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 80-020-1054
CITIES SERVICES COMPANY
LAKE CHARLES, LOUISIANA

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

On November 9, 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Oil, Chemical, and Atomic Worker°s Union for a health hazard evaluation at the Cities Services Co. Lube Plant, Lake Charles, Louisiana. The request concerned exposures to chemicals in the Duo-Sol area, specifically phenol/cresol, and with possible relationships of these exposures to hematuria and bladder/kidney cancer. Other concerns were with past exposures to free silica (Clay Contact Unit) and to asbestos (used as insulating material). NIOSH conducted a preliminary survey on June 9-10, 1980; an environmental survey on November 10-14, 1980; and a medical survey on December 10-12, 1980.

Air samples were collected for B-naphthylamine, furfural, phenol, benzene, total hydrocarbons, total and respirable particulates, cresols, naphthalene, 1-methyl naphthalene, 2-methyl naphthalene, cyclohexane solubles, eight different polynuclear aromatic hydrocarbons (PNA's), nitrosamines, hydrogen sulfide, and mercaptans. Of the 267 analyses, 200 (75%) indicated non-detectable air concentrations. Air concentrations for 12 cresol samples were all non-detectable. Air concentrations for 24 phenol samples ranged from non-detectable to 6.5 mg/M^3, as compared to the survey criteria of 20 mg/M^3. Three of 19 samples for cyclohexane solubles exceeded the survey criteria of 0.1 mg/M^3 (PNA analyses on these 19 samples were mostly non-detectable). A bulk sample of the diatomaceous earth showed 44% cristobalite (free silica) and a bulk sample of insulation showed 5-10% chrysotile asbestos.

Health effects of phenol and cresol were sought by questionnaire and urine tests for blood, phenol level, and mutagenicity among exposed (operators and maintenance workers) and unexposed (clerical) workers. The exposed workers were more likely to have had ringing in the ears, eye irritation, and muscle twitching and had higher urine phenol levels (median 7.3 mg/g creatinine, unexposed: 3.6). Duo-Sol operators had higher urine phenol levels (median 12.0) than maintenance workers serving the Duo-Sol Unit (median 3.7). All three workers with hematuria had high urine phenol levels, including the highest (149.5) and third highest (21.9) in this study. Chest films showed signs of asbestosis in 10 of 18 workers.

The air sample results of the NIOSH surveys did not indicate hazardous exposures during normal plant operations. The medical findings suggest exposures to phenol/cresol, probably through skin contact, among Duo-Sol operators and maintenance workers which might account for some symptoms and hematuria. A relationship between cresol/phenol exposure and consequent bladder or kidney cancer could not be established. The chest films indicate hazardous exposures to asbestos...likely from past years. Recommendations for improved environmental controls and strengthening the medical surveillance programs are included in this report.

KEYWORDS: SIC 2911 (Petroleum Refining), asbestos, cristobalite, furfural, cresol, phenol, total particulates, respirable particulates, benzene, cyclohexane solubles, polynuclear aromatic hydrocarbons, hematuria, urine phenol, skin burns, asbestosis.

II. INTRODUCTION

On November 9, 1979, NIOSH received a request from tne Oil, Chemical, and Atomic Worker's International Union (OCAW) and its Local 4-500 for a health hazard evaluation at the Cities Service Company Lube Plant in Lake Charles, Louisiana. The request cited employee exposures to various chemicals such as phenol, cresol and aromatic hydrocarbons in the "Duo-Sol" area and expressed concern over possible relationships of these exposures to hematuria and bladder/kidney cancer. Further matters of concern were past exposures to silica at the Clay Contact Unit and to asbestos wnich has been used as an insulating/construction material.

In response to this request, NIOSH conducted a preliminary survey during June 9-10, 1980; an environmental survey during November 10-14, 1980; and a medical survey during December 10-12, 1980.

III. BACKGROUND

The production portion of the refinery is located on 38 acres with most of the equipment exposed to the environment, as is common of many chemical plants in warmer climates. The process operations are typical for a refinery which produces lubricating oils and waxes and include the following unit operations.

Reduced Crude from Refinery -- Vacuum Distillation Units -- Light Oils & Heavy Oils

Light Oils -- Furfural Treating Unit -- MEK-I Dewaxing Unit - Wax & Light Oils

Wax -- Wax Finishing Unit - Wax Slabbing Unit -- Finished Wax Products

Light Oils -- Clay Contact Unit #2 -- Finished Light Oils

Heavy Oils -- Duo-Sol Treating Unit -- MEK-II Dewaxing Unit -- Wax & Heavy Oils

Wax -- Wax Finishing Unit - Wax Slabbing Unit -- Finished Wax Products

Heavy Oils -- Clay Contact Unit #1 -- Finished Heavy Oils

The units operate at various temperatures and consist of towers, tanks, filters, heaters, and recovery systems which are typical of refineries of this type. Several hundred tons of wax and several thousand barrels of lube oils are produced on a daily basis. Additional operations are testing and research laboratories, product loading, and decontamination vats. There are several hundred acres of land available for storage tanks and plant expansion.

There are about 500 employees of whom about 408 (208 operators, 158 craftsmen, 42 supervisors) are considered production workers. The plant operates 3 shifts per day, 7 days per week, with most of the craftsmen working during the day shift. Although the operators conduct sampling, testing, and monitoring programs within the production units, they spend much of the shift in unit control rooms during normal operations. There are a number of different craftsmen such as insulators, electricians, welders, machinists, and pipe fitters. Any of the employees are potentially exposed to various chemicals (e.g., cresol, phenol, furfural) when working in the production areas.

During the preliminary survey of June 9-10, 1980, company health policies, medical facilities, and medical records were reviewed. Additionally, nondirected interviews were conducted with several employees at the union hall. These employees expressed concern over the following issues:

1. Lung cancer and laryngeal cancer among maintenance personnel with known asbestos exposure (insulators, carpenters, riggers, painters). These employees are under asbestos surveillance, consisting of an annual pulmonary function test and chest X-ray; the chest films are not, however, interpreted by a "B-reader" according to the ILO/UC pneumoconiosis classification.[1]

2. Cancer of large bowel/colon among workers at the Furfural Unit. There was, however, no specific evidence of a cancer cluster.

3. Exposure to clay/silica at the Clay Contact Unit. The company provides operators with annual pulmonary function tests and respirators.

4. Largely unexplained hematuria and a case of transitional cell cancer of the renal pelvis among Duo-Sol operators. An association with exposure to cresol/phenol, and polynuclear aromatic hydrocarbons was suspected.

IV. EVALUATION METHODS

A. Environmental

On June 9-10, 1980, a preliminary survey was conducted at the plant to familiarize the NIOSH industrial hygienist with plant processes, potential exposures, number of exposed persons, etc. During this survey a number of bulk samples of process materials were collected for laboratory analysis.

During November 10-14, 1980, an environmental survey was conducted. Based upon the bulk sample analyses and the findings of NIOSH studies in other petroleum refineries, it was judged appropriate to conduct air sampling for B-naphthylamine, furfural, phenol, benzene, total hydrocarbons, total and respirable particulates, cresols, naphthalene, 1-methyl naphthalene, 2-methyl naphthalene, cyclohexane solubles, polynuclear aromatic hydrocarbons (PNA's), nitrosamines, hydrogen sulfide, and mercaptans. Since one of the workers' major concerns was exposures in the Duo-Sol area, a major part of the air sampling was conducted there. Also, bulk samples of insulation to be analyzed for asbestos and diatomaceous earth (used in clay contact area) to be analyzed for free silica analysis were collected during the environmental survey. On December 10-11, 1980. (during the medical study) several additional air samples were collected for phenol analysis.

The air sampling and analytical methodologies for the different contaminants are shown in Table I. Included in Table I are, for each substance evaluated, the collection device, the pump flow rate, the range of sample durations, the analysis method, the analytical detection limit, and where applicable, the reference for the detailed sampling and analytical method. Personal air samples are those for which the worker wears the air sampler with the collection device pinned to his/her shirt lapel or collar so as to obtain air samples representative of what he/she is breathing. The fixed location (area) samples are obtained by placing the sampling apparatus either in general work areas or in positions thought to have air quality similar to that to which the workers are exposed.

B. Medical

To evaluate asbestos exposures among maintenance workers and health effects among Duo-Sol operators, the medical study of December 10-12, 1980, consisted of the following:

1. The chest X-rays (first and last available) of the 18 employees at the plant under asbestos surveillance were interpreted by a B-reader according to the ILO/UC pneumoconiosis classification.[1]

2. Health effects at the Duo-Sol Unit were evaluated by questionnaire and blood and urine tests

The questionnaires sought demographic data, occupational history, medical history, and information on smoking, alcohol consumption, and medication. They were to be administered to all 21 Duo-Sol operators, and to clerical workers matched for age (within 5 years), race, and smoking habits. All Duo-Sol operators and the clerical controls were to have their urine tested for blood and phenol level.[2] The 14 Duo-Sol operators with the highest seniority (6-31 years) and their clerical matches were to have their urine tested for mutagenicity.[3] All urine samples were to be collected after the work shift.

Since heavy labor may cause hematuria, a second set of matched controls with an amount of physical labor comparable to the Duo-Sol operators was requested by the company. Therefore, 21 maintenance workers were selected to answer the same questionnaire and to provide a urine sample to be tested for blood and phenol level.

Because of inadequate employee participation, the medical study was not as complete as planned (See Results section).

V. EVALUATION CRITERIA

A. Environmental

The environmental evaluation criteria used for this study are presented in Table II. Listed in Table II, for each substance, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current OSHA legal standard. Several substances listed on Table II do not have legal (OSHA) standards. The NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH) recommendations are often more stringent than the legal standards because they incorporate newer information and are mainly based on health considerations and technical feasibility.

B. Toxicology

Since asbestos, phenol, and cresol were of major concern in this investigation, a detailed discussion of their toxicology follows:

1. Asbestos

Asbestos is a generic term applied to a number of hydrated mineral silicates. These silicates are of various size, color and texture. In the past they were commonly used for thermal and electrical insulation. Exposure, therefore, among insulation workers and maintenance personnel was (and still is) common. Asbestos has been shown to cause chronic conditions such as asbestosis, cancer of the lungs and digestive tract, and mesotheliomas.[4-7] Cigarette smoking is strongly implicated as a co-carcinogen among asbestos workers,[8] and cigarette-smoking asbestos workers have approximately eight times the risk of developing lung cancer compared with other smokers.

Asbestosis is a chronic lung disorder characterized by a diffuse interstitial fibrosis, at times including pleural changes of fibrosis ("pleural thickening" on chest X-ray) and calcification ("pleural plaques"). The onset probably depends upon the asbestos dust concentration, the fiber morphology, and the length of exposure. Asbestosis is a progressive disease which may develop fully in seven to nine years and may cause death as early as 13 years after first exposure. Usually the pneumoconiosis becomes evident 20 to 40 years after the exposures have began.[6]

Signs and symptoms of asbestosis include rales, dyspnea, cyanosis, dry cough and finger clubbing. The characteristic X-ray changes of asbestosis are small, irregular opacities in the lower and middle lung fields, often accompanied by pleural thickening and pleural calcifications. Restrictive changes on pulmonary function tests are typical. In some cases, minor fibrosis with considerable respiratory impairment and disability can be present without equivalent X-ray changes; conversely, extensive radiographic findings may be present with little functional impairment.[7]

Medical surveillance should consist of preplacement and annual physical examinations with emphasis on the pulmonary and gastrointestinal systems, chest X-rays, and pulmonary function tests. To protect against asbestosis and reduce the development of neoplasms to a low risk, the OSHA standard for occupational exposure was set at 2 fibers greater than 5 micrometers in length per cubic centimeter of air (fibers/cc). NIOSH recommends an exposure limit of 0.1 fibers/cc for an 8-nour time-weighted average daily exposure.

2. Cresol

Cresol occurs in three isomers, all of which cause central nervous system disorders, gastroenteric disturbances, dermatitis, and damage to liver, kidneys, or lungs.

Exposure occurs through skin contact, ingestion and inhalation. Because the cresol isomers have low vapor pressures, inhalation of appreciable amounts of their vapors under normal condition is unlikely. However, at high process temperatures, vapors can be produced and may lead to adverse effects upon inhalation. In addition, inhalation of particulate cresol as an aerosol is possible.[9]

Toxic manifestations which may develop within 20 to 30 minutes after absorption include eye irritation, conjunctivitis, headache, dizziness, dimness of vision, tinnitus (ringing in the ears), irregular and rapid respiration, weak pulse, dyspnea (shortness of breath), and profound muscular weakness, occasionally followed by mental confusion.[9]

Repeated or prolonged exposure may cause gastrointestinal disturbances (vomiting, loss of appetite), nervous disorders, headache, dizziness, and dermatitis. Death may occur in cases with extensive liver or kidney damage (hemorrhagic nephritis and pulmonary edema have been observed).[9]

Cresols have a marked corrosive action on tissue. On the skin, prickling and intense burning occur after a few minutes, followed by local anesthesia; affected tissues initially show white discoloration, wrinkling, and softening, which subsequently may become gangrenous. Fatalities may occur from prolonged or extensive skin contact. Sensitization may occur.

To date there are no reports of mutagenic or reproductive effects from cresol. It has been suggested that cresol may promote the production of benign tumors.[10]

The odor of cresol is recognized at concentrations as low as 5 ppm. The TLV was set at 5 ppm to prevent irritation. Medical surveillance should include preplacement and annual examinations with emphasis on the liver, kidney, respiratory systems, and skin.

3. Phenol

Phenol is an irritant of the eyes, mucous membranes, and skin. Systemic absorption causes convulsions, as well as liver and kidney damage. Routes of exposure are skin absorption, ingestion, and inhalation. The skin may be the main route of entry.

Skin absorption can occur at low vapor concentrations, apparently without discomfort. Signs and symptoms can develop rapidly with serious consequence, including shock, tremor, muscle twitching, convulsions, cyanosis, coma, and death. Phenol vapors cause marked irritation of eyes, nose, and throat. Solutions of phenol have a marked corrosive action on tissue, similar to cresol.[11]

Phenol has been shown to be a weak skin carcinogen in mice.[10,12,14] Conditions of these experiments, however, do not reflect industrial experiences with phenol. Results of these studies suggest that phenol functions primarily as a nonspecific irritant and may be capable of promoting tumors. To date, there is no evidence that phenol acts as a specific carcinogen or mutagen at low concentrations within normal physiologic limits.[11]

VI. RESULTS

A. Environmental

Tables III, IV, V, and VI summarize the air sampling results for nitrosamines, naphthalene, 1-methyl naphthalene, 2-methyl naphthalene, o-cresol, m-cresol, p-cresol, and B-naphthylamine. The five samples for nitrosamines, 23 samples for naphthalenes, 13 samples for cresols, and six samples for B-naphthylamine all indicated air concentrations which were non-detectable at the laboratory's lower limit of quantitation.

Table VII summarizes the results of air sampling for furfural. Concentrations of furfural for the six samples ranged from 1.2 to 2.6 mg/M^3 (mean of 1.9 mg/M^3) as compared with the survey criterion of 8.0 mg/M^3 for an 8 to 10-hour average daily allowable exposure.

Table VIII summarizes the results of air sampling for phenol. Concentrations of phenol for the 24 samples ranged from "none detected" to 6.5 mg/M^3 (mean of 0.5 mg/M^3). The survey criterion is 20 mg/M^3 for an 8 to 10-hour average daily allowable exposure.

Table IX summarizes the results of air sampling for total particulates and respirable particulates. The 11 air samples for total particulates had concentrations which ranged from "none detected" to 0.2 mg/M^3 (mean of 0.1 mg/M^3). The survey criterion is 10 mg/M^3 for an 8-hour average daily allowable exposure. The five air samples for respirable particulates ranged from "none detected" to 0.2 mg/M^3 (mean of 0.1 mg/M^3) as compared to the survey criterion of 5.0 mg/M^3 for an 8-hour average daily allowable exposure.

Table X summarizes the results of air sampling for benzene and total hydrocarbons. The 18 air samples for benzene ranged from "none-detected" to 0.05 mg/M^3 (mean of 0.02 mg/M^3) as compared to the survey criterion of 3.2 mg/M^3 for a 60-minute ceiling allowable exposure. The 18 air samples for total hydrocarbons ranged from "none detected" to 20 mg/M^3 (mean of 2.1 mg/M^3). Although there is not a recommended or legal standard for total

hydrocarbons per se, the NIOSH recommended standard for occupational exposure to such refined petroleum solvents as petroleum ether, rubber solvent, mineral spirits, and stoddard solvents is 350 mg/M^3 determined as a time-weighted average concentration for up to a 10-hour work shift, 40-hour work week. This comparison is not intended to imply the hydrocarbon measurements reflect refined petroleum solvent vapors solely, but is intended to serve as sort of a "yard-stick".

Table XI presents the results of air sampling for cyclohexane solubles (air contaminents soluble in cyclohexane) and specific polynuclear aromatic hydrocarbons. The 19 air samples for cyclohexane solubles ranged from "none detected" to 0.26 mg/M^3 (mean of 0.04 mg/M^3) as compared to the survey criterion of 0.10 mg/M^3 (three samples exceeded the survey criterion). The 19 analyses for phenathrene ranged from "none-detected" to 0.70 ug/M^3, with a mean of 0.16 ug/M^3. Benzo(a)pyrene, benzo(e)pyrene, pyrene, fluoranthene, chrysene, benzo(a)anthracene, and anthracene were not detected on any of the 19 samples except that one sample had trace quantities of benzo(a)pyrene, benzo(e)pyrene, and benzo(a)anthracene

On November 11, 1980, two indicator tube air samples each for hydrogen sulfide and mercaptans were collected by the sump (Duo-Sol). These air samples indicated non-detectable air concentrations.

The bulk samples of insulation contained chyrsotile asbestos. The diameters of the fibers were less than 1.0 micrometer (um) and the lengths varied from about 1.0 to 80 um. The fibers comprised approximately 5 to 10% of the total sample volume.

The bulk sample analysis of the diatomaceous earth used for the filters in the clay contact units indicated a cristobalite concentration of 44.1 $\pm$ 2.6%, and a quartz concentration of less than 1%. These analyses were for the portion of the sample that passed through a 10 um pore size sieve. A material safety data sheet from the manufacturer indicated that the flux-calcined diatomaceous earth contains approximately 2% quartz, 65% cristobalite, 18% amorphous silica and 15% inert material.

B. Medical

1. Asbestos Surveillance

The 18 maintenance workers under asbestos surveillance ranged in age from 33 to 66 years (mean 54) and had worked at the company from 1 to 35 years (mean 27). Eight had small, irregular (6 persons) or rounded (2 persons) opacities (Table XII). In two workers the profusion was 1/0; in the others it was 0/1. The lower lung zones were involved in all eight cases, the middle zones in five, and the upper zones in one. Two additional workers had pleural plaques. Thus, 10 of the 18 workers had findings suggestive of asbestos exposure.

2. Cresol/phenol Exposures at Duo-Sol Unit

Twenty of 21 Duo-Sol operators answered the questionnaire, and 18 submitted urine samples for testing. Of the 14 operators with higher seniority, one did not participate, another did not provide a urine sample, and four did not provide a sufficient amount of urine for all tests to be performed. Of twenty-one clerical workers selected to participate, five refused, and only 13 provided urine, in some cases an insufficient amount for all three tests. Six of the 14 clerical workers who were supposed to serve as controls for the Duo-Sol operators with high seniority did not provide urine. Altogether, 10 urines were checked for hematuria (three were excluded because of menstrual bleeding), 12 urine phenol levels were determined, and eight urines were screened for the presence of mutagenic substances.

Because 15 of the 21 maintenance workers were found to spend considerable time at the Duo-Sol unit (and are thus potentially exposed to cresol/phenol), and because participation among both Duo-Sol operators and clerical workers was incomplete, the matched-pair analyses originally planned could not be performed. Therefore, the participants were re-grouped as follows for the questionnaire analysis:

1. An exposed group consisting of 20 Duo-Sol operators and 15 maintenance workers who work in the Duo-Sol area, and

2. Sixteen presumably unexposed clerical workers.

For the epidemiologic analysis of the urine tests, four maintenance workers without cresol/phenol exposure were also included.

Age distribution and racial composition of the two groups were similar, but the exposed workers tended to have more seniority (Table XIII). The exposed workers were mostly men, the unexposed mostly women. Both groups had comparable proportions of current and former smokers. The two groups reported nearly identical rates of occasional alcohol intake, but the unexposed workers tended to drink less frequently: only one of the 16 drank three or more times a week, compared to 12 of the 35 exposed workers ($x^2 = 4.54$, $0.05 > p > 0.02$). Not surprisingly, workers exposed to cresol/phenol reported more past and present occupational exposure to various other toxic substances than did the unexposed clerical workers.

All exposed workers reported inhalation exposure to cresol/phenol. Most operators (80%) said they smelled cresol/phenol frequently, while most exposed maintenance workers (80%) smelled it only occasionally. Most maintenance workers (64%) reported inhalation exposure only during specific operations, while most operators (80%) felt exposed all of the time. Statements as to whether these exposures were confined to certain areas were about as often confirmed as denied among both operators and maintenance workers. About 50% of both groups felt their present and past exposures were similar, whereas the other half felt their exposure had changed, some stating an increase, some a decrease.

Skin burns on at least one occasion were reported by 90% of the operators and by 87% of the maintenance workers. One maintenance worker and six operators had received one or more burns during the past month. Half of the operators and none of the maintenance workers reported symptoms other than skin effects after being burned by cresol/phenol; these effects were described as dizziness (1 person), nausea (2), stomach upset (1), breathing difficulties (3) and throat irritation (1).

Although most workers eat in their work areas, exposure to cresol/phenol by ingestion appears to be unlikely. They eat meals in certain confined areas (control room, etc.), and smoking on the job is not permitted.

Most symptoms that would be expected from overexposure to cresol or phenol were reported at higher frequencies by exposed employees, but only three of these differences were significant at the 0.1 level: ringing ears, eye irritation, and muscle twitching (Table XIV). A variety of medical conditions, including those that might suggest overexposure to phenol or cresol (lung, liver, or kidney disease, dermatitis) were reported at rates not significantly different from the unexposed group (Table XV).

The company monitors urine phenol levels and provides routine urine tests to Duo-Sol operators and maintenance personnel serving the unit, if so requested by the employee. These data are available as far back as 1975 but became more regular in 1976. We reviewed the Duo-Sol operator results and checked the maintenance personnel results in a random manner. Twenty of 21 operators have been screened at least once. The recorded phenol levels ranged from 39 to 948 mg/gm creatinine. Four of the 20 operators showed occasional hematuria (dipstick method). Although maintenance personnel appeared to have acute exposures to higher levels of solvents (as detected by urine phenol levels) hematuria apparently was not seen.

Except for a Duo-Sol operator with a urine level of 149.5, NIOSH urine phenol results ranged from not detectable to 22.3 mg/g creatinine. Workers exposed to cresol/phenol had higher urine phenol levels than non-exposed workers (Table XVI). This difference was due to the generally higher levels among operators; exposed maintenance workers' levels did not differ significantly from those of non-exposed workers.

In the NIOSH testing, two of the operators and one of the 14 maintenance workers serving the Duo-Sol unit, but none of the clerical workers and none of the other four participating maintenance workers, had hematuria. The two workers with a "small" amount of hematuria were an operator with a urine phenol level of 8.0 mg/g creatinine and a cresol/phenol exposed maintenance worker with a level of 21.9, the third highest of all study participants. The worker with the qualitatively greatest amount of hematuria (a "moderate" amount) was the operator with the urine phenol level of 149.5.

None of the Duo-Sol operators displayed mutagenic activity in their urines. Two urine samples from the clerical workers showed mutagenic activity (only after S-9 activation) in one of the two Salmonella tester strains (TA 98) used; both of these employees are smokers.

VII. DISCUSSION/CONCLUSIONS

A. Environmental

The air sample results indicated generally low concentrations of contaminants during what were judged to be normal operations. Of 267 analyses, 200 (75%) indicated non-detectable (at the laboratory's lower limit of quantitation) air concentrations. For just two personal air samples did the air sample analysis show a value in excess of the survey criteria (however, both of these samples were below the OSHA standard). These two samples were for cyclohexane solubles, but it must be recognized that the cyclohexane solubles recommended criteria is intended to reflect exposures to polynuclear aromatic hydrocarbons. Since the polynuclear aromatic hydrocarbon air concentrations were so very low, it is judged that the two samples for cyclohexane solubles are of little significance. In an industrial area such as Lake Charles, "cyclohexane solubles" may originate from sources other than the Cit-Con plant. Also, the "cyclohexane solubles" concept of air sampling and analysis will reflect anything soluble in cyclohexane, not just polynuclear aromatic hydrocarbons.

The analyses of insulation (5 to 10% chrysotile) showed that at least some of the insulation found at the plant presents a potential health threat. It is concluded that protective measures (OSHA standard) are warranted.

The analyses of the diatomaceous earth indicated a high concentration of cristobalite (44%) as did the supplier's material safety data sheet (65%). Although the bag dumping process at the clay contact filters was not sampled during the survey (NIOSH was not informed that this procedure would occur), the product's composition makes it potentially hazardous. It is concluded that protective measures (including improvement of current respirator program) are appropriate.

It was noted in discussions with employees and through other observations that the company did not have a formalized program for educating the employees as to the chemicals used, hazards thereof, good work practices, etc. It is concluded that establishment of an educational program is warranted.

B. Medical

Maintenance workers at this plant were exposed to asbestos in the past and probably continue to have occasional exposure. Eighteen of them are currently employed at the plant; most of them are in their fifties and have been with the company some 30 years. All are covered by the company's asbestos surveillance program and thus receive an annual pulmonary function test and a chest X-ray. Chest films showed signs of asbestosis in 10 of 18 workers (including two individuals who displayed only pleural thickening).

Because of concern among operators at the Duo-Sol unit over previous cases of recurrent unexplained hematuria, one of which was due to transitional cancer of the renal pelvis, and because all these cases occurred in workers exposed to cresol/phenol, NIOSH attempted a study looking at several urinary indicators of exposures (hematuria; total urinary phenol, corrected for creatinine; presence of mutagenic substances). The study was to be controlled by matching exposed workers with otherwise comparable unexposed workers. This approach, however, had to be abandoned, since participation was incomplete and amounts of urine donated were inadequate in several cases. Most maintenance personnel were found to have occasional exposure to cresol/phenol and were thus not usable as unexposed controls. Data were therefore analyzed comparing the two groups with different levels of exposure to cresol/phenol (Duo-Sol operators and maintenance workers) with unexposed, clerical controls. These groups differed, however, with respect to sex ratio, seniority, and other occupational exposures.

Most workers exposed to cresol/phenol reported previous skin burns, and exposed workers were more likely to have certain symptoms consistent with exposure to cresol or phenol. Hematuria occurred only among exposed workers, two operators and one maintenace worker. All three had elevated urinary phenol levels, one very high.

Mean urinary phenol levels were highest among operators, lower among exposed maintenance workers, and lowest among unexposed workers. None of the exposed workers had urine that showed mutagenic activity.

In summary, these findings suggest that exposure to cresol/phenol apparently occurs in large part through skin contact, among Duo-Sol operators and maintenance workers and might account for some symptoms and hematuria. A relationship between cresol/phenol exposure and consequent bladder or kidney cancer cannot be established by this study.

VIII. RECOMMENDATIONS

A. Because of the potential asbestos exposures, the OSHA asbestos standard should be closely followed. Additionally, since asbestos is a carcinogen, any exposures should be minimized to the degree feasible. The medical surveillance program should be continued, but chest X-rays should be read by a specially trained radiologist or pulmonary physician (B reader).

Anyone with medical findings suggestive of asbestosis should be referred for a more complete medical evaluation, preferably by a pulmonary specialist. Anyone with asbestosis should not be further exposed to asbestos.

B. Because of the high silica content of the diatomaceous earth, engineering controls should be used at the Clay Contact Unit to reduce any dust exposures. Operators who are potentially exposed to crystalline silica should be offered periodic chest X-rays in addition to pulmonary function tests.[15] These X-rays should also be read by an appropriately trained radiologist or pulmonary physician (B reader).

C. Exposures to phenol/cresol should be controlled by engineering methods, personal protective equipment, and good work practices. Exposed workers should continue to have regular, rather than occasional (spill-related) urine tests for hematuria. These tests should be performed on a monthly basis if feasible, along with the annual blood testing for indicators of liver and kidney disease. Whenever repeated test results are positive in a person, efforts should be made to determine the cause.

D. The protective clothing, respirator, and worker education programs need to be frequently scrutinized and upgraded when appropriate. These disciplines will be of particular value for reducing acute exposures resulting from spills, maintenance, etc. The worker education programs should include discussions of the various process chemicals, hazards and toxic effects of these chemicals, and good work practices for reducing exposures.

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Criteria Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available from the National Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH at the Cincinnati address.

Copies of this report have been sent to:

1. Cit-Con Oil Corporation
2. Oil, Chemical, and Atomic Workers International Union
3. Oil, Chemical, and Atomic Workers Local 4-500
4. Louisiana Department of Labor
5. Louisiana Health & Human Resources Administration
6. OSHA, Region VI, Dallas, Texas
7. NIOSH, Region VI, Dallas, Texas
8. NIOSH, Region VII, Kansas City, Missouri

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

XI. REFERENCES

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10. Boutwell RK, Bosch DK: The tumor-promoting action of phenol and related compounds for mouse skin. Cancer Res. 19:413-24, 1959.

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TABLE I
AIR SAMPLING AND ANALYSIS METHODOLOGY

Substance	Collection Device	Flow Rate (lpm)	Duration (Hours)	Analysis	Detection Limit (ug/sample)	NIOSH Reference
B-naphthylamine	Glass Fiber Filter Silica Gel Tube	1.0	6-7	Gas Chromatograph	1.0	P&CAM 264
Furfural	Impinger-Girard's Soln	1.0	3-4	High Press. Liquid Chromatograph	7.0	S-17
Phenol	Impinger-NaOH Soln	1.0	5-8	Gas Chromatograph	10	S-330
Benzene	Charcoal Tube	0.1	5-8	Gas Chromatograph	2	P&CAM 127
Total Hydrocarbons	Charcoal Tube	0.1	5-8	Gas Chromatograph	200	P&CAM 127
Total Dust	M-5 Filter	1.7	3-7	Electrobalance	10	---
Respirable Dust	M-5 Filter, cyclone	1.7	3-7	Electrobalance	10	---
o-Cresol	Silica Gel Tube	0.1	5-8	Gas Chromatograph	10	S-167
m-Cresol	Silica Gel Tube	0.1	5-8	Gas Chromatograph	20	S-167
p-Cresol	Silica Gel Tube	0.1	5-8	Gas Chromatograph	20	S-167
Naphthalene	Charcoal Tube	0.2	5-8	Gas Chromatograph	10	P&CAM 127
1-methyl naphthalene	Charcoal Tube	0.2	5-8	Gas Chromatograph	10	P&CAM 127
2-methyl naphthalene	Charcoal Tube	0.2	5-8	Gas Chromatograph	10	P&CAM 127
Cyclohexane Solubles	Glass Fiber Filter Ag. Memb. Filter Porus Polymer Tube	1.5	5-8	Cyclohexane Extraction	20	P&CAM 217
Polynuclear Aromatics	Glass Fiber Filter Ag. Memb. Filter Porus Polymer Tube	1.5	5-8	HPLC-UV Detector	0.03-0.13	P&CAM 217
Nitrosamines	Thermosorb Cartridges	1.5	5-7	Gas Chromatography Thermal Energy Anal.	$\leq$0.015	Not Published

TABLE II
ENVIRONMENTAL EVALUATION CRITERIA

Substance	Recommended Environmental Limit	Source	Primary Health Effects	OSHA Standard
Benzene is a human carcinogen--exposures should be minimized		NIOSH	Blood changes including leukemia	10 ppm
Cresols	10 mg/M^3	NIOSH	Skin, liver, kidney and pancreas effects	22 mg/M^3
Furfural	8 mg/M^3	ACGIH*	Irritation of eyes and respiratory passages	20 mg/M^3
Benzene(Cyclohexane) solubles	0.1 mg/M^3	NIOSH	Lung and skin cancer	0.2 mg/M^3
Naphthalene	50 mg/M^3	ACGIH	Eye irritation	50 mg/M^3
1-methyl naphthalene - U.S. standard does not exist				
2-methyl naphthalene - U.S. standard does not exist				
B-naphthylamine	No exposures are permitted	ACGIH NIOSH	Carcinogen	Minimize exposure
Nitrosamines are potent animal carcinogens--exposures should be minimized				
Phenol	20 mg/M^3	NIOSH	Skin, eye, CNS, liver, kidney effects	20 mg/M^3
Polynuclear Aromatics - Certain PNA's are carcinogenic--exposures should be minimized				
Total Particulates	10 mg/M^3	ACGIH	Pulmonary effects	15.0 mg/M^3
Respirable Particulates	5 mg/M^3	ACGIH	Pulmonary effects	5.0 mg/M^3

All air concentrations are time weighted average (TWA) exposures for a normal (8 to 10 hours) work day of a 40 hour work week unless otherwise designated.

*American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLV's) for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981.

TABLE III
RESULTS OF AIR SAMPLING FOR NITROSAMINES

DATE	TIME	LOCATION	NITROSAMINES*
11/10/80	0939-1435	Clay contact - clay bins	N.D.*
11/11/80	0934-1427	Clay contact - second level between charge	N.D.
11/11/80	0939-1529	Duo-Sol - extraction area	N.D.
11/12/80	0902-1523	Duo-Sol - Selecto G-15 pumps area	N.D.
11/13/80	0753-1448	Duo-Sol - control room	N.D.

Survey Criteria--any exposures should be minimized

*NOTES: 1. N-nitrosamines analyzed for were N-nitrosodimethylamine, N-nitrosodiethylamine, N-nitrosodi-i-propylamine, N-nitrosodi-n-propylamine, N-nitrosodibutylamine, N-nitrosopyrrolidine, and N-nitrosomorpholine.

2. N.D. means none detected at laboratory lower limit of quantitation.

TABLE IV
RESULTS OF AIR SAMPLING FOR NAPHTHALENE, 1-METHYLNAPHTHALENE, AND 2-METHYLNAPHTHALENE

DATE	TIME	JOB DESCRIPTION OR LOCATION	1-METHYL-NAPHTHALENE	2-METHYL-NAPHTHALENE	NAPHTHALENE
11/10/80	0950-1440	Clay Contact, second level	N.D.	N.D.	N.D.
11/10/80	0727-1440	Clay Contact, outside operator	N.D.	N.D.	N.D.
11/10/80	0803-1527	Duo-Sol, pipefitter	N.D.	N.D.	N.D.
11/10/80	0735-1435	Duo-Sol, pride operator	N.D.	N.D.	N.D.
11/10/80	0940-1502	Duo-Sol, sump area	N.D.	N.D.	N.D.
11/11/80	0935-1529	Duo-Sol, extraction area	N.D.	N.D.	N.D.
11/11/80	0931-1531	Duo-Sol, sump area	N.D.	N.D.	N.D.
11/11/80	0720- ?	Duo-Sol, gopher operator	N.D.	N.D.	N.D.
11/11/80	0832-1522	Duo-Sol, utility man	N.D.	N.D.	N.D.
11/11/80	0928-1437	Clay Contact, by clay bins	N.D.	N.D.	N.D.
11/12/80	0915-1535	Clay Contact, control room	N.D.	N.D.	N.D.
11/12/80	0717-1419	Clay Contact, board operator	N.D.	N.D.	N.D.
11/12/80	0726-1427	Duo-Sol, outside operator	N.D.	N.D.	N.D.
11/12/80	0754-1530	Duo-Sol, machinist	N.D.	N.D.	N.D.
11/12/80	0902-1523	Duo-Sol, Selecto G-15 area	N.D.	N.D.	N.D.
11/12/80	0905-1529	Duo-Sol, GB-12 pumps	N.D.	N.D.	N.D.
11/13/80	0753-1448	Duo-Sol, control room	N.D.	N.D.	N.D.
11/13/80	0759-1449	Duo-Sol, G-17 pump area	N.D.	N.D.	N.D.
11/14/80	0735-1406	Duo-Sol, chief operator	N.D.	N.D.	N.D.
11/14/80	0830-1411	Duo-Sol, utility operator	N.D.	N.D.	N.D.
11/14/80	0840-1412	Duo-Sol, machinist	N.D.	N.D.	N.D.
11/14/80	0745-1419	Furfural, board operator	N.D.	N.D.	N.D.
11/14/80	0755-1429	Furfural, G-8 pumps	N.D.	N.D.	N.D.
Survey Criteria (8 hour average daily exposure)					50.0 mg/M^3

N.D. means none detected at laboratory lower limit of quantitation.

TABLE V
RESULTS OF AIR SAMPLING FOR ORTHO, META AND PARA CRESOLS

DATE	TIME	JOB DESCRIPTION OR LOCATION	O, M, P-CRESOLS
11/10/80	0751-1506	Duo-Sol, maintenance man	N.D.
11/10/80	0720-1438	Duo-Sol, chief operator	N.D.
11/10/80	0950-1505	Duo-Sol, extraction area	N.D.
11/10/80	0950-1505	Duo-Sol, extraction sump area	N.D.
11/11/80	0931-1531	Duo-Sol, sump area	N.D.
11/11/80	0722-1425	Duo-Sol, N-tower operator	N.D.
11/11/80	0724-?	Duo-Sol, pride operator	N.D.
11/11/80	0752-1525	Duo-Sol, pipe fitter	N.D.
11/12/80	0724-1429	Duo-Sol, gopher operator	N.D.
11/12/80	0750-1517	Duo-Sol, utility operator	N.D.
11/13/80	0753-1448	Duo-Sol, control room	N.D.
11/13/80	0759-1449	Duo-Sol, control room	Lost
11/14/80	0734-1402	Duo-Sol, outside operator	N.D.

Survey Criteria (8 to 10 hour average daily exposure) 10.0 mg/m^3

*N.D. means none detected at laboratory lower limit of quantitation.

TABLE VI

RESULTS OF AIR SAMPLING FOR B-NAPHTHYLAMINE

DATE	TIME	JOB DESCRIPTION OR LOCATION	B-NAPHTHYLAMINE
11/11/80	0931-1531	Duo-Sol, sump area	N.D.*
11/12/80	0747-1518	Duo-Sol, utility man	N.D.
11/12/80	0902-1523	Duo-Sol, G-15 Selecto area	N.D.
11/12/80	0905-1529	Duo-Sol, GB-12 pumps area	N.D.
11/13/80	0753-1448	Duo-Sol, control room	N.D.
11/14/80	0754-1428	Furfural, GA-8 extract mix pump area	N.D.

Survey Criteria -- No exposures are permitted.

*N.D. means none detected at laboratory limit of quantitation.

TABLE VII

RESULTS OF AIR SAMPLING FOR FURFURAL

DATE	TIME	JOB DESCRIPTION OR LOCATION	FURFURAL (mg/M^3)
11/14/80	0743-1117	Furfural, outside operator	1.7
11/14/80	0750-1114	Furfural, chief operator	1.2
11/14/80	0754-1119	Furfural, GA-8 extract mix pump area	1.4
11/14/80	1121-1430	Furfural, GA-8 extract area	2.6
11/14/80	1116-1424	Furfural, chief operator	2.2
11/14/80	1118-1426	Furfural, outside operator	2.2
		Survey Criteria (8 to 10 hour average daily exposure)	8.0

TABLE VIII

RESULTS OF AIR SAMPLING FOR PHENOL

DATE	TIME	JOB DESCRIPTION OR LOCATION	PHENOL (mg/M^3)
11/10/80	0755-1521	Duo-Sol, laborer	0.5
11/10/80	0725-1434	Duo-Sol, outside operator	0.2
11/10/80	0940-1502	Duo-Sol, sump area	6.5
11/10/80	0950-1505	Duo-Sol, extraction area	N.D.
11/11/80	0717-1426	Duo-Sol, chief operator	0.1
11/11/80	0745-1522	Duo-Sol, maintenance man	0.2
11/11/80	0830-1527	Duo-Sol, laborer	N.D.
11/12/80	0723-1427	Duo-Sol, N-Tower	N.D.
11/12/80	0717-1431	Duo-Sol, Pride Tower-01	0.4
11/12/80	0800-1519	Duo-Sol, maintenance man-03	0.1
11/12/80	0902-1523	Duo-Sol, G-15 Selecto area	0.2
11/13/80	0753-1448	Duo-Sol, control room	0.3
11/13/80	0759-1449	Duo-Sol, control room	0.5
11/14/80	0731-1405	Duo-Sol, gopher operator	0.1
11/14/80	0839-1416	Duo-Sol, machinist	N.D.
12/10/80	0722-1529	Duo-Sol, catwalk, pump area	N.D.
12/10/80	0715-1527	Duo-Sol, control room	0.2
12/10/80	0729-1530	Duo-Sol, pump area	N.D.
12/10/80	0723-1529	Duo-Sol, pump area w. of catwalk	0.1
12/10/80	0808-1549	Duo-Sol, traffic dept. office	N.D.
12/10/80	0803-1548	Duo-Sol, purchasing dept. office	N.D.
12/10/80	0748-1542	Duo-Sol, carpenter shop	N.D.
12/10/80	0740-1540	Duo-Sol, welding shop	N.D.
12/11/80	0840-1340	Duo-Sol, sump area	3.0
Survey Criteria (8 to 10 hour average daily exposure)			20.0

N.D. means none detected at laboratory limit of quantitation.

TABLE IX

RESULTS OF AIR SAMPLING FOR RESPIRABLE AND TOTAL PARTICULATES

DATE	TIME	JOB DESCRIPTION OR LOCATION	TOTAL PARTICULATES (mg/M^3)	RESPIRABLE PARTICULATES (mg/M^3)
11/10/80	0939-1435	Clay Contact, clay bin area	0.1	--
"	0940-1501	Duo-Sol, sump area	0.2	--
"	0724-1430	Clay Contact, board operator	--	0.02
"	0720-1430	Clay Contact, chief operator	N.D.	--
"	0938-1435	Clay Contact, clay bin area	N.D.	--
"	0938-1435	Clay Contact, clay bin area	--	N.D.
11/11/80	0935-1529	Duo-Sol, extraction area	0.1	--
"	0709-1422	Clay Contact, chief operator	--	N.D.
"	0708-1422	Clay Contact, board operator	0.04	--
"	0934-1427	Clay Contact, 2nd operator	--	0.08
"	0934-1427	Clay Contact, 2nd operator	0.04	--
11/12/80	0947-1518	Duo-Sol, utility man	0.2	--
"	0718-1421	Clay Contact, outside operator	0.1	--
"	0915-1535	Clay Contact, control room	--	0.2
"	0915-1535	Clay Contact, control room	0.02	--
11/14/80	0754-1429	Furfural, G-8 pumps area	0.1	--
Survey Criteria (8 hour average daily exposure)			10.0	5.0

*N.D. means none detected at laboratory limit of quantitation.

TABLE X

RESULTS OF AIR SAMPLING FOR BENZENE AND TOTAL HYDROCARBONS

DATE	TIME	JOB DESCRIPTION OR LOCATION	BENZENE (mg/M^3)	TOTAL HYDROCARBONS (mg/M^3)
11/10/80	0803-1527	Duo-Sol, pipefitter	0.03	N.D.*
"	0735-1438	Duo-Sol, pride operator	0.03	N.D.
"	0950-1505	Duo-Sol, extraction area	0.02	1
11/11/80	0720-1427	Duo-Sol, gopher operator	0.03	3
"	0832-1522	Duo-Sol, utility man	0.04	7
"	0928-1437	Clay Contact, clay bins area	0.02	N.D.
11/12/80	0717-1419	Clay Contact, board operator	0.05	20
"	0726-1427	Duo-Sol, outside operator	0.03	N.D.
"	0754-1530	Duo-Sol, machinist	0.04	3
"	0902-1523	Duo-Sol, Selecto G-15 area	N.D.	1
"	0905-1529	Duo-Sol, GB-12 pumps area	0.01	2
11/13/80	0753-1448	Duo-Sol, control room	0.02	N.D.
"	0759-1449	Duo-Sol, G-17 pumps area	N.D.	N.D.
11/14/80	0735-1406	Duo-Sol, chief operator	0.03	N.D.
"	0830-1411	Duo-Sol, utility man	N.D.	N.D.
"	0840-1412	Duo-Sol, machinist	0.03	N.D.
"	0745-1419	Furfural, board operator	0.03	N.D.
"	0755-1429	Furfural, G-8 extract area	N.D.	N.D.
Survey Criteria (60 minute ceiling)			3.2	

*N.D. means none detected at laboratory limit of quantitation.

TABLE XI

RESULTS OF AIR SAMPLING FOR CYCLOHEXANE SOLUBLES AND SPECIFIC POLYNUCLEAR AROMATIC HYDROCARBONS

DATE	TIME	JOB DESCRIPTION OR LOCATION	CYCLOHEXANE SOLUBLES (mg/M^3)*	PHENANTHRENE (ug/M^3)*
11/10/80	0756-1521	Duo-Sol, utility man	N.D.*	N.D.
"	0803-1525	Duo-Sol, boilermaker	N.D.	0.30
"	0728-1434	Duo-Sol, gopher operator	N.D.	N.D.
"	0940-1502	Duo-Sol, sump area	N.D.	0.70
11/11/80	0718-1428	Duo-Sol, outside operator	N.D.	0.22
"	0749-1521	Duo-Sol, machinist	N.D.	0.50
"	0935-1529	Duo-Sol, extraction area	N.D.	0.21
"	0721-1424	Clay Contact, outside operator	N.D.	N.D.
11/12/80	0732-1420	Clay Contact, chief operator	N.D.	0.23
"	0902-1523	Duo-Sol, Selecto G-15 pumps area	N.D.	N.D.
"	0719-1432	Duo-Sol, chief operator	N.D.	0.02
"	0746-1521	Duo-Sol, machinist	0.16	0.23
"	0905-1529	Duo-Sol, GB-12 pumps area	0.26	0.33
11/13/80	0753-1448	Duo-Sol, control room	N.D.	N.D.
"	0759-1449	Duo-Sol, G-17 pumps	0.07	N.D.
11/14/80	0732-1407	Duo-Sol, N-tower operator	0.07	0.29
"	0827-1406	Duo-Sol, utility man	0.04	N.D.
"	0824-1406	Duo-Sol, pipefitter	0.06	N.D.
"	0745-1428	Furfural, G-8 pump area	0.12	N.D.
Survey Criteria (8 to 10 hour average daily exposure)			0.10	

*Notes:
1. mg/M^3 means milligrams per cubic meter of air
2. ug/M^3 means micrograms per cubic meter of air
3. N.D. means non detected at laboratory lower limit of quantitation
4. Benzo(a)pyrene, benzo(e)pyrene, pyrene, fluoranthene, chrysene, benzo(a)anthracene, and anthracene were not detected on the above samples except that one sample had trace quantities of benzo(a)pyrene, benzo(e)pyrene, and benzo(a)anthracene.

TABLE XII
RESULTS OF CHEST X-RAYS OF 18 EMPLOYEES UNDER ASBESTOS SURVEILLANCE

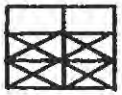
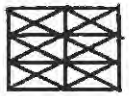
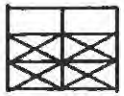
CASE	DATE OF LAST X-RAY	OPACITIES	PROFUSION*	TYPE	EXTENT**	PLEURAL THICKENING	OTHER FINDINGS
1	6/80	small rounded	0/1	diameter 1.5-3mm		both chest walls & diaphram sites, about 10mm & more thick, exceeding 1/2 of the projection of 1 lateral chest wall	pleural calcificatio abnormal heart confi guration
2	3/78 (5/80; poor film quality)	small irregular	0/1	medium		right costophrenic angle, less than 5mm thick, not exceeding 1/2 of the projection of 1 lateral chest wall	
3	5/80	small irregular	1/0	medium			
4.	2/79	small rounded	0/1	diameter 1.5-3mm		both chest walls and diaphram sites, between 5-10mm thick, not exceeding 1/2 of the projection of 1 lateral chest wall	
5.	5/80	small irregular	1/0	medium			
6.	5/80	small irregular	0/1	medium			pleural calcificatio abnormal heart confi ration
7.	5/80	small irregular	0/1	medium		right costophrenic angle, less than 5mm thick, not exceeding 1/2 of the projection of 1 lateral chest wall	
8.	6/80					both chest walls and diaphram sites, between 5-10mm thick, not exceeding 1/2 of the projection of 1 lateral wall	pleural plaques

TABLE XII CONTINUED

9.	5/80						pleural plaques abnormal heart configuration
10.	5/80	small irregular	0/1	medical		both chest walls and diaphram sites less than 5mm thick, exceeds 1/2 of the projection of 1 lateral chest wall	
11.	5/79					left costophrenic angle, less than 5mm thick, not exceeding 1/2 of the projection of 1 lateral chest wall	
12.	5/79	(normal)					
13.	5/79	(normal)					
14.	5/80	(normal)					
15.	5/80	(normal)					
16.	5/80	(normal)					
17.	5/80	(normal)					
18.	2/74	(normal)					

*0/- 0/0 0/1 = category 0 (small rounded/irregular opacities absent or less profuse than in category 1)

1/0 1/1 1/2 - category 1 (small rounded/irregular opacities definitely present, but relatively few in number)

** 

right & left upper lungfields
right & left middle lungfields
right & left lower lungfields

TABLE XIII

DISTRIBUTION OF SEX, RACE, AGE AND SENIORITY AMONG 35 WORKERS WITH CRESOL/PHENOL EXPOSURE AND 16 CLERICAL CONTROLS

VARIABLE	35 EXPOSED WORKERS		16 CONTROLS		
	Number	%	Number	%	
Sex:					
males	33	94	3	19	
females	2	6	13	81	
Race:					
white	25	71	11	69	
black	10	29	5	31	
Age (years):					
20-29	14	40	9	56	
30-39	9	26	3	19	
Total <40	23[A]	66	12[A]		75
40-49	4	11	2	12	
50-59	7	20	2	12	
≥60	1	3	0	0	
Total ≥40	12[A]	34	4[A]		25
Plant Seniority (years):					
Range	1.2-31.5		0.2-35		
Median	6.7[B]		1.9[B]		

A - $X^2 = 0.44$ $p > 0.4$

B - $p = 0.015$, Wilcoxon rank sum test with continuity correction of 0.5

TABLE XIV

SYMPTOMS REPORTED BY 35 WORKERS WITH CRESOL/PHENOL EXPOSURE AND 16 CLERICAL CONTROLS

SYMPTOM	35 EXPOSED WORKERS REPORTING SYMPTOMS		16 CLERICAL WORKERS REPORTING SYMPTOMS		p-VALUE (FISHER'S EXACT TEST, 1-TAILED)
	Number	%	Number	%	
Frequent headache (3 or more per week)	7	20	1	6	0.2
Frequent dizziness	2	6	0	0	
Blurred vision	6	17	1	6	
Ringing ears	13	37	1	6	0.02
Muscle twitch	6	17	0	0	0.09
Muscle weakness	1	6	0	0	
Trouble breathing	3	9	0	0	
Irritability, moodiness	4	11	0	0	0.2
Convulsions	0	0	0	0	
Eye irritation	10	29	1	6	0.07
Burning nose	7	20	1	6	0.2
Sore throat	5	14	1	6	
Muscle aches	4	11	0	0	0.2
Nausea/vomiting	0	0	0	0	
Unexplained loss of appetite	2	6	0	0	
Unexplained loss of weight	0	0	0	0	

TABLE XV

MEDICAL HISTORY AS REPORTED BY 35 WORKERS WITH EXPOSURE TO CRESOL/PHENOL AND 16 CLERICAL CONTROLS

CONDITION	35 EXPOSED WORKERS WITH POSITIVE HISTORY		16 CLERICAL WORKERS WITH POSITIVE HISTORY	
	Number	%	Number	%
Back Trouble	7	20	1	6
Arthritis, Rheumatism	7	20	2	12
Dermatitis, Rash	6	17	1	6
Diabetes	1	3	1	6
Head injury, Concussion	0	0	0	0
Epilepsy	0	0	0	0
Encephalitis, Meningitis	1	3	0	0
Hypertension	8	23*	1	6*
Heart Trouble	0	0	1	6
Lung Condition	1	3	1	6
Liver Condition	0	0	1	6
Kidney Trouble	3	9	0	0
Bladder Trouble	1	3	0	0
Prostatitis**	2	6	0	0
Trouble passing Urine	2	6	0	0

* p = 0.15, Fisher's exact test, 1-tailed.
**33 exposed workers and 3 clerical workers were men.

TABLE XVI

URINE PHENOL LEVELS OF DUO-SOL OPERATORS, MAINTENANCE WORKERS, AND CLERICAL WORKERS

GROUP	PERSONS IN GROUP	URINE PHENOL[A] RANGE	URINE PHENOL[A] MEDIAN
Duo-Sol Operators	13	0.7 - 149.5	12.0[C]
Maintenance Workers Serving Duo-Sol Unit	17	N.D.[B] - 22.3	3.7[C]
TOTAL Cresol/Phenol - exposed	30	N.D. - 149.5	7.3[D]
Maintenance Workers Not Serving Duo-Sol Unit	4	0.5 - 3.3	1.1
Clerical Workers	12	N.D. - 11.8	4.0
TOTAL Cresol/Phenol - not exposed	16	N.D. - 11.8	3.6[D]

A - Milligrams of total phenol per gram of creatinine.
B - No detectable phenol
C - p = 0.047, Wilcoxon rank sum test with continuity correction of 0.5
D - p = 0.024, Wilcoxon rank sum test with continuity correction of 0.5