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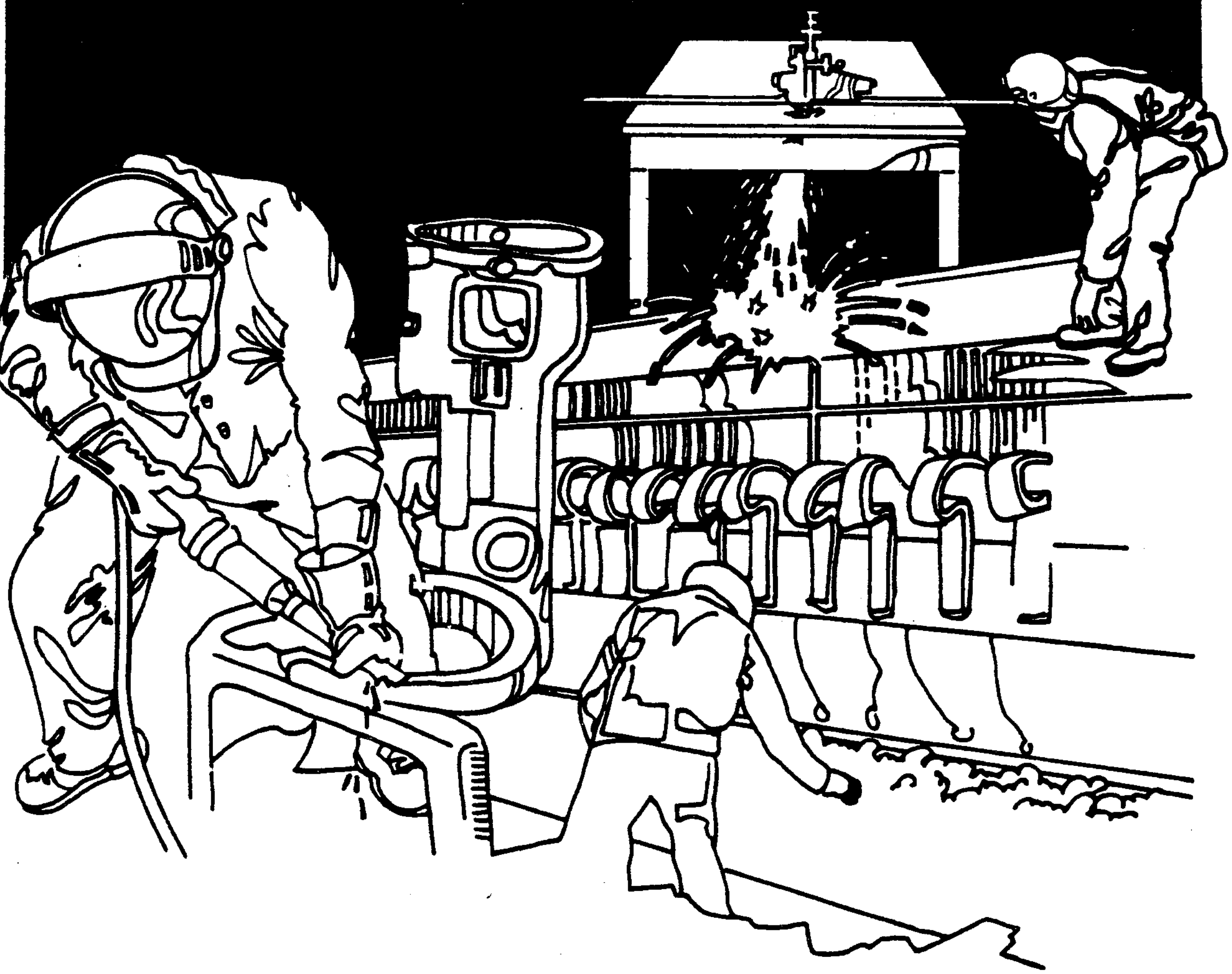

Health Hazard Evaluation Report

HETA 83-166-1594
WITCO CHEMICAL CORPORATION
PERTH AMBOY, NEW JERSEY

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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Witco Chemical Corporation
Perth Amboy, New Jersey

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I. SUMMARY

In February, 1983, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate possible health effects of polychlorinated biphenyls (PCBs), glycols, and ethylene oxide Witco Chemical Corporation, Perth Amboy, New Jersey. NIOSH assigned the evaluation to the New Jersey State Department of Health (NJSDH), Occupational Health Program, under a Cooperative Agreement, in April, 1983.

To determine if there were exposures or health effects related to exposures to these chemicals, NJSDH conducted an opening meeting and walkthrough on June 29, 1983, site visits at the plant for industrial hygiene on November 30 and December 9, 1983, and a final walkthrough on May 15, 1984.

PCBs were used in heat exchangers as the heat transfer medium in polyester resin production from 1964 to 1972. They were removed from the heat exchangers in 1972. Polyester Department and Maintenance Department workers presumably had had the highest exposures to PCBs but, because of soil contamination around the heat exchangers, all workers may have had some exposure. There was minimal current exposure at the time of the HHE, because soil containing PCB levels above 50 ppm was removed in early 1983. Because Polyester workers complained that use of adipic acid was irritating, air monitoring of adipic acid levels was conducted as part of the Hazard Evaluation.

On December 14, 1983, NJSDH staff performed medical examinations of 52 workers. Workers were selected for potential exposure to PCBs, EtO, glycols, adipic acid and other irritants. The examinations included medical and work histories, physical examinations, pulmonary function testing (spirometry), and the following nonfasting blood tests: complete blood counts, multiphasic chemical screens, and serum PCB samples. Workers from the following departments were examined: Polyester, Maintenance, Stearate, NIS, Low-Temperature Emcol, and Management.

The industrial hygiene survey included personal air sampling for eight glycols, adipic acid, and ethylene oxide, and area sampling for the glycols. During the walkthrough inspections, NJSDH evaluated engineering controls, work practices, availability and use of personal protective equipment, and the potential for other employee exposures.

On December 9, 1983, personal air samples were collected on 3 chemical operators for EtO in NIS and Low-Temperature Emcol and on 6 operators in Polyester for glycols and adipic acid. Average 8-hour levels of EtO were 7.1 parts per million (ppm), 0.95 ppm, and 0.7 ppm; all three exceeded the OSHA action level of 0.5 ppm for workplace exposure to EtO. The 7.1 ppm of EtO also exceed the OSHA TWA of 1.0 ppm. Levels of glycols all were well below OSHA permissible exposure levels (PELs); there are no specific OSHA PELs for adipic acid or other fatty acids.

The medical examinations revealed a high rate of mucosal irritation (56%), with the highest rate in Low-Temperature Emcol (100%). A positive response was defined as work-related irritation of two or more of these areas at least once a week: eyes, nose, and throat. By history, 6 of the 52 workers had bronchitis (12%). Of these, 4 of 15 (27%) ever employed in Stearate for more than one year had bronchitis, versus 2 of 37 (5%) others. On physical examination, there was one worker with severe acne on his face and trunk that probably was occupational. He had worked in the former Asphalt Department, and currently in Maintenance since 1974. Physical examinations were otherwise unremarkable for possible occupational disease. Spirometry revealed that working more than one year in Stearate was associated with a reduction in FVC, FEV_1, FEV_1%, and FEF 25-75 values, independent of cigarette smoking. The reduction in FEV_1 was statistically significant; the reduction in FEF 25-75 was of borderline significance. When controlled for smoking, only the reduction in FEV_1 was statistically significant. While serum PCB levels generally were within the usual population range, they were significantly higher in those who worked in Polyester or Maintenance before 1973, both before and after adjustment for age. The highest serum level was 28.1 parts per billion (ppb); all other serum PCBs were below 22 ppb. (The mean serum PCB in unexposed populations has been estimated to be from 2.1 to 24.4 ppb in various studies.) Serum PCB levels were weakly associated with worker systolic blood pressures and liver enzyme levels; however, liver enzymes all were within the normal range.

Work practices, ventilation controls, and the use of personal protective equipment, including respirators, all were considered inadequate to protect workers from potentially high exposures to chemicals used in several departments, including ethylene oxide, various stearates, and alkanolamine compounds, among others. Also considered inadequate was education and training in toxicity of chemicals and safe handling procedures.

Based on these results, NIOSH concluded that there were 1) possible respiratory effects associated with working in the Stearate Department, 2) mildly increased body burden of PCBs in previously exposed employees, 3) a health hazard from exposure to ethylene oxide, and 4) irritative complaints in those working with adipic acid and other chemical irritants at Witco Chemical Corporation. Ethylene oxide has been linked to cancer, experimental mutagenicity, and reproductive damage. PCBs are animal carcinogens, although human cancer data is inconclusive. A secondary hazard is posed by the use of a large number of irritating chemicals without use of adequate control technology. A health hazard is also posed by poor work practices and lack of training on chemical handling and toxicity. Finally, there are potential exposures to other toxic agents which NIOSH has not assessed, which should be further evaluated.

Work practices, ventilation controls, use of personal protective equipment, and training in chemical toxicity and safe handling need to be improved to mitigate existing hazards. Because of both past and ongoing exposures, workers at Witco require periodic medical evaluations and future study. Recommendations for hazard reduction and medical followup are found in Section VIII of this report.

Keywords: SIC 28.16, polyester manufacture, polychlorinated biphenyls, ethylene oxide, glycols, stearates, adipic acid, pulmonary effects

II. INTRODUCTION

In February, 1983, the National Institute for Occupational Safety and Health received a request for a Health Hazard Evaluation at the Witco Chemical Corporation, Organics Division Plant, Perth Amboy, New Jersey. The request was made by the Oil, Chemical and Atomic Workers International Union (OCAW), on behalf of Local 8-337, OCAW, and the HHE was assigned to the New Jersey State Department of Health, Occupational Health Program, under a Cooperative Agreement.

In the letter requesting the HHE, OCAW expressed concern about "chronic health effects of potential exposures to polychlorinated biphenyls (PCBs) used in the plant as the heat transfer medium for heat exchangers", and requested medical and industrial hygiene evaluation. OCAW also requested assessment of exposures to ethylene oxide (EtO) and glycols.

NIOSH distributed an Initial Report and Proposal for further study in October, 1983, after initial meetings and walkthrough inspections.

III. BACKGROUND

The Organics Division facility of Witco Chemical Corporation in Perth Amboy was constructed in 1948 and currently has seven operating departments. The facility produces approximately 70 specialty organic chemicals, including a variety of stearates, sodium isoethionate (a soap intermediate made using EtO), other surfactants, polyester resins, and a rubber accelerator. In December, 1983, the facility employed 102 hourly and 50 salaried workers. There was no medical screening program at the plant.

With regard to the chemicals in the HHE request, PCBs were used as the heat-transfer fluid in the heat exchange units in the Polyester Department from 1964 to 1972. During that time, fluid leaks, spills, and maintenance repairs reportedly caused ground contamination. In 1972 the PCBs were drained from the units, the units cleaned, and a non-PCB oil substituted. Cleanup of the soil occurred in early 1983, to a PCB level of 50 parts per million (ppm). Glycols are used in polyester production and EtO is used to make a soap intermediate, as previously noted. Since workers in other departments had work-related health complaints, and since the initial walkthrough revealed areas of concern, those departments were evaluated.

The processes in each department are as follows:

Polyester

In the Polyester Department, the reaction of a glycol with adipic acid, in the presence of a tin catalyst and certain additives, produces a polyester resin. Operations are batch processes in six reaction vessels. There are four operators. Job titles are upstairs operator, downstairs operator, outside operator, and reactor #6 operator. The upstairs operator charges the reaction vessels with glycols, glycerine, adipic acid and other components. Liquid ingredients are pumped into open drums to be weighed. From there they are pumped into the reactor. Adipic acid is conveyed from storage silo to the scale room to be weighed. The operator then charges the measured amount of adipic acid using a hose which is inserted through the reactor hatch. No local exhaust ventilation is present in this area and the upstairs operator did not wear respiratory protection. The batch is periodically sampled, and additives such as catalyst or antioxidants are added as needed through the hatch. Both the downstairs and outside operators are responsible for sampling and drumming the reactor product after it has been "dropped" from a reactor vessel to a "drop tank." Workers reported that clouds of adipic acid and other materials were routinely generated during charging of reaction vessels and complained of eye and respiratory irritation. Reactor #6 is totally enclosed and automated, so the potential for exposures there appears to be greatly reduced. One operator charges, samples, and drops batches at reactor #6. Annual glycol use at this facility in 1983 was estimated at 18,400 lbs.; the most-used glycols were 1,4-butanediol, 1-6-hexanediol, diethylene glycol, 1,3-butylene glycol, and ethylene glycol.

NIS

In this area sodium isoethionate, an intermediate used in the manufacture of soaps, is made from EtO, water, sodium hydroxide (NaOH), and sulfur dioxide (SO_2). EtO comes into the plant by rail car, is pumped into a storage tank, and is metered into the closed reaction vessel. The reaction process is as follows: first water, then SO_2 and NaOH are added, then the mixture is tested for clarity, pH, and particulate matter. After laboratory testing and approval, the operator charges the vessel with EtO, a process requiring 3 to 4 hours and proper temperature, pressure, and volume. The reaction product is mixed, sampled and, if satisfactory, steam and vacuum stripped to recover unreacted EtO. The batch is transferred to a filter tank; NaOH to adjust pH, and celite (calcined diatomaceous earth), a filtering agent, are added by hand through an open hatch. After further testing, the batch is pumped into a storage tank. A single operator works directly with the NIS operation, setting supply lines and values for charging, and making needed additions. He is potentially exposed to SO_2, NaOH, and EtO if there are leaks in lines or valves, and to EtO and celite (which contains free crystalline silica) when making corrections during the filtration process. The NIS Operator spends 80-90% of his time in the control room. Witco has an industrial hygiene protocol for the handling of EtO.

Low-Temperature Emcol

This department manufactures basic surfactants for cosmetics. Five reactor vessels are used; most of the reactants are added manually either by hose or by hand scooping through the charge port. There is no local exhaust ventilation; one supplied-air respirator is available. A large number of specialty organic chemical intermediates are manufactured here. A typical batch might begin with the Low-Temperature Emcol operator pouring liquids and hand-scooping dry raw materials into one of the reactors. A partial list of materials used here includes maleic anhydride, phosphoric acid, phosphorous pentoxide, succinic anhydride, chloramide, pyridine, and a variety of aliphatic amines. As in other areas, there was no local exhaust ventilation, and significant exposures could occur during material handling and charging of reaction vessels. Employees complained of respiratory irritation during such charging. The Low-Temperature Emcol and NIS Departments are in the same building, unseparated, so that the Low-Temperature Emcol workers may also be exposed to EtO and other NIS-chemicals.

High-Temperature Emcol

This department was inspected only briefly during the initial NIOSH walkthrough. A variety of amine and amide esters are produced here, and two employees per shift work this department.

Stearate

The Stearate Department Manufactures stearates used in soaps and lubricants. These are two kinds of processes: fused (water not used in process) and precipitate (water solutions) operations. Materials commonly used include compounds of aluminum, magnesium, calcium, zinc, lithium, and sodium; various fatty acids, such as stearic, oleic, and palmitic; flake caustic, and water. The Witco safety officer reported total dust levels of less than 5 mg/M^3 for precipitate operations, and between 5 and 15 mg/M^3 for fused operations, on repeated air sampling. Copies of the Witco sampling results were provided. At the time of the walkthrough, workers complained of constant upper respiratory irritation, with nosebleeds, which increased when working with certain fatty acids, principally oleic acid. There was no respiratory protection program, but half-face respirators (equipped with particulate filters) were available on worker request.

Rubber Accelerator

Production of the rubber accelerator was not being carried out at the time of our evaluation, so observations of this manufacturing process could not be made. According to Witco management, a liquid rubber accelerator is produced in a batch process in an enclosed system using butyraldehyde, butyric acid, and aniline. The reaction is run at about $128^{\circ}F$ - $132^{\circ}F$, and requires approximately 16 hours to complete. The product is diluted with an oil and is drummed for shipping. One employee per shift works here when it is operational.

Insulation

During the walkthroughs on November 30, 1983 and December 9, 1983, NIOSH staff observed removal of insulation materials from reactor vessels and pipes. Employee and employer representatives stated that reinsulation of reactors was an ongoing process. The Witco safety officer acknowledged that asbestos insulation materials were used in the past and that, in some areas, asbestos still might be present.

Neither employees conducting removal and replacement of insulation nor management representatives were aware if an asbestos exposure might still be occurring. However, a concern regarding this potential was raised by some workers.

IV. METHODS AND MATERIALS

A. Environmental

To quantify the exposure of employees to ethylene oxide, glycols, and adipic acid, NJSDH performed air monitoring on November 30 and December 9, 1983. By mid-1983, nearly all PCB-laden soil was fully removed from Witco, so industrial hygiene assessment of PCB exposure was not possible.

1. November 30, 1983. Seven employees wore personal air samplers. Four Polyester operators were monitored for exposure to glycols and adipic acid. The NIS operator was monitored for EtO, and two Low-Temperature Emcol operators also were monitored for EtO. Numerous problems in conducting the sampling developed. The two most serious were that (1) the EtO reaction was not run at all so meaningful EtO levels could not be obtained and (2) the glycol sampling used a liquid collection system with two midget impingers in series, and the employees who wore them spilled some of the collecting media when bending and reaching. Therefore, NJSDH chose not to analyze these samples, but to resample.

2. December 9, 1983. Again, four Polyester operators were monitored for glycols and adipic acid, and the NIS operator and two Low-Temperature Emcol workers (one operator and one trainee) were monitored for EtO. Sampling and analysis for glycols was done according to NIOSH method P & CAM 338 for ethylene glycol. Air was drawn through a three-stage sampler

consisting of a 13 mm glass fiber filter followed by two sections of silica gel to collect ethylene glycol, diethylene glycol, and propylene glycol aerosol and vapor, using DuPont P4000 air pumps calibrated to draw 25 ml/minute of air. Adipic acid was sampled with 37 mm mixed cellulose ester membrane matched weight filters in closed cassettes, using DuPont P2500 pumps calibrated to draw 1.0 liter/minute of air. There is no published NIOSH method for adipic acid. Ethylene oxide sampling was done according to a NIOSH method revised and published in July, 1983, by the Methods Research Branch, Organic Methods Development Section. NIOSH used 600 mg charcoal tubes (400 mg front section, 200 mg backup section), with DuPont P4000 pumps calibrated to draw 25 ml/minute of air.

During walkthrough inspection and on sampling days, work practices and manufacturing operations were observed. Job and process descriptions were obtained through interviews with employees and management.

B. Medical

The meeting and walkthrough investigation established that there were multiple potential chemical exposures to all production workers at this Witco facility. PCB exposures had been greatest among those who worked in Maintenance or Polyester from 1964 through 1972 but, because of soil contamination, all employees had potential PCB exposure. Potential exposure to irritant chemicals also was universal, and in several departments, exposures other than those on the HHE request were possible. Therefore, NJSDH chose several groups within the plant for comparison to each other, since a true unexposed group was not available.

A total of 54 workers were invited for medical evaluations. These included all 18 workers who worked in Maintenance or Polyester from 1964 to 1972 (probable high PCB exposure), the remaining 9 current Polyester workers, and 27 workers randomly chosen from other departments as a comparison group of equal size. The other departments represented were Stearate, Low-Temperature Emcol, NIS (one worker), and Management. Fifty-two (52) subjects actually attended the medical evaluations; 16 were from the high PCB exposure group. Using standard forms, NJSDH obtained past work history and work history at Witco, current symptoms (skin, upper and lower respiratory), past medical history, and data on smoking and alcohol intake. Onset and duration of work in each Witco department was recorded. Each subject underwent physical examination, including one-time blood pressure measurement and examination of skin, head and neck, chest, and abdomen.

For the purpose of data analysis, NJSDH used the following definitions of symptom complexes: mucosal irritation was defined as presence of weekly, work-related current irritative symptoms in two or more of these three areas: nose, throat, and eyes; bronchitis was defined as cough productive of sputum on most days of the week, for at least 3 months of the year, for over one year.

Nonfasting blood samples were collected by venipuncture for complete blood count (CBC), multiphasic chemical screen, and serum PCB. CBCs and chemical screens were analyzed by Metpath Laboratories, Teterboro, New Jersey. PCB in serum was chosen to measure PCB body burden. Serum PCBs were analyzed by the State Health Department Laboratory.

Pulmonary function studies were performed by a private contractor using a Collins survey spirometer with Apex 420 microprocessor incorporating the predicted values of Morris (1).

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and

ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighed average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8 to 10 hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

Published criteria are available for some, but not all, of the chemicals evaluated at Witco.

Adipic Acid - Like all organic acids, particles of adipic acid can irritate human tissue, so symptoms of respiratory irritation can be caused by inhaling adipic acid dust. Currently no environmental criteria exist (NIOSH, OSHA, or ACGIH) regarding exposure to adipic acid, and its particular health effects are not well-studied.

Ethylene Glycol - can enter the body by ingestion, inhalation, and skin absorption. Vapor pressure at room temperature is low, so toxic concentrations are likely only if ethylene glycol liquid is heated or large amounts are swallowed. Symptoms and signs of chronic intoxication include: loss of appetite, respiratory irritation, eye twitching, central nervous system depression, and loss of consciousness. There are no current NIOSH criteria or OSHA proposed standards, but in 1975, ACGIH published a TLV of 10 mg/m^3 for particulate ethylene glycol and 260 mg/m^3 for vapor.

Diethylene Glycol - is similar to ethylene glycol in terms of heath hazard from exposure; there are no published criteria.

Propylene Glycol - Toxicology studies have revealed no significant health hazard and there are no published criteria.

Ethylene Oxide - Hazardous exposure can occur with eye and skin contact with EtO liquid or solutions as dilute as 1 percent, and with vapor inhalation. EtO is a severe eye, skin, and respiratory tract irritant, and in high concentrations produces headache, nausea, vomitting, diarrhea, blood count changes, and central nervous system depression. Serious chronic effects from exposure have recently been reported, including cancer, genetic mutations, and birth defects in laboratory animals and chromosomal damage in humans. (3) As a result, NIOSH has recommended that EtO be regarded as a potential occupational carcinogen, and recommended, in 1983 testimony to OSHA, an 8-hour TWA of 0.1 ppm, with a 5 ppm ceiling for 10 minutes daily. On June 15, 1984, OSHA issued an EtO standard that set a PEL of 1 ppm as an 8-hour TWA, with an action level of 0.5 ppm.

Fatty Acids - such as oleic acid, are irritating to the skin, eyes, and respiratory tract. No criteria exist. Exposure to airborne fatty acids can produce skin rashes and irritant syndromes of the eyes and respiratory tract.

Polychlorinated Biphenyls - were widely used from 1930 to the mid-1970's in electrical transformers and condensers. They had multiple uses, including use in sealants for wood and cement, as hydraulic fluids, cutting oils, plasticizers, and as heat exchange media. Initially thought to be non-toxic, their widespread use and chemical stability has allowed them to bio-accumulate in the environment, and over 90% of the general population now has detectable PCB in fatty tissue. Non-occupational exposure has been primarily through ingestion of meats, especially seafood. Working with PCBs may produce additional exposure and higher body burdens; studies have shown variable elevations in serum PCB in exposed workers (5). U.S. production was halted in the mid-1970's. PCBs have caused cancer and immune suppression in laboratory animals. Initial reports of occupational disease associated with PCB exposure consistently reported chloracne (a distinctive, persistent acne), eye irritation, and gastrointestinal disturbances. Used PCBs that have been heated may contain chlorinated dibenzofurans (CDF) as impurities. The toxic effects of PCBs are thought to be caused, in part at least, by CDFs, since recent studies have shown only mild skin and respiratory disease in workers exposed to pure PCBs (5). Severe dietary PCB poisoning has produced chloracne, increased pigmentation of the skin and nails, weakness and numbness of limbs, decreased conduction velocity in peripheral nerves, elevated serum triglycerides, menstrual disorders, and bronchitis, all of which persisted for a number of years (5). Current OSHA and ACGIH standards are a TLV of 0.5 mg/m^3 for 54% chlorine PCB, and 1 mg/m^3 for 42% chlorine PCB. The NIOSH-recommended criterion for PCB is 1.0 $microgram/m^3$ total

PCB in air, 8-hour TWA. Serum halogenated hydrocarbon levels correlate well with levels in adipose tissue and, therefore, with the body burden (10). The New Jersey State Health Department Laboratory considers 0 to 10 ppb its usual range in individuals without occupational exposure, with a mean of approximately 5 ppb, according to its experience. Seventy-five percent of people have serum PCB levels below 10 ppb and 95% of the population is below 27.4 ppb, in one study (12). In other studies of non-occupationally exposed populations, serum PCB levels have ranged to 42 ppb, with means from 2.1 to 24.4 ppb (11-12).

VI. RESULTS

A. Environmental

Air monitoring results are presented in Table 1. All glycol levels were not detectable, or detectable at less than 1 ppm. Adipic acid levels were 0.55 mg/m^3, 0.47 mg/m^3, and 0.79 mg/m^3. All EtO levels exceeded the OSHA action level of 0.5 ppm. The NIS operator had an 8-hour TWA exposure of 7.1 ppm (current OSHA standard = 1 ppm), and the Low-Temperature Emcol operators were exposed to 0.701 ppm and 0.950 ppm, respectively.

NIOSH observed a number of poor work practices, including:

1. In Low-Temperature Emcol, employees leaning into the heptane wash tank in order to perform their job, adding powdered materials to reaction vessels by hand scooping and without local exhaust ventilation, and grinding the material known as 607 (a surfactant made from stannous chlorate, lauric acid, and chloramide) resulting in visible dust;

2. In NIS, potential exposure to EtO from opening the filtration tank to make hand additions, and adding NaOH and celite, a product containing crystalline silica, by hand to the NIS filtration tank.

Other problems observed at Witco were as follows:

1. Local exhaust ventilation was absent over reactor vessels and other sources of exposure in Low-Temperature Emcol, Polyester, Stearate, and NIS, resulting in potential exposures to adipic acid, stearate dust, amines and other chemicals in Low- Temperature Emcol, and to ethylene oxide. Visible dust was released through open charge ports.

2. In Polyester, clouds of adipic acid dust were observed when it was manually added to reaction vessels; walking and working surfaces were covered with white powder, presumably adipic acid.

3. The Stearate Department was visibly dusty, and a number of dust sources were seen, other than open charge ports. These included the drying of Stearate produced by precipitate reactions, and the grinding, blending, and bagging operations from the fused processes.

4. There was no formal respiratory protection program in place at Witco as required by OSHA 1910.134. Discussions with employees revealed that many individuals were unaware of the basic uses and limitations of respiratory protection equipment necessary for particular jobs. In Low-Temperature Emcol, the respirator appeared to be poorly maintained, and was inadequate to protect workers during hand-charging of reactor vessels.

5. Training and education, with respect to informing employees of the hazards and safe use of chemicals at the facility, was inadequate. Most employees did not know the specific chemical names of products with which they worked and were not well-informed about workplace toxicity.

B. Medical

Fifty-two male workers from the Polyester, Maintenance, Stearate, NIS, and Low-Temperature Emcol Departments, and from Management, were examined. Table 2 describes the population by current job assignment. The one NIS worker was analyzed together with Low-Temperature Emcol workers. Past medical histories were evaluated; no subjects required elimination from analysis because of reported pre- existing cardiac or pulmonary disease.

Because of the small sample size, results with borderline significance are presented. To analyze the relationship between serum PCB and blood pressure and liver function (Table 6 and 7), regressions were done. In Tables 5 through 7, B is the standardized increase in the dependent variable per unit increase in the independent variable (13).

Respiratory symptoms reported at interview are summarized in Table 3. Twenty-nine subjects (56%) complained of work-related symptoms that indicated mucosal irritation, in all areas of the plant. The highest rate was in Low-Temperature Emcol, 5 of 5 (100%). The number of irritative symptoms per subject also was highest in Low-Temperature Emcol (mean = 2.2). Notably, all but one of the Low-Temperature Emcol employees were non-smokers.

Six of the 52 workers had bronchitis (12%) as determined by interview. Bronchitis was associated with smoking and was independent of age, length of employment, and current job assignment (Table 4). Of the 15 who ever worked in the Stearate Department for more than 1 year, 4 (27%) had bronchitis, versus 2 of 37 others (5%). This should be considered as only suggestive of an association, since it may be explained by differences in the rate of smoking, which is high in Stearate. The small sample size precludes further interpretation.

On physical examination 19 subjects had blood pressure exceeding 140/90. Skin examination identified one worker with severe acne; he had been a maintenance worker since 1974, had a serum PCB of 12.9 ppb, and began working at Witco in 1962. He had worked in the Asphalt Department for two periods in the past when it existed. He had no other physical signs that might be PCB-related. No other worker had apparent PCB related disease on physical examination. Six subjects had abnormal findings on chest examination, including wheezes, rales, rhonchi, gross resonance, and altered breath sounds. One subject had liver enlargement; he reported heavy alcohol use, and had physical signs of alcoholism. Physical examinations otherwise were unremarkable.

Fifty serum PCB results were obtained; one worker declined blood tests, and one sample was lost in a laboratory accident. Three results exceeded 20 ppb; the highest value was 28.1. Results were analyzed by work-years in Polyester or Maintenance during 1964 to 1972 (Table 5). PCB values were higher in Polyester and Maintenance workers exposed during 1964 to 1972. The average value of workers with high exposure was 11.7 ppb, as compared to 7.2 ppb in workers with low exposure employed during the same time period. There was a statistically significant association between PCB levels and work-years in these departments. Serum PCBs in those hired after 1973 all were lower.

There was a slight association between serum PCB and systolic blood pessure, independent of age, and no association with diastolic blood pressue (Table 6).

Serum PCBs were associated with slightly higher values of two serum liver enzymes, gamma-glutamyl transpeptidase (GGTP) and glutamic pyruvate transferrse (GPT) (Table 7). The association was borderline between PCB and GGTP and strong between PCB and GPT, and was independent of age. However, values were all in the normal range, and other liver function parameters did not correlate with PCB. After controlling for alcohol intake, there was no statistical association between GGTP and PCB levels. Complete drinking history was not available for 11 workers, so the n and df varied according the number of factors analyzed in the regression.

Since the tests were non-fasting, serum triglycerides were not meaningful and were not analyzed. The CBC and other chemical tests showed no trends, nor clear differences between departments.

To initially analyze spirometry according to worker exposures, workers' average values of FVC, FEV_1, $FEV_1\%$, and FEF_{25-75} were compared by current department assignment (Table 8). The average of each lung function test was lower in current Stearate workers than in other departments. Since abnormal spirometry may reflect chronic disease, workers were then analyzed for having worked more than one work- year in Stearate, versus one or less (Table 9). There were consistent reductions in all lung function test values in those exposed; these were statistically significant for FEV_1 and of borderline significance FEF_{25-75}. After adjustment for cigarette smoking, the reduction in FEV_1 remained statistically significant. These results suggest a trend towards obstructive lung disease in these workers, and are consistent with the prevalence of bronchitis also found in these workers.

VII. DISCUSSION AND CONCLUSIONS

The Health Hazard Evaluation of the Witco Chemical Corporation, Perth Amboy, facility has indicated that there have been chemical exposures in that facility with potential adverse health effects, and that there appear to be health effects from such exposures. Most notable of the health effects are decrements in workers' spirometry in the Stearate Department, and mucosal irritation throughout the plant. There was a weak association between serum PCB and systolic blood pressure. Tests also showed increased absorption of PCBs by those most exposed, and an association between serum PCBs and two liver enzymes, although liver enzyme values were within the normal laboratory range. Air monitoring measured elevated ethylene oxide levels on the day it was done.

As in many organic chemical facilities, exposure and medical data were difficult to analyze because subjects had multiple exposures within departments, because of possible bystander exposure to chemicals from other departments, because the number of workers in some departments was too small for statistical comparison, and because there are no available past medical records. Because of the small population at Witco, the one-time nature of this cross-sectional study, and lack of data on prior blood-pressure treatment, these results all should be interpreted cautiously. Nonetheless, there were positive findings.

Since the heaviest PCB exposure at Witco ended in 1972, and most remaining onsite PCBs were removed early in 1983, past exposures could be evaluated only indirectly by work histories, serum PCBs, and physical examinations. Current body burden, which reflects past exposure, is directly related to serum PCB. In the Witco workers, the increase in serum PCB in the high-exposure group was moderate; those exposed since 1973 are normal, so the workforce has absorbed little if any excess PCB since that time. Not unexpectedly, with all PCB values below 30 ppb, NIOSH found no PCB-related systemic disease, and only one case of acne, in a worker with other potentially acneigenic exposures such as other oils and asphalt. In other studies, including one by NIOSH (MMWR, 1983), there were few abnormal findings in workers with mean values well above those at Witco, including values over 100 ppb. Because PCBs are carcinogenic in animals and are suspect human carcinogens, however, future disease is possible.

The glycols are handled in a closed system, and all glycol levels were below 1 ppm, far below standards. Although glycol exposures may be irritating, for brief times when reactor-vessel hatches are opened in the Polyester Department, exposures to adipic acid may be more significant in explaining the complaints of irritation which we received. Adipic acid is a respiratory irritant and is handled in a manner which results in airborne exposures (Table 1) as well as contamination of walking and working surfaces.

Because of the air levels of ethylene oxide found in both NIS and Low-Temperature Emcol, EtO must be considered a potential health hazard at Witco. Witco's sampling results from a year earlier indicated an exposure problem which was diagnosed as being due to a detective gasket on the filtration tank. This was subsequently corrected. However, our sampling results indicate that an exposure problem may still exist, and irritative complaints were highest where EtO is used. Because of EtO's cancer-causing potential and known irritant effects, improved workplace exposure controls are necessary.

The workers had low-level exposures to irritants, and work-related irritation of the eyes, nose, and throat in all production areas. Such a constellation of symptoms is seen in many settings of chemical exposure, and may be associated with other complaints such as headache, skin irritation, gastrointestinal complaints, and other constitutional symptoms. The prevalence of irritation was 100% in Low-Temperature Emcol. Associated with this irritation may be increased numbers of respiratory illnesses and sick days, and diminished worker-satisfaction. Reducing the irritant level will improve symptoms.

The association between systolic blood pressue and PCB differs from the conclusions of another study (8), which reported increased diastolic blood pressure. Further study is indicated. Although there was an association between PCBs and liver enzymes, all enzyme levels were normal, so there is no known clinical significance of this finding. In the Stearate Department there was bronchitis, a statistically significant reduction of FEV_1, and reduction in other pulmonary function parameters, but not at statistical significance. The analysis of these effects included workers who both currently and previously worked in Stearate, so the irritation that produced the effects apparently has been ongoing. This suggests that continued exposure to Stearate Manufacture may lead to chronic obstructive lung disease. Although no criteria exist for fatty acids in air, applying the OSHA nuisance dust standard of 10 mg/m^3 is inappropriate for these irritants. The reported levels of 5 to 15 mg/m^3 total dust in the Stearate Department, which may be periodically higher and may include caustics, soaps, and fatty acids, could cause the pulmonary function abnormalities. In Stearate, there is potential exposure to any of these chemicals, so it is unclear which, if any one agent, is responsible. Workers stated that oleic acid was particularly annoying, but this requires further study. Annual pulmonary function testing is needed to determine if loss of pulmonary will occur at a greater rate than usual.

In addition to PCB and EtO exposure, there has been past asphalt exposure, and workers have anecdotally reported several cases at colon cancer. This study did not address cancer rates at Witco, but a study of such rates should be done.

In summary, based on the results of environmental evaluations of June 29, November 30, and December 9, 1983, and May 15, 1984, and medical evaluations on December 14, 1983, NIOSH has determined that health hazards exist at Witco Chemical Corporation, Organics Division. The hazards include current exposure to airborne fatty acids in the Stearate Department, with diminished pulmonary function, exposure to ethylene oxide, irritative respiratory complaints throughout the facility, most pronounced in Low-Temperature Emcol, and increased absorption of PCBs in certain workers from 1964 to 1972. Steps are required to reduce current exposure to EtO and irritants, and future medical and epidemiological study of the workforce are necessary.

VIII. RECOMMENDATIONS

Based on the information presented above, NIOSH recommends the following preventive measures:

A. Stearate.

1. Visible dust released through open charge ports of the stearate tanks in the precipitation area should be controled. Local exhaust ventilation should be upgraded over the charge ports to minimize dust exposure during charging operations. Also, to eliminate the need for visual monitoring through open ports, transparent hatches should be installed.

2. The ceiling and wall fans currently in use do not adequately control dust in the department. Specific sources of high dust generation noted earlier should be controlled with local exhaust ventilation. The grinder appears to be one of these sources. In addition, a regular and frequent vacuuming program should be established.

B. Polyester

1. As in the Stearate Department, employees are exposed to powdered chemicals including adipic acid when manually charging through open ports. Local exhaust ventilation should be designed and installed over such ports. This has already been done on Reactor #6 and appears to have considerably reduced potential exposures to employees.

C. Low-Temperature Emcol

1. As in Stearate and Polyester, employees are exposed to numerous chemicals while charging vessels by hand. Some, such as phosphorus pentoxide and maleic anhydride, are highly toxic. Local exhaust ventilation should be designed and installed to reduce exposures, and manual handling of such materials should be minimized.

2. The heptane washing/centrifuging operation should be equipped with local exhaust ventilation. Work practices which involved employees bending or reaching into the tank should be eliminated.

3. The grinding station should be enclosed and a hopper installed to more efficiently convey materials to the grinder. Powders should be vacuum bagged to prevent powder releases.

4. The drying operation should be controlled by a properly designed local exhaust ventilation system.

D. NIS

1. We were informed by Witco's industrial hygienist that a previously identified ethylene oxide exposure problem had been corrected. However, our sampling indicated that the NIS department still had EtO overexposures. We recommend instituting a periodic sampling protocol for EtO in this area. Sampling should include personal and area sampling designed to identify sources of

continuing exposure and the extent of exposure to employees in the department.

2. The NIS operator was observed opening the hatch of the filtration tank to test the batch and add celite (a calcined diatomaceous earth). Calcined diatomaceous earth may contain crystalline silica. To control this potential exposure, and the possible EtO emissions from this tank, the charge port should be fitted with local exhaust ventilation. In addition, the celite should be substituted with a crystaline-silica-free product if possible.

E. General Industrial Hygiene

1. The ventilation system in all parts of the plant should be maintained to prevent buildup of dust in ducts and other malfunctions in the system. A preventive maintenance program should be established to ensure effective maintenance.

2. Where respiratory protection is used to prevent exposures, all sections of the OSHA regulation of respirator usuage (CFR 1910.134) must be followed.

3. A periodic training and education program should be implemented to inform employees of health and safety hazards of chemicals used at the Witco plant. This program should include providing chemical names, toxicity information, proper use and handling procedures, and appropriate respiratory protection training.

4. Insulation which requires repair or removal should be analyzed for asbestos content. Where asbestos is found, proper removal procedures should be followed. During removal, access should be restricted, hazard warning information should be posted, and employees should be properly trained and protected.

F. Medical and Epidemiological

1. Because of the observed exposures to irritant chemicals in several departments and because of our findings of bronchitis and pulmonary function decrements, the workforce requires followup with pulmonary function testing. To better characterize the findings in this report, all workers should undergo annual spirometry, and the results compared with previous testing, to determine if there is unusual loss of pulmonary function over time. Quality control during testing should be stringent, to assure that small decrements are real and not artifactual.

2. Because of past and current use of carcinogens at this facility, Witco should henceforth retain work histories, by Department, on all employees, and obtain and retain death certificates on past and all future employee deaths. These should be kept in readily available files for future mortality studies. A proportionate mortality study (PMR) utilizing death certificates, comparing U.S. and New Jersey rates to overall Witco rates and rates within departments, should be performed.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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, 22161.

Copies of this report have been sent to:

1. Authorized representatives of OCAW, Local 8-337
2. Authorized representatives of OCAW, Health and Safety Department
3. Witco Chemical Corporation, Woodcliff Lake, N.J.
4. Chief, HETAB, NIOSH
5. Director, HETAB, NIOSH
6. Dr. Jacqueline Messite, Region II, NIOSH
7. OSHA, Region II

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

TABLE 1

AIR SAMPLING RESULTS, DECEMBER 9, 1983

DEPARTMENT	JOBS SAMPLED	CHEMICALS MONITORED	SAMPLING PERIOD, MINUTES	RESULTS, 8-hr. avg.	APPLICABLE STDS
Polyester	Upstairs Operator	Glycols*	473	<0.7 ppm	Ethylene glycol- 50 ppm (ACGIH TLV)
		Adipic Acid		0.55 mg/m3	None
Polyester	Outside Operator	Glycols*	444	<0.3 ppm	Ethylene glycol- 50 ppm (ACGIH TLV)
Polyester	Downstairs Operator	Glycols*	446	<0.3 ppm	Ethylene glycol- 50 ppm (ACGIH TLV)
Polyester	Reactor 6 Operator	Glycols*	457	<0.5 ppm	Ethylene glycol- 50 ppm (ACGIH TLV)
Polyester	Area Sample (Glycol line) Reactor 3	Adipic Acid	419	0.47 mg/m^3	None
Polyester	Area Sample (Glycol line) Reactor 4	Adipic Acid	419	0.79 mg/m^3	None
NIS	NIS Operator	Ethylene Oxide	460	7.10 ppm	1 ppm (OSHA PEL)
Low Temp Emcol	Emcol Operator	Ethylene Oxide	459	0.7 ppm	1 ppm (OSHA PEL)
Low Temp Emcol	Emcol Trainee	Ethylene Oxide	390	0.95 ppm	1 ppm (OSHA PEL)

*Glycols detected were ethylene, diethylene, and propylene glycols. There are no recommended exposure levels for diethylene or propylene glycol.

RESULTS - TABLE 2

DESCRIPTION OF WITCO WORKERS BY CURRENT JOB ASSIGNMENT

Department	N	Age	Total Years at Witco	Average Pack Years	Smokers		
					% Current	% Ex	% Never
Emcol	5	37.6	9.4	1.9	20	20	60
Polyester	12	39.8	9.2	12.1	33	42	25
Stearate	8	40.9	13.5	19.0	63	12	25
Maintenance	20	46.1	20.2	24.6	50	35	15
Management	7	43.0	12.5	20.2	14	82	14
Total	52	42.6	14.5	18.1	40	37	23

RESULTS - TABLE 3

MUCOSAL IRRITATION[1]

Current Department	Symptoms Present	Symptoms Absent	%	Symptom Score[2]
Emcol	5	0	100	2.2
Polyester	7	5	58	1.4
Stearate	4	4	50	1.6
Maintenance	11	9	55	1.4
Management	2	5	29	0.7
Total	29	23	56	1.4

Emcol vs. others

For Fisher exact test $p = 0.0456$
For Mann-Whitney test statistic $p = 0.001$

[1]Mucosal irritation is defined in Methods and Materials section

[2]Average number of symptoms per employee in each department

BRONCHITIS - TABLE 4

A. DESCRIPTION OF INDIVIDUALS WITH AND WITHOUT BRONCHITIS

	N	AGE	YRS EMPLOYED	% EVER SMOKE	AVERAGE PACK/YRS
Bronchitis	6	39.2	14.1	100	21.62
No Bronchitis	46	43.0	14.6	74	17.61
Total	52	42.6	14.5	77	18.1

B. BRONCHITIS IN STEARATE WORKERS

		Bronchitis	No Bronchitis	Total
Stearate Workers: (employed in stearate department for more than one year)	Current Smoker	3	7	10
	Ex Smoker	1	3	4
	Never Smoker	0	1	1
	Total	4	11	15
Other Workers:	Current Smoker	1	10	11
	Ex Smoker	1	14	15
	Never Smoker	0	11	11
	Total	2	35	37
Total		6	46	52

RR associated with working in Stearate Department for more than one year = 4.9

After adjustment for smoking (never, present, ex) there was no association.

Mantel Haenszel $X^2 = 1.186$ $p = 0.55$
RR = 4.4 confidence interval for relative risk = 0.305 - 63.61

Bronchitis defined in Methods and Materials section

RESULTS - TABLE 5

PCB LEVELS (ppb) AND EXPOSURE HISTORY

	Total Population			Employed Prior to 1973		
	N	Age	PCB	N	Age	PCB
Low exposure	32	39.4	6.47	14	47.4	7.25
High exposure	18	48.6	11.68*	18	48.6	11.68**
Total Population	50	42.6	8.34	32	48.0	9.74

*p = 0.014; T = -2.72 by Student's t-test

**p = 0.067; T = -1.90

PCB LEVELS AND EXPOSURE DURATION
REGRESSION RESULTS

Dependent Variable		B	p	r^2
PCB	Regression		0.0255	0.15550
	PCB Year***	0.3943	0.0255	
PCB	Regression		0.0414	0.19712
	PCB Year	0.32668	0.075	
	Age	0.21494	0.230	

***Years of exposure calculated as sum of months worked in Polyester or Maintenance during the period 1964 and 1972.

RESULTS - TABLE 6

ASSOCIATION OF BLOOD PRESSURE WITH PCB LEVELS

Dependent Variable		B	p	r^2
Diastolic Pressure	Regression		0.086	0.101
	Age	0.089	0.566	
	PCB	0.269	0.988	
	Regression		0.032	0.094
	PCB	0.307	0.032	
	Regression		0.128	0.046
	Age	0.216	0.128	
Systolic Pressure	Regression		0.024	0.150
	Age	0.171	0.260	
	PCB	0.282	0.066	
	Regression		0.012	0.126
	PCB	0.355	0.012	
	Regression		0.045	0.079
	Age	0.282	0.045	

RESULTS - TABLE 7

ASSOCIATION OF SERUM LIVER ENZYMES AND SERUM PCB LEVELS (CONTROLLING FOR ALCOHOL INGESTION)

Dependent		Residual df	B	P	r^2
Serum GGTP[1]	Regression	47		0.0271	0.09964
	PCB		0.31566	0.0271	
	Regression	37		0.0315	0.11904
	Drinks		0.34503	0.0412	
	Regression	36		0.0372	0.16715
	Drinks		0.32356	0.0412	
	PCB		0.22037	0.1580	
SGOT[2]	Regression	47		0.4563	0.01186
	PCB		-0.10892	0.4563	
SGPT[3]	Regression	46		0.0000	0.31099
	PCB		0.55767	0.0000	
	Regression	36		0.8707	0.00073
	Drinks		0.02694	0.8707	
	Regression	35		0.0005	0.355520
	PCB		0.60003	0.0001	
	Drinks		-0.12384	0.3722	
PCB	Regression	37		0.5646	0.00881
	Drinks		0.09385	0.5646	

[1] Serum gamma glutamyl transpeptidase
[2] Serum glutamic-oxaloacetic transaminase
[3] Serum glutamic-pyruvate transaminase

TABLE 7 (CONTINUED)

SERUM ENZYME LEVELS OF WITCO WORKERS

	GGTP	SGOT	SGPT
Average Level in Witco Population	25.0	30.2	31.9
Normal Values (U.S. Population)	1.0-70.0	1.0-70.0	1.0-70.0

COMPARISON OF AGE AND PCB LEVELS OF INDIVIDUALS GROUPED ACCORDING TO LOW AND MODERATE ENZYME LEVEL

Group	N	Age		PCB(ppb)	
GGTP ≤ 29	37	43.3	p = 0.278	7.54	p = 0.114
GGTP > 29	13	40.4		10.63	
SGPT ≤ 39	38	42.6	p = 0.973	6.77	p = 0.018
SGPT > 39	12	42.5		13.32	

RESULTS - TABLE 8

MEAN SPIROMETRY RESULTS BY CURRENT

JOB ASSIGNMENT

		FVC	FEV_1	FEV_1%	FEF 25-75
Emcol	5	98.2	103.0	81.8	95.0
Polyester	12	95.2	97.3	77.8	86.7
Stearate	8	97.2	92.0	72.1	70.5
Maintenance	20	92.7	94.3	75.7	80.0
Management	7	93.6	94.7	76.7	83.1
TOTAL	52	94.6	95.4	76.2	81.7

RESULTS - TABLE 9

COMPARISON OF SPIROMETRY RESULTS IN STEARATE WORKERS* VERSUS ALL OTHER WORKERS

	N	FVC (avg. % predic.)	FEV_1 (avg. % predic.)	FEV_1% (avg. ratio)	FEF 25-75 (avg. % predic.)
Stearate	15	90.7	88.9	73.9	72.0
Other	36	96.2	98.1	77.2	85.7
p value (t-test)		0.15	0.02	0.10	0.056
SMOKING ADJUSTED**					
Stearate		91.3	89.9	74.6	74.2
Other		95.9	97.7	76.9	84.8
p value (t-test)		0.23	0.05	0.23	0.13

*Definition - a worker who has ever worked for 1 year or more in Stearate.

**Using ancova with pack years as the covariate.

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