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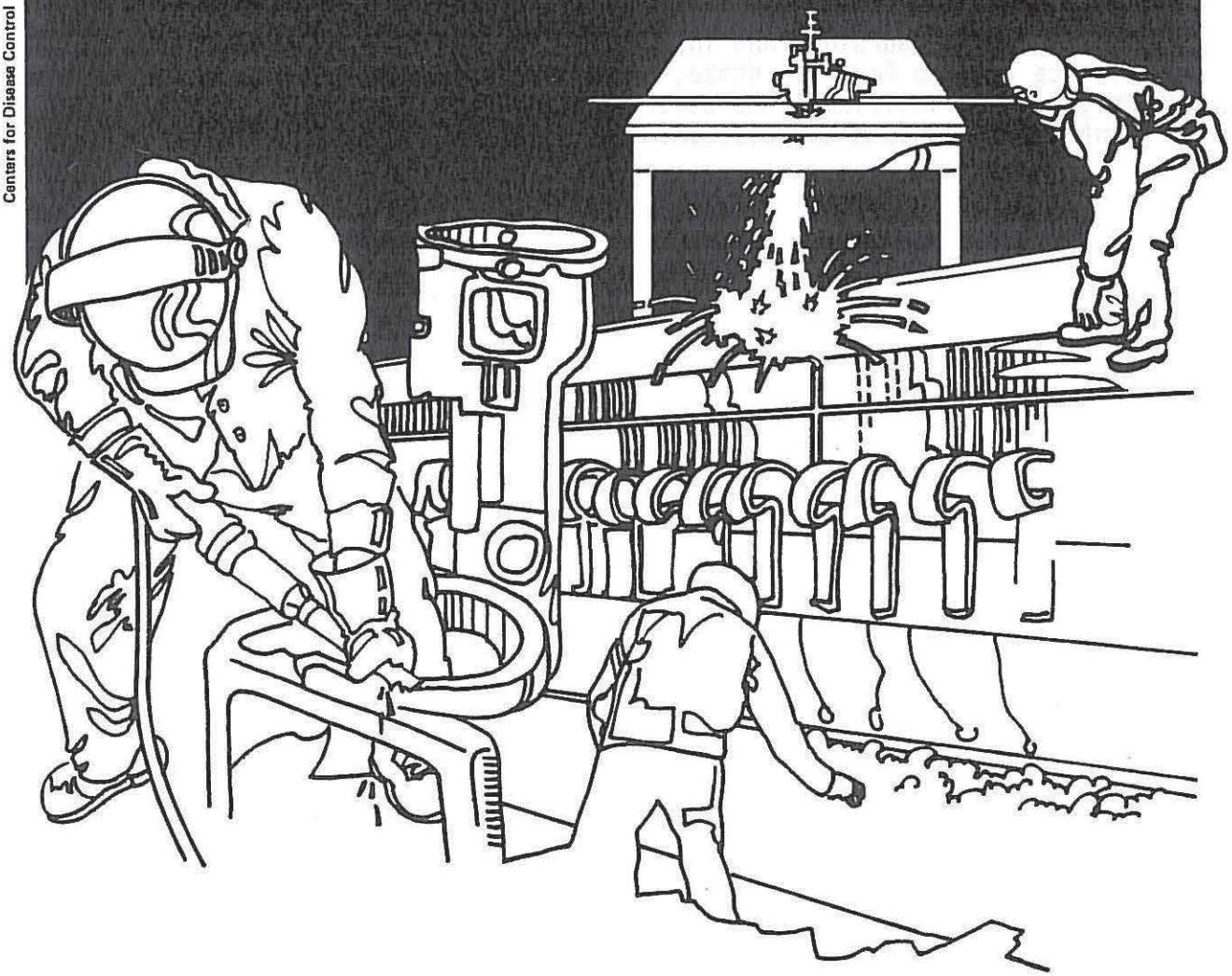

Health Hazard Evaluation Report

HETA 81-089-965
FMC CORPORATION
NITRO, WEST VIRGINIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

At the request of the United Steelworkers of America, the National Institute for Occupational Safety and Health (NIOSH) conducted a follow-up medical survey of a group of employees exposed to phosphorus trichloride and phosphorus oxychloride at the FMC Corporation in Nitro, West Virginia in May 1981. A previous NIOSH study of 37 exposed and 22 unexposed workers in May 1979 showed a significantly higher prevalence of intermittent respiratory distress (wheezing, chest tightness, and breathlessness) in the exposed workers, but no significant or consistent difference in pulmonary function could be demonstrated between the two groups.

In the follow-up study, which was requested by the union because of concern over possible longitudinal effects of PCl_3 and $POCl_3$ exposure, 26 exposed and 11 unexposed workers from the original study participated. Half of the exposed employees reported intermittent respiratory distress (wheezing, breathlessness, and chest tightness) compared with none of the unexposed workers, a statistically significant difference ($p=0.002$, Fisher's exact test). Of the 13 persons in the exposed group who reported intermittent respiratory distress, 5 (38%) perceived these symptoms as work-related. There was no significant difference in the prevalence of current or former smokers in the two groups. The average predicted rate of annual loss in FEV_1 is between 20 and 40 cc in "normal" populations. In our study, the exposed group showed a slight loss in FEV_1 (-16 cc) and the unexposed group showed an improvement in FEV_1 (+84 cc), but this was not a statistically significant difference (p greater than 0.10). (However, a statistical test called a power calculation revealed that a sample size of at least 66 in both the exposed and control groups would be required if we are to have a 90% chance of showing that this magnitude of difference is significant. Thus the lack of statistical significance may indicate only that our sample size may be too small to show it.) Sixteen of the 26 exposed employees (62%) reported that their exposure to phosphorous trichloride and phosphorous oxychloride had decreased since the NIOSH survey in 1979, a change apparently resulting from alterations in the procedure for "washing out" of tanks.

The data from this survey suggest that significantly more employees in the group exposed to $PCl_3/POCl_3$ experience intermittent respiratory distress, but that a significant decrement in pulmonary function over a two year period could not be demonstrated in this small group of exposed workers when compared with controls. Recommendations for continuing monitoring of exposure and effects are made.

Key words: SIC Code 2819 (Industrial Inorganic Chemicals); phosphorus trichloride and phosphorus oxychloride; respiratory distress (wheezing, breathlessness, chest tightness)

II. INTRODUCTION AND BACKGROUND

In November 1980, the United Steelworkers of America requested that the National Institute for Occupational Safety and Health conduct a follow-up study of pulmonary function in workers exposed to phosphorous trichloride and phosphorous oxychloride (PCl_3 and $POCl_3$) in the Nitro, West Virginia plant of the FMC Corporation. NIOSH had originally performed a questionnaire and pulmonary function survey of 37 maintenance workers intermittently exposed to PCL_3 and $POCl_3$, and of 22 non-exposed employees, in May 1979. Although symptoms of respiratory distress were significantly more common in the exposed group, no consistent differences in the pulmonary function of the two groups could be demonstrated.[1] Reasoning that intermittent exposure to PCl_3 and $POCl_3$, both profound pulmonary irritants, might result in greater than normal longitudinal decrements in pulmonary function, the Steelworkers requested a follow-up survey of the workers studied in 1979.

III. EVALUATION DESIGN AND METHODS

The study was entirely medical and epidemiological, and we made no environmental measurements. The NIOSH investigators prepared a questionnaire based on the original questionnaire used in the 1979 investigation. We asked questions pertaining to demographic information and smoking history. We asked a series of health questions about respiratory symptoms and diagnoses, such as shortness of breath with exercise, symptoms compatible with chronic bronchitis, a diagnosis of emphysema, episodes of pneumonia, bronchitis, asthma, allergy symptoms, wheezing, breathlessness, and chest tightness, with appropriate questions about frequency and the setting in which the symptoms occurred. We also asked whether the individual's breathing seemed better, worse, or unchanged since the last NIOSH visit, whether the employee thought that his exposure to PCl_3 and $POCl_3$ had decreased, increased, or stayed the same. Finally, we inquired about the duration of exposure to the phosphorous compounds and about other job parameters.

On May 20-22, 1981, NIOSH performed the follow-up study. In addition to the questionnaire, NIOSH investigators administered a standard pulmonary function test to each participant. The test consisted of at least three properly performed forced exhalations to measure the forced vital capacity (FVC) and the one-second forced expiratory volume (FEV_1). The NIOSH technician utilized a Spirotech (Ohio Medical Products 822 dry rolling seal spirometer and a computer linkage which records the flow curves and analyzes them, as well as calculating expected values based on age, height, sex, and race[9,10]). The test was considered adequate if the FVC's and the FEV_1's on the best two of at least three properly performed exhalations differed from each other by no more than 5%. (The equipment used on this study was different from that used in the 1979 study. Although the final report from the 1979 study designated the pulmonary function apparatus as an Ohio Medical Products 842 spirometer, the study actually utilized the Mass Four Spirometry System consisting of an OMP 800 spirometer with a computer linkage which performs similarly to the system used in this study. Predicted normal values for age, height, and sex were based on Morris's work.[7]) The best FEV_1 and FVC were used in subsequent calculations.

IV. EVALUATION CRITERIA

PCl_3 and $POCl_3$ are potent irritants of the skin, mucous membranes, and respiratory tract, and repeated exposure has been reported to lead to chronic cough, wheezing, and bronchitis.[2]

Although no standard exists for a permissible exposure to $POCl_3$, the American Conference of Governmental Industrial Hygienists (ACGIH) has promulgated a Threshold Limit Value of 3 mg/M^3 for PCl_3, and the Occupational Safety and Health Administration (OSHA) has set its standard at the same level. This exposure limit is established at a level designed to protect workers exposed for an 8-hour day, 40-hour work week over a working lifetime.

Of the 13 environmental samples taken during the study in 1979[1], two showed air concentrations of PCl_3 which exceeded the standard, and both of those were personal samples taken on employees wearing chlorine gas masks. PCl_3 in the other 11 samples was below the limit of laboratory detection.

V. RESULTS

Of the 37 exposed and 22 unexposed workers who participated in the original study, 26 exposed and 11 unexposed workers participated in the follow-up survey. Workers who did not participate had retired, quit, or died. One unexposed worker declined to participate because of a bad cold.

Twenty-two of the 26 exposed workers still worked in maintenance. The other four had become, respectively, a gate watchman, a truck driver, an issuing clerk, and a retired person.

When compared with unexposed workers, the exposed group experienced more of the following respiratory symptoms and conditions (Table 1), although none of these excesses were statistically significant: shortness of breath after climbing one flight of stairs, symptoms compatible with a diagnosis of chronic bronchitis (a morning cough productive of sputum at least four days a week, for at least three consecutive months a year, for at least two years), a diagnosis of emphysema by their physician, episodes of pneumonia, bronchitis, asthma, and a chest illness within the past two years. The exposed group contained a higher proportion of present or former smokers (81%) compared with the unexposed group (64%), but this difference also was not statistically significant. Exposed workers did experience significantly more episodes of chest tightness, wheezing, and/or breathlessness than the control group (50% vs. 0%, $p = 0.002$ by Fisher's exact test, one-tailed). Five of the 13 exposed persons who reported episodes of respiratory distress attributed these to "work" or exposure to PCl_3 or $POCl_3$. Fewer exposed workers than controls complained of allergic or hay fever-like symptoms (38% vs. 54.5%) but this difference was not significant. Sixteen of 26 exposed workers (61.5%) felt that their exposure to PCl_3 and $POCl_3$ had decreased since the NIOSH visit in 1979, including 3 of the 4 men who had left their maintenance jobs. Eight workers (31%) felt that their exposure was unchanged, and two (7.5%) felt that the exposure had

increased, including one man who had left his job in maintenance. According to the union leadership, changes in procedures for washing out the tanks (initiated after the last NIOSH study) lead to a decrease in exposure to PCl_3 and $POCl_3$.

In a comparison of the pulmonary function tests of the two groups (Table 2), the exposed workers exhibited an average decrement in FEV_1 of 16 cc (with a standard deviation of 250cc), and the unexposed workers showed an improvement in their mean FEV_1 of 84 cc (SD $\pm$ 175 cc). This difference did not attain statistical significance, and it could not be accounted for by a change in smoking status. The FVC, which was of less relevance in this study, similarly did not show a statistically significant difference between the groups in the change over the two year period (FVC in the exposed group declined 25 cc $\pm$ 286 cc; FVC in the unexposed group increased 85 cc $\pm$ 206 cc). One individual in the exposed group exhibited a 1000 cc drop in both his FEV_1 and his FVC, a quantity in part responsible for the seemingly large mean difference between the exposed and control groups. If average values for the change in FEV_1 and FVC are computed without including this individual's results, then the mean change in FEV_1 for the exposed group becomes an increase of 22 cc $\pm$ 166, and the mean change for FVC an increase of 15 cc $\pm$ 203. (The mean FEV_1/FVC ratio--a measurement which might be expected to be less affected by variables such as different equipment, since it is a ratio--improved by 0.12 $\pm$ 3% in the exposed group, and by 0.27 $\pm$ 3% in the unexposed group, but this was not a significant difference by the Student's t test--t=0.14, p 0.5.)

VI. DISCUSSION

As in the earlier study, the exposed workers continued to report more signs and symptoms of acute and chronic respiratory disease than the control workers. Only episodes of acute respiratory distress (wheezing, breathlessness, and chest tightness) were reported significantly more frequently, and more than a third of the exposed group (5 of 13 or 38%) reporting these symptoms associated them with work. Although symptom reports are obviously subjective information, the reports suggest that workers are continuing to experience the type of pulmonary effects associated with exposure to irritants. While the majority of workers (61.5%) felt that their exposure to PCl_3 and $POCl_3$ had decreased since 1979, acute respiratory distress apparently remains a problem in the exposed group, and this difference cannot be accounted for entirely by differences in cigarette smoking.

Because symptom surveys are based on subjective data, investigators rely on pulmonary function tests to provide more "objective" information. Even such apparently "objective" data, however, are subject to wide variability. NIOSH did not find a statistically significant difference in the change in FEV_1 over a two year period in the exposed and unexposed groups. In studied normal populations, the expected annual change in FEV_1 is a loss of 20-40cc,[3-8] although this has not been demonstrated to be a uniformly regular event. In our study, the exposed group lost less pulmonary function than would have been expected for a "normal" population, and the control group showed clear improvement in function, an improvement not related to a change in smoking habits. This

suggests that other events--such as respiratory infections, other non-occupational exposures, the variability in the annual decrement already mentioned, changes in subject effort, technician, equipment, and formulas for computing the "expected" normal values between the 1979 and 1981 studies, or some other unsuspected or unexamined factor--may account for this finding.

The lack of statistical significance in the difference in the change in FEV_1 between the groups must be interpreted with extreme caution. Power calculations based on a difference of 100 cc (with a standard deviation of 175cc) in the change in FEV_1 between the two groups--as is seen in this study--revealed that the power of this study was 0.37. Stated another way, given this small sample size, we would have had only a 37% chance of detecting a significant difference between the two groups. Further calculations revealed that to have a 90% chance of finding a real and significant difference between the groups (a study with a power of 0.9, based on a difference of 100 cc and a standard deviation of 175 cc) would require a study population of at least 66 exposed and 66 unexposed workers. To detect a smaller but significant difference, e.g. 50cc, would require an even larger study population. Thus the lack of statistical significance observed between the two groups may mean that the study population is simply too small to show a difference in a parameter with as much variability as the FEV_1.

VII. RECOMMENDATIONS

1. FMC appears to have a good respiratory protection program. This program should continue, and employees must be encouraged to wear adequate respiratory protection at any time that exposures to irritants such as PCl_3 and $POCl_3$ can be expected. Workers should also be encouraged to carry a mouthpiece escape respirator on the belt at any time that they may come in contact with noxious vapors when they are not wearing a full-facepiece acid gas respirator. Obviously, any worker encountering noxious or irritating vapors and gases should leave the area as quickly as possible. Although full-face escape respirators would be desirable in order to provide eye protection, carrying a full-face respirator on the belt may be impractical.

2. The current practice of pre-placement and periodic pulmonary function testing carried out by FMC should continue, recognizing that pulmonary function is a variable parameter, and that changes in the spirometer, the spirometry technician, and subject effort may produce apparent changes in pulmonary function. If a larger than expected drop in FEV_1 is determined on an annual exam, the study should be repeated after a month and/or when the individual has had no recent respiratory infection or other irritant exposure. Any current smoker should be required to refrain from smoking for at least one hour prior to each pulmonary function test. If an employee exposed to known pulmonary irritants such as PCl_3 and $POCl_3$ demonstrates a consistently larger drop in FEV_1 or FEV_1/FVC than expected, a careful investigation of exposure levels of potential irritants should be made by the company and appropriate engineering or work practice controls initiated if high exposures are found or suspected. The employee should also be carefully

counselled regarding these exposures and his use of respiratory protection. Although smoking practices have traditionally been a sensitive political issue in occupational health, we believe that union leadership should strongly encourage workers to stop smoking cigarettes.

3. We encourage union and management to work together on an information program for workers regarding the potential toxic hazards of the substances with which they may come in contact on the job. Material safety data sheets may not provide adequate toxicologic information, and we would encourage FMC to acquire a toxicology file on the substances to which the workers are exposed. The information on substances can be provided by the manufacturers or providers, and NIOSH may also be able to provide useful information. Such a toxicology file may be envisioned as a resource for both employers and employees. Workers who are well-informed about the actual and potential hazards of the substances with which they work are more likely to handle toxic substances with the care they deserve, and are less likely to come to inadvertent harm from such substances.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22216.

Copies of this report have been sent to:

1. Local 12757, USWA
2. District No. 23, USWA
3. USWA, Safety and Health Department
4. FMC Specialty Chemicals Division

For the purpose of informing the employees of the results of this investigation, the employer shall promptly "post" for a period of 30 calendar days this report in a prominent place(s) near where employees work.

TABLE 1

Respiratory Symptoms and Conditions in a group of 26 workers intermittently exposed to PCl_3 and $POCl_3$, and in a group of 11 unexposed employees

(May 1981, FMC Corp, Nitro, W. V.)

	short of breath climbing stairs	symptoms of chronic bronchitis	diagnosis of emphysema	episodes of pneumonia	episodes of bronchitis	episodes of asthma	episodes of chest illness	wheezing, chest tightness or breathlessness	current or former smoker
exposed n= 26	6 (23%)	7 (27%)	3 (11.5%)	4 (15%)	1 (4%)	2 (8%)	3 (11.5%)	13 (50%)	21 (81%)
unexposed n= 11	1 (9%)	1 (9%)	0	1 (9%)	0	0	1 (9%)	0	7 (64%)
	p = 0.49	p = 0.18	p = 0.33	NS	NS	NS	NS	p = 0.002*	p > 0.5

*Fisher's exact test, one-tailed; $p < 0.05$ is statistically significant