less than 50 ug/100 g must also be removed. At present, medical removal of workers is necessary at blood lead levels of 60 ug/100 g or greater. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels adequately decline and they can return to lead exposure areas.

2. Nuisance Particulates

In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, so-called "nuisance" dusts are stated to have little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics: (1) The architecture of the air spaces remains intact; (2) Collagen (scar tissue) is not formed to a significant extent; and (3) The tissue reaction is potentially reversible.

Excessive concentrations of nuisance dusts in the workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears and nasal passages (Portland Cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.[4]

3. Chromium

Chromium compounds can act as allergens in some workers to cause dermatitis. Acute exposure to chromium dust and mist may cause irritation of the eyes, nose and throat. Chromium exists in chromates in one of three valence states 2+, 3+, and 6+. Chromium compounds in the 3+ state are of a low order of toxicity. In the 6+ state, chromium compounds are irritants and corrosive. This hexavalent form may be carcinogenic or non-carcinogenic depending on solubility. The less-soluble forms are carcinogenic. Workers in the chromate-producing industry have been reported to have an increased risk of lung cancer (Bidstrup and Case, 1956).[8]

4. Organic Solvents
(Cellosolve acetate, ethyl acetate, methyl ethyl ketone, xylene, and toluene)

These solvents as a group have some common systemic effects. They can cause fatigue, headache, drowsiness, nausea, vomiting, dizziness, loss of coordination and other central nervous system effects. Irritation of the eye, mucous membranes and the respiratory tract can also occur. Liver damage can result, with increase in blood levels of liver enzymes such as alanine aminotransaminase, aspartate aminotransaminase and gamma glutamyl transpeptidase. Cellosolve acetate cuases central nervous system depression in animals and similar effects may be expected in humans with severe exposure (Proctor and Huges, 1978).[9] Cellosolve acetate is of the same order of toxicity as methyl ethyl ketone (MEK) but is less hazardous due to the lower vapor pressure. MEK has an objectionable odor but there are relatively few reports of serious ill-effects (ACGIH, 1981). Ethyl acetate irritates the eyes and respiratory tract at concentrations above 1400 mg/M^3 (NIOSH/OSHA, 1981).[10]

5. Hexamethylene Diisocyanate

Hexamethylene diisocyanate (HMDI) an aliphatic diisocyanate, is a volatile liquid. HMDI has a volatility and toxicity similar to TDI. Splashes of the chemical into the eyes may cause severe chemical conjunctivitis. Skin splashes can cause a mild irritant effect and skin sensitization is rare. The main effects however are on the respiratory system. In high enough concentrations isocyanates have a primary irritant effect on the respiratory tract. They can also act as respiratory sensitizers producing asthma-like symptoms in sensitized individuals even at very low concentrations. Asthmatic attacks may occur immediately on or after exposure or at an interval of hours after cessation of exposure, presenting as nocturnal cough and breathlessness. Exposure to isocyanates may also result in chronic impairment of pulmonary function.[11]

6. Hexamethylene Diisocyanate - Biuret

The biuret compound of HMDI or tri-molecular structure 1,3,5-tris (6-isocyanatohexyl) biuret (TICH-B), an aliphatic diisocyanate, is a high molecular weight, biuret-containing polyisocyanate, having only trace amounts of monomeric hexamethylene diisocyanate. It is made by reacting three moles of HMDI with one mole of water.[12]

In general, the potential respiratory hazards encountered during the use of diisocyanates in the workplace are related to their vapor pressures. The lower molecular weight diisocyanates tend to be more readily volatilized into the workplace atmosphere than the higher molecular weight diisocyanates. In this regard, it is noted that HMDI has about the same molecular weight (M.W. approximately 168) and cyanate-NCO-groups as TDI, while HMDI-biuret has a molecular weight of approximately 478 (TDI-174) and three cyanate-NCO-groups (TDI-2 cyanate groups). The potential for skin irritation and eye injury is generally higher for the lower molecular weight diisocyanates and the severity of these irritant responses is reduced with increasing molecular weight.[13]

In a review of the hygienic aspects of urethane coatings, Ziegler[14] reports on aerosal inhalation studies in rats of monomeric toluene diisocyanate (TDI), hexamethylene diisocyanate (HDI), and polyisocyanates based on these materials. While TDI and HDI possessed comparable acute toxicities, the polyisocyanates did not. The toxicity of the monomeric materials was greater (by a factor of 10) than the TDI-based polyisocyanates, but only slightly greater than that based on HDI. He also reports that Ames tests conducted on these polyisocyanates indicate that they are not mutagenic.

The aerosols of some HMDI-based paints may contain a substantial quantity of isocyanate prepolymer with unreacted isocyanate groups. Hardy and Devine[15] attribute adverse respiratory effects to the inhalation of isocyanate-containing aerosols. They state that inhalation of any species with multiple unreacted isocyanate groups may impair respiratory function or give rise to sensitization.

Presently, there are no published criteria for permissible exposure to HMDI-Biuret. The NIOSH recommended standard for diisocyanates applies to monomers only and not to higher polymers of these, compounds. However, free monomeric diisocyanate may still be present in polymerized products and may constitute a hazard during spraying operations.[16]

VI. RESULTS AND DISCUSSION

A. Environmental

Results of the environmental air samples obtained on May 19-20, 1981 (initial survey), are presented in Table III-VI: Nuisance (mist) particulate levels ranged from 19.8 milligrams per cubic meter of air (mg/m^3) to 35.4 mg/m^3, with an approximate 13-hour time-weighted-average (TWA), of 27.0 mg/m^3. This is well in excess of the ACGIH recommended standard of 10 mg/m^3[4], 8-hour TWA. Lead samples collected ranged from 0.01 mg/m^3 - 1.54 mg/m^3. Of the four personal samples for lead, two were significantly above the OSHA standard of 0.05 mg/m^3 and a third sample, at 0.04 mg/m^3 was 80% of the standard. The hexamethylene diisocyanate (HMDI) values ranged from nondetectable (N.D.) to 180 micrograms per cubic meter of air (ug/m^3). The majority of TWA samples for HMDI were in excess of the NIOSH recommended standard of 35 ug/m^3.[11] The environmental sample values for total chromium ranged from N.D. - 0.31 mg/m^3. Two of the four samples for chromium were at 40 and 60 percent of the NIOSH recommended standard of 0.5 mg/m^3. No detectable concentrations were found on any samples collected for hexavalent chromium.

The environmental air sample values for the several solvent samples collected on the initial survey, May 19-20, 1981, are presented in Table VI. Personal breathing zone and area air samples were obtained for cellosolve acetate, methyl ethyl ketone, ethyl acetate, methyl isobutyl ketone, aromatic naphtha, total naphtha, toluene, and xylene. The majority of measured concentrations of individual solvents were within NIOSH recommended standards and OSHA standards. However, when two or more hazardous substances having similar health effects are present exposure to the combination, in addition to, each individual substance should be considered. That is, the sum of the fractions, actual concentration divided by the exposure limit for each substances ($C_1/T_1 + C_2/T_2 + ... + C_n/T_n$) should not exceed unity (must equal 1.0 or less).[5] Using this concept, overexposure based on the additive effect of the solvent vapor mixtures were found in the primer and finish truck spray booths (1.2-1.8) and a near overexposure occurred in the finish parts spray paint booth (0.9) (see Table VI - Additive Effects).

As discussed earlier, personal breathing-zone and area air sampling was conducted in all three spray paint booths on the follow-up evaluation. Eighteen side-by-side stationary area air samples (placed at approximate breathing zone levels) for both HMDI and HMDI-biuret, were collected over a consecutive 3-day period in the three paint booths.

In addition, 12 personal air samples were collected for the same two diisocyanates using only the impregnated glass fiber filter sampling medium. The results of these diisocyanate air samples obtained on the follow-up survey are included in Tables VII and VIII. Among area samples collected on the follow-up survey, the impinger yields of both HMDI and TICH-B are significantly higher than those obtained using glass fiber filters. The differences between the two sampling methods (glass fiber filter vs impinger) were consistent from day to day. Though the analytical methods for HMDI collected by impinger and glass fiber filter were the same, it is believed that the collection efficiency between the two air sampling methods differed. In the impinger air samples, the paint particulates were dissolved in the absorbing nitro-reagent and HMDI had access to the liquid collection medium, whereas on the glass fiber filter, the paint particulates (upon drying) created a barrier between the HMDI and the nitro reagent and thus isolated the HMDI from the impregnated filter collection device. This suggests that the HMDI values (collected on glass fiber filters) in Tables V, VII and VIII are lower than actual due to this inefficiency in sample collection method.

An overall review of Tables V and VIII show a noticeable decline in the personal air sample values for HMDI between the initial survey and the follow-up survey. Most of this variation in HMDI sample results may be attributable to the significant reduction in painting operations with the follow-up paint operations only 1/2 to 1/3 of those performed on the initial survey. Another factor explaining the decrease in measured diisocyanate air sample values may have been the more frequent changing of the filters in the paint booth exhaust ventilation system on the follow-up survey.

B. Ventilation

1. Prime and Finish Truck Booths

The ventilation readings made by NIOSH personnel on May 19, 1981 at various locations (breathing-zone areas) surrounding the fire truck parked in the primer truck booth were extremely erratic. The smoke tube tests indicated poor air movement and a great amount of air turbulence surrounding the fire truck. The time, number of measurements (N), and mean (x), and range (R) of values found are noted below:

16:30
N = 13
x = 35 FPM
R = 0-75 FPM

On May 20, 1981, under similar working conditions, ventilation measurements were made in the finish truck spray paint booth. Two employees were spray painting the same fire truck while the air flow measurements were made. The ventilation data collected was as follows:

9:00	9:50	15:05
N = 13	N = 10	N = 12
x = 75 FPM	x = 65 FPM	x = 29 FPM
R = 0-200 FPM	R = 25-200 FPM	R = 0-125 FPM

The OSHA standard regarding spray finishing using flammable and combustible materials requires that the average air velocity over the booth cross section during spraying operations be not less than 100 linear feet per minute.[17] As evidenced by the data above, the exhaust ventilation system provided for the primer and finish truck spray booths does not meet this criterion.

As described earlier, this drive-through booth is made up of two booths which share a center exhaust plenum. The booths were originally separated at the plenum with two sets of bi-fold filter doors. By manipulating the doors, one chamber could be used as a spray paint booth, while a second vehicle could dry in the other chamber, at a reduced exhaust volume. Contrary to the original concept and design, only one set of bi-fold filter doors separate these two booths, and both sections are now used for painting. The use of the booth for purposes other than those for which it had been designed has resulted in ineffective ventilation (air velocity measurements were all below the minimum OSHA requirement of 100 linear feet per minute in both the finish and the primer truck paint booths) and overexposure of workers to various substances (see Tables III-VI).

Long-term solutions for these two booths would require installation of new spray booths as dry-filter booths are generally not suitable for high production painting operations such as those at FMC. A water-wash booth should provide better results. The size and shape of the fire trucks suggest that a downdraft style might be more satisfactory. The toxicity of the paint raw materials make a design air velocity of 150 feet per minute (FPM) desirable. Also, since the painter must spray the underbody, any new booth should incorporate provisions for this task. A pit running the length of the truck with fresh air supplied up through the floor is recommended[16] (see also Section VII. Recommendation #8).

2. Finish Parts Truck Booth

As mentioned previously, the finish parts spray paint booth is located adjacent to the finish truck booth. Total airflow was measured on the follow-up survey at 12,500 CFM which results in an average air velocity (80 FPM theoretical, based on a booth cross section of 150 sq. ft.)

slightly below OSHA minimum requirements. Parts within the booth are mounted on racks placed perpendicular to the flow of air, resulting in dead spots within the booth. Excessive atomizing air pressures (105 psi) are used in this booth (see Section VII. Recommendation #9).

C. General

During NIOSH's surveys, deficiencies in the use of personal protective equipment and work process controls were recognized. The respiratory protection program was inadequate as evidenced by bearded employees wearing respirators and the lack of standard operating procedures for respirator use, instruction, fit testing, maintenance, and storage. Smoking was permitted in areas adjacent to the spray-painting booths where flammable paints and solvents were either used or stored. Eye protectors were not provided to employees working in the spray-painting booths. When flammable or combustible liquids were transferred from one container to another (in the spray-painting areas), neither container was bonded or grounded.[18] Recommendations concerning some of these shortcomings are included in Section VII.

D. Medical

1. History and Physical Examination

All five current spray painters and two former spray painters exposed to isocyanates were examined. These seven workers consisted of six men and one woman, aged 27-47 years (mean age - 34 years). Five were current smokers and two non-smokers. Breathlessness on effort was reported by four individuals and occasional wheezing by two. None gave a definite history of episodic wheezing or breathlessness following exposure to chemicals at work. Physical examination of the chest showed the absence of crepitations or rhonchi. No other signs of respiratory system abnormalities were detected except for one worker with acute tonsillitis and pharyngitis. None of the workers seen had abdominal colic with constipation and none had any weakness of the extensor muscles of the wrists. Ulceration and perforation of the nasal septum was not detected. No rashes were seen on exposed skin surfaces.

2. Lead Exposure

All blood lead levels, FEP levels, red blood cell parameters and renal function test results were within the normal range:

No.	Parameter	Range	Mean	Normal Range
1.	Blood lead	11-13 ug/dl	22.4 ug/dl	<40 ug/dl
2.	FEP	24-30 ug/dl	26.8 ug/dl	<50 ug/dl
3.	Hemoglobin	Normal		* Males: 14-18 g/dl * Females: 12-16 g/dl
4.	Hematocrit	Normal		* Males: 40-54% * Females: 37-47%
5.	Serum creatinine	0.8-1.0 mg/dl	0.88 mg/dl	0.4-1.3 mg/dl
6.	BUN	9-15 mg/dl	11.8 mg/dl	6-22 mg/dl

* Wintrobe, 1974[19]

3. Urinary Chromium

The correlation between chromium exposure, absorption and biological concentrations of chromium is not well established, hence caution must be exercised in the interpretation of urinary chromium levels. The results obtained for the five current workers and a control group of ten workers from other departments are shown below. The ten controls were similar in age (mean age = 33 years; range = 21-55 years).

	Group	Urinary Chromium Level in Parts Per Billion
1.	Normal range	≤350 ppb (Mertz, 1969)[20]
2.	Current workers	Mean = 47 ppb; Range = 20-110 ppb
3.	Controls	Mean = 80 ppb; Range = 30-160 ppb

The control group seemed to have a higher mean level of 80 ppb but the difference is not statistically significant ($p>0.05$, Wilcoxson's rank sum test).[21] This was due mainly to three high urinary chromium levels in the control group, viz. 120, 130, and 160 ppb. With the exclusion of these three high readings, the mean urinary chromium in the control group, 50 ppb is comparable to the exposed group. The difference between the urinary chromium levels in the two groups is not statistically significant (p 0.05 by Wilcoxson's rank sum test).

4. Solvent Exposure

Blood levels of MEK were estimated as an indicator of current solvent exposure. MEK was not detected in the blood samples of any of the five current workers. The laboratory detection limit is 0.05 ug/ml.

5. Liver Function Tests

The liver function tests showed normal values for serum transaminases and gamma glutamyltranspeptidase (see below).

Enzyme	Result for 4 of the 5 Workers*	Normal Range
1. Aspartate aminotransaminase	16-21 IU (mean - 18 IU)	7-24 IU
2. Alanine aminotransaminase	11-15 IU (mean - 13 IU)	4-50 IU
3. Gamma-glutamyl transpeptidase	12.8-29.6 IU (mean - 17.8 IU)	5-37 IU

* Results for one worker excluded because of a laboratory problem with this blood sample.

6. Pulmonary Function Tests (PFT's)

Two workers gave a history of a respiratory tract infection within three weeks of the tests. Their PFT results are therefore excluded from the analysis. The remaining three workers in the spray painting department and the two ex-workers of this department had serial PFT results within normal limits. The FEV1 ranged from 82%-111% of predicted; the FVC ranged from 87%-116% of predicted and the FEV1/FVC ratio ranged from 74%-84% of predicted. There were no significant changes in pulmonary function between the immediate post-shift and 4-6 hours post-shift results compared to the pre-shift results.

VII. RECOMMENDATIONS

A. Medical

Medical recommendations for current and future new workers exposed to such levels are as outlined in the NIOSH criteria document on diisocyanates.[11] These recommendations include the need for the company to institute a pre-placement examination and periodic medical surveillance program (to include periodic clinical evaluation and pulmonary function testing) for isocyanate-exposed workers.[11,22]

The company has a system of 6-monthly blood and urinary lead determinations for workers exposed to lead compounds. A review of their results showed no lead levels above 40 ug/dl since July 1980. This system for regular blood lead determinations should continue. In addition, company biological monitoring data, such as blood lead results, should be furnished to the affected employees or their designees upon request.

B. Environmental

Overexposure to HMDI, lead, nuisance-mist particulates and organic solvents was demonstrated by air sampling. The ultimate reduction of the overexposures to levels of known or potential health effects must be accomplished by the implementation of improved engineering control of workplace contaminants such as substitution of less hazardous process materials, automation, redesign or replacement of existing mechanical ventilation systems, or a combination of these measures.

Improved respiratory protection is necessary to initially minimize the potential health consequences of these exposures. The respirators currently in use did not afford the painters adequate protection due to the inefficient operating conditions of respiratory use as well as the types and concentrations of contaminants measured. Since several diisocyanate samples in the 3 spray paint booths exceeded the NIOSH recommended standard, the use of the type C continuous flow, supplied air respirators with impervious hoods, operated in a positive-pressure mode is recommended. The supplied air respirator would also be appropriate for protection from lead overexposure.

C. General

Although NIOSH's environmental air sample results at FMC indicated employee overexposures to HMDI, lead, nuisance (mist) particulates and organic solvents and the medical assessments of the spray painters showed no evidence of excessive absorption of lead, chromium or organic solvents, nor any isocyanate hypersensitivity, the occupational health literature contains documentation of employees experiencing symptoms (acute and chronic) as a result of their exposures to concentrations of substances similar in magnitude to those found at FMC. In view of the findings of the medical and environmental investigations, the following recommendations are made to ameliorate existing or potential hazards, and to provide a better work environment for the employees covered by this determination:

1. Employee exposure to excessive contaminants within the various paints should be immediately reduced to the lowest level possibly through effective engineering controls and through improved work practices.

2. Respirators (described previously) as a means of control should be used in the interim period while effective engineering controls are being implemented. In addition, FMC management should construct and enforce a respiratory program consistent with the guidelines found in DHEW (NIOSH) Publication No. 76-189, "A Guide to Industrial Respiratory Protection," and to the General Industry Occupational Safety and Health Standards (29 CFR 1910.134). (Copies have been sent to plant management and local union representatives).

3. Provide personal protective equipment for the hands and forearms of all spray painters. Ascertain that the gloves provided are of sufficient length and are impervious to the paints, solvents and other materials used.

4. Do not use solvents for removing paint from skin. Instead, apply a non-allergic barrier cream before beginning to paint.

5. Provide suitable facilities for quick drenching or flushing of the eyes within all spray painting areas.

6. Conduct all spray painting operations in an area provided with locally exhausted ventilation.

7. Replace the cardboard squares used to redistribute the air flow at the face of the plenum chamber with noncombustible materials.

8. Immediate interim changes which may help in reducing exposures in the primer and finish truck booths are as follows:

   a. Present practice calls for changing the paper paint arrestor filters on an every other day basis. A more frequent change interval would provide some temporary relief.

   b. Painters in the finish booth work directly opposite one another. This results in each being engulfed in overspray. Overspray contamination was especially severe when truck compartment interiors were painted. A switch to airless spray equipment for painting these out-of-sight areas would allow more repid coating of these surfaces coupled with reduced overspray. Both painters in the finish booth operate their equipment at reasonable atomizing air pressures (75 psi), however, satisfactory results might be obtained at still lower pressures.[16]

c. The painter in the primer truck booth used much lower air pressure (35 psi) when painting non-appearance areas such as the vehicle frame and underbody to minimize the generation of overspray. Here again, airless equipment might be a suitable substitute.[16]

9. Control of overspray (mist) particulates in the finish parts truck booth could be facilitated by placing part racks parallel to the direction of airflow and reducing gun air pressures to 50-60 psi.

10. Containers with various paints and solvents should have tight-fitting lids in place when not in use.

11. Whenever flammable or combustible liquids are transferred from one container to another, both containers should be bonded and grounded to prevent ignition by sparks of static electricity.[18]

12. Enforce a no smoking rule in and adjacent to spray paint booths.

13. Eating and drinking should be prohibited in the work areas covered by this evaluation. Workers should wash their hands before eating, drinking, or smoking.

14. Provide shower facilities and change rooms equipped with separate storage facilities for the work gear and street clothes for all spray painters.

15. A continuing education program conducted by a person or persons qualified by experience or special training, should be instituted to ensure that all employees have current knowledge and understanding of job safety and health hazards, proper work practices and maintenance procedures, and that they know how to use respirators correctly.

16. Greater involvement from the corporate industrial hygiene services is needed in establishing an occupational safety and health program at the FMC Corporation in Tipton, Indiana. Furthermore, NIOSH suggests that FMC conduct periodic environmental evaluations of employee exposures to organic solvents, lead, isocyanates and other paint components to assure that the extent of implementation of the above recommendations are adequate to protect the affected employees.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. Occupational diseases: a guide to their recognition. Revised ed. Cincinnati, Ohio: NIOSH 1977 (DHEW (NIOSH) Publication No. 77-181).

2. Horvath Jr EP. Pulmonary function testing in occupational medicine, Technical manual #77-1 Navy Environmental Health Center, Naval Station, Norfolk, Virginia 23511. 1977 (Rev. 2/79).

3. Morris JF, Koski A, Johnson LC. Spirometric standards for healthy non-smoking adults. Am. Rev. Dis. 1971 Vol 103, pp. 57-67.

4. American Conference of Governmental Industrial Hygienists. Threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1981. Cincinnati, Ohio: ACGIH, 1981.

5. Occupational Safety and Health Administration. OSHA safety and health standards, 19 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

6. Eisinger J, Blumberg WE, Fischbein A, Lilis R, Selikoff IJ. Zinc protoporphyrin in blood as a biologic indicator of chronic lead intoxication. J. Env. Path & Tox. 1978, 1:897-910.

7. Centers for Disease Control: Special Article on Preventing Lead Poisoning in Young Children. Journal of Paeds. 1978 Vol 93,4: pp. 709-720.

8. Bidstrup PL, Case RAM. Carcinoma of the lung in workers in the bichromate-producing industry in Great Britain. Brit J. Ind. Med. 1956, 13:260.

9. Proctor NH, Hughes JP. Chemical hazards of the workplace. Philadelphia: J.B. Lippencott Company, 1978.

10. National Institute for Occupational Safety and Health. NIOSH/OSHA occupational health guidelines for chemical hazards. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1981. (DHHS (NIOSH) Publication no. 81-123).

11. National Institute for Occupational Safety and Health. Criteria for a recommended standard ... occupational exposure to diisocyantes. Cincinnati, Ohio. National Institute for Occupational Safety and Health, 1978. (DHEW publication no. (NIOSH) 78-215).

12. Mobay Chemical Corporation, Plastics and Coatings Division, Pittsburgh, Pennsylvania. Chemistry for coatings (unpublished) pp. 1-16.

13. National Institute for Occupational Safety and Health. Health hazard evaluation report no. 72-96-237. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1972.

14. Ziegler PD. Industrial hygiene and urethane coatings, modern paint & coatings, (1979) a Publication of Communication Channels Inc.

15. Hardy ML, Devine JM. Use of organic isocyanates in industry-some industrial hygiene aspects. Annals of Occupational Hygiene. 1979, Vol 22, pp. 421-427.

16. NIOSH Technical, Report, An evaluation of engineering control technology for spray painting DHHS (NIOSH) Publication No. 81-121.

17. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.107. Spray finishing using flammable and combustible materials. Occupational Safety and Health Administration, revised 1980.

18. Occupational Safety and Health Administration. OSHA General Standards. 29CFR 1910.106 Revised 1980.

19. Wintrobe MM. Clinical Hematology 7th Ed. 1974. Lea and Febiger, Philadelphia. pp. 1791.

20. Mertz W. Chromium occurence and function in biological systems. Physiological Reviews, 1969, 49 2:175.

21. Armitage P. Statistical Methods in Medical Research 1977. Blackwell Scientific Publications.

22. OSHA Medical Surveillance Requirements and NIOSH Recommendations for Employees Exposed to Toxic Substances and Other Work Hazards, Booklet Prepared by Biotechnology Inc. for the NASA Occupational Health Office. January 1980.

23. National Institute for Occupational Safety and Health. NIOSH manual of analytical methods: Vol 1, Publication no. 77-157-A, 1977; Vol 3, Publication no. 77-157-C, 1977; Vol 4, Publication no. 78-175, 1978; Vol 5, Publication no. 79-141, 1979.

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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. FMC Corporation, Tipton, Indiana
2. United Steel Workers, Local 2166
3. NIOSH, Region V
4. OSHA, Region V

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

TABLE I

AIR SAMPLING AND ANALYSIS METHODOLOGY

FMC CORPORATION
TIPTON, INDIANA

HE 81-269

Substance	Collection Device	Flow Rate (liters per minute)	Analysis	References[23]
Aromatic Naphtha	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Total Naphtha	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Cellosolve Acetate	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Chromium	AA-MCEF Filter	1.5	Atomic Absorption	NIOSH P&CAM 173 with modifications
Chromium VI	Tared PVC Filter	1.5	Colorimetric	NIOSH P&CAM 169
Ethyl Acetate	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modificati[...]
Hexamethylene diisocyanate	Midget Impinger and Glass Fiber Filter and Nitro-reagent[1]	1.0	High Pressure Liquid Chromatography	
Hexamethylene diisocyanate Biuret-TICH B	Midget Impinger and Glass Fiber Filter and Nitro-reagent[1]	1.0	High Pressure Liquid Chromatography	
Lead	AA-MCEF Filter	1.5	Atomic Absorption	NIOSH P&CAM 173 with modifications
Methyl Ethyl Ketone	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Methyl Isobutyl Ketone	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Nuisance Particulates	Tared PVC Filters	1.5	Gravimetric	
Toluene	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modifications
Xylene	Charcoal Tube	0.05	Gas Chromatography	NIOSH P&CAM 127 with modificati[...]

1. Nitro reagent (N-P-nitrobenzyl-N-propylamine)

TABLE II

ENVIRONMENTAL EVALUATION CRITERIA

FMC CORPORATION
TIPTON, INDIANA

HE 81-269

Substance	NIOSH Recommended Standard (mg/M^3)	ACGIH TLV (mg/M^3)	OSHA Standard (mg/M^3)
Cellosolve Acetate	-	270	540
Chromium	-	0.5	1.0
Chromium VI	0.001[1]	0.05	0.1
Ethyl Acetate	-	1400	1400
Hexamethylene diisocyanate	0.035	-	-
Hexamethylene diisocyanate-Biuret	-	-	-
Lead	<0.1	0.15	0.05
Methyl Ethyl Ketone	590	590	590
Methyl Isobutyl Ketone	200	205	410
Aromatic Naphtha	350[2]	-	-
Total Naphtha	350	-	2000[3]
Nuisance Particulates	-	10	15
Toluene	375	375	750
Xylene	435	435	435

1. Value given for carcinogenic Cr VI
2. The NIOSH recommended standard for occupational exposure to refined petroleum solvents is 350 mg/M^3. NIOSH does not have a recommended standard for exposure to aromatic naphthas. Since aromatic naphthas in general, are considered to have greater toxicological effects than aliphatic naphthas, this value (350 mg/M^3) should be regarded as a maximum allowable exposure.
3. Value given is for petroleum distillates (naphtha)
4. All air contaminants are time-weighted average (TWA) exposures for a normal workday, 40-hour workweek unless otherwise designated.

TABLE III

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR CHROMIUM VI AND NUISANCE PARTICULATES

FMC CORPORATION
TIPTON, INDIANA

HETA 81-269

Sample Location	Date/Time	Sample Volume (liters)	Chromium VI (mg/M^3)	Nuisance Particulates (mg/M^3)	Time-Weighted Averages (mg/M^3)
Primer Truck Booth Spray-Painter	5/20/81 6:15-12:45	585	N.D.	19.8	
" " "	5/20/81 12:48-15:40	258	N.D.	35.4	27.0
" " "	5/20/81 15:43-19:00	296	N.D.	34	
Evaluation Criteria			0.001	10	

1. N.D. = nondetectable
2. Laboratory analytical limits of detection in mg/sample = 0.001

TABLE IV

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR CHROMIUM AND LEAD

FMC CORPORATION
TIPTON, INDIANA

HETA 81-269

Sample Location	Date/Time	Sample Volume (liters)	Chromium (mg/M^3)	Lead (mg/M^3)
Primer Truck Booth Spray-Painter	5/19/81 12:26-17:25	449	N.D.	0.04
Finish Parts Booth Spray-Painter	5/19/81 8:21-11:56	296	0.20	1.12[3]
Finish Truck Booth Spray-Painter	5/20/81 7:00-12:35	503	N.D.	0.01
Finish Parts Booth Spray-Painter	5/20/81 12:10-19:00	615	0.31	1.54[3]
Evaluation Criteria			0.5	0.05

1. N.D. = nondetectable
2. Laboratory analytical limits of detection in mg/sample = 0.003 (Chromium), 0.003 (Lead)
3. These samples are not full-shift time-weighted-averages. The employees were spray-painting during the remaining period of their shift when samples were not taken.

TABLE V

RESULTS OF ENVIRONMENTAL AIR SAMPLES FOR HEXAMETHYLENE DIISOCYANATE

FMC CORPORATION
TIPTON, INDIANA

HETA 81-269

Sample Location	Date/Time	Sample Volume (liters)	Hexamethylene Diisocyanate (ug/M3)	Time-Weighted Averages (ug/M3)
Finish Truck Booth Spray Painter	5/19/81 7:11-11:40	269	70	65.4
" " "	5/19/81 11:40-15:26	226	60	
" " "	5/19/81 7:15-11:45	270	30	42.9
" " "	5/19/81 11:45-14:40	175	30	
" " "	5/19/81 14:40-17:15	155	80	
Masking Area Masker	5/19/81 7:29-12:07	278	N.D.[1]	
Truck Primer Area Spray Painter	5/19/81 7:24-8:54	90	60	66.1
" " "	5/19/81 8:54-9:25	31	180	
" " "	5/19/81 9:25-12:30	185	50	
Finish Parts Booth Spray Painter	5/19/81 12:02-19:20	438	10	
Finish Truck Booth Spray Painter	5/20/81 7:15-12:15	420	20	32.4
" " "	5/20/81 12:35-15:30	175	100	
Finish Parts Booth Spray Painter	5/20/81 7:10-12:05	415	10	
Finish Truck Booth Spray Painter	5/20/81 12:15-13:45	90	90	
Evaluation Criteria			35	

1. N.D. = nondetectable
2. Laboratory analytical limits of detection in ug/sample = 0.4

TABLE VI

RESULTS OF ENVI ITAL AIR SAMPLES FOR SOLVENTS

FMC CORPORATION
TIPTON, INDIANA

HE 81-269

Sample Location	Sample Volume (liters)	Date/Time (minutes)	Cellosolve Acetate (mg/M3)	Methyl Ethyl Ketone (mg/M3)	Ethyl Acetate (mg/M3)	Xylene (mg/M3)	Toluene (mg/M3)	Methyl Isobutyl Ketone (mg/M3)	Aromatic Naphtha (mg/M3)	Total Naphtha (mg/M3)	Additive Effect
Personal-Finish Truck Booth	30.2	5/19/81 600	42.0	4.7	21.2	--	--	--	--	43.7	0.3
Personal-Finish Truck Booth	27.0	5/19/81 509	156.0	13.2	86.6	--	--	--	--	184.8	1.2
Personal-Primer Truck Booth	30.3	5/19/81 612	165.3	13.7	111.3	18.0	58.7	--	--	297.1	1.8
Personal-Masking Area	27.2	5/19/81 515	8.9	N.D.[1]	N.D.	N.D.	10.9	N.D.	--	N.D.	0.1
Personal-Finsih Parts Booth	34.4	5/19/81 655	55.9	2.6	22.9	--	--	--	--	52.2	0.4
Personal-Finish Parts Booth	32.7	5/20/81 627	116.9	6.3	60.5	--	--	--	--	139.6	0.9
Personal-Masking Area	32.7	5/20/81 595	2.2	N.D.	N.D.	--	3.0	N.D.	--	N.D.	--
Area-Paint Mixing Area	31.8	5/20/81 573	4.1	1.0	6.0	--	14.2	N.D.	--	3.1	0.1
Personal-Primer Truck Booth	38.2	5/20/81 701	77.9	5.7	23.5	22.1	30.1	--	231.5	206.8	1.7
Personal-Finish Truck Booth	32.4	5/20/81 639	124.1	9.5	68.6	--	--	--	--	124.4	0.9
Personal-Finish Truck Booth	33.3	5/20/81 503	172.8	17.8	95.7	--	--	--	--	197.8	1.3
Evaluation Criteria (normal workday, 40 hr/wk time-weighted average)			270	590	1400	434	375	200	350[2]	350	
Laboratory analytical limit of detection (mg/sample)			0.01	0.01	0.01	0.01	0.01	0.01	0.1	0.1	

1. N.D. = nondetectable concentrations

2. The NIOSH recommended standard for occupational exposure to refined petroleum solvents is 350 mg/M3. NIOSH does not have a recommended standard for exposure to aromatic naphthas. Since aromatic naphthas in general, are considered to have greater toxicological effects than aliphatic naphthas, this value (350 mg/M3) should be regarded as a maximum allowable exposure.

TABLE VII

AREA AIR SAMPLES FOR HEXAMETHYLENE DIISOCYANATE AND HEXAMETHYLENE DIISOCYANATE-BIURET

FMC CORPORATION
TIPTON, INDIANA

September 29-October 1, 1981

Date/Location	Impinger - Sample Volume (liters) Sample Time (minutes)	Glass Fiber Filter - Sample Volume (liters) Sample Time (minutes)	Glass Fiber Filter Conc. of HMDI-Biuret ug/m³	Glass Fiber Filter Conc. of HMDI ug/m³	Impinger Conc. of HMDI ug/m³	Impinger Conc. of HMDI-Biuret ug/m³
9/29/81 Southwest corner of primer truck booth	394 09:06-15:40	422 09:06-16:08	14.7	2.6	38.5	117.8
9/29/81 North wall of finish truck booth	519 08:51-17:30	519 08:51-17:30	32.4	15.2	28.9	366.9
9/29/81 South wall of finish truck booth	524 08:45-17:29	524 08:45-17:29	38.2	9.9	43.5[1]	384.4[1]
9/29/81 West end of finish truck booth	540 08:32-17:28	540 08:32-17:28	17.0	12.0	40.4	310.7
9/29/81 South wall of primer truck booth	416 09:12-16:08	416 09:12-16:08	33.2	6.7	55.1	115.4
9/29/81 West end of finish parts booth	385 09:38-16:03	385 09:38-16:03	61.8	12.5	84.4	503.9
9/30/81 West end of finish parts booth	200 12:08-15:28	200 12:08-15:28	9.5	9.0	64.5	515.5
9/30/81 Southwest corner of primer truck booth	280 09:04-13:44	280 09:04-13:44	23.6	349.3	33.9	347.9
9/30/81 West end of finish truck booth	288 08:46-13:34	288 08:46-13:34	36.1	8.3	47.9	297.9
9/30/81 South wall of finish truck booth	277 08:56-13:33	277 08:56-13:33	18.8	2.2	42.2	306.5
9/30/81 North wall of finish truck booth	281 08:53-13:34	281 08:53-13:34	43.4	27.1	27.8	318.9
9/30/81 South wall of primer truck booth	273 09:10-13:43	273 09:10-13:43	2.6	3.3	18.0	14.3
10/1/81 North wall of finish truck booth	380 08:14-14:34	380 08:14-14:34	64.0	9.7	81.3[1]	295.0[1]
10/1/81 South wall of finish truck booth	375 08:18-14:33	375 08:18-14:33	87.4[1]	13.7[1]	76.3	367.7
10/1/81 West end of finish parts booth	344 08:41-14:25	344 08:41-14:25	40.4	4.9	75.6	671.2
10/1/81 Southwest corner of primer truck booth	356 08:32-14:28	356 08:32-14:28	22.2	1.1	40.7	47.5
10/1/81 West end of finish truck booth	373 08:21-14:34	373 08:21-14:34	25.7	4.0	40.8	638.6
Evaluation Criteria (normal workday, 40 hour/week time-weighted average)				35	35	
1. Values given should be regarded as minimums due to sampling inefficiency						
2. Laboratory analytical limits of detection in ug/sample			5	1	1	5

TABLE VIII

PERSONAL AIR SAMPLES FOR HEXAMETHYLENE DIISOCYANATE AND HEXAMETHYLENE DIISOCYANATE-BIURET

FMC CORPORATION
TIPTON, INDIANA

September 29-October 1, 1981

Job/Location	Glass Fiber Filter - Sample Volume (liters) Sample Time (minutes)	Glass Fiber Filter Concen. of HMDI ug/M^3	Glass Fiber Filter Concen. of HMDI-Biuret ug/M^3
9/29/81 Spray painter finish truck booth	564 07:17-15:41	25.0	50.9
9/29/81 Spray painter primer truck booth	610 07:19-17:29	15.6	34.9
9/29/81 Spray painter finish parts booth	477 07:21-15:18	23.1	82.2
9/29/81 Spray painter finish truck booth	498 07:23-15:41	47.2	79.3
9/30/81 Spray painter finish truck booth	394 07:00-13:34	36.0	43.7
9/30/81 Spray painter primer truck booth	412 06:47-13:39	30.6	34.7
9/30/81 Spray painter finish parts booth	536 06:33-15:29	10.1	13.1
9/30/81 Spray painter finish parts booth	397 06:59-13:36	28.0	90.7
10/1/81 Spray painter finish truck booth	448 07:22-14:46	10.5	49.8
10/1/81 Spray painter primer truck booth	425 07:25-14:30	18.6	108.5
10/1/81 Spray painter finish parts booth	415 07:29-14:24	13.5	75.4
10/1/81 Spray painter finish truck booth	438 07:32-14:46	29.0	111.2
Evaluation Criteria (normal workday, 40 hour/week time-weighted average)		35	
1. Laboratory analytical limits of detection in ug/sample		1	5