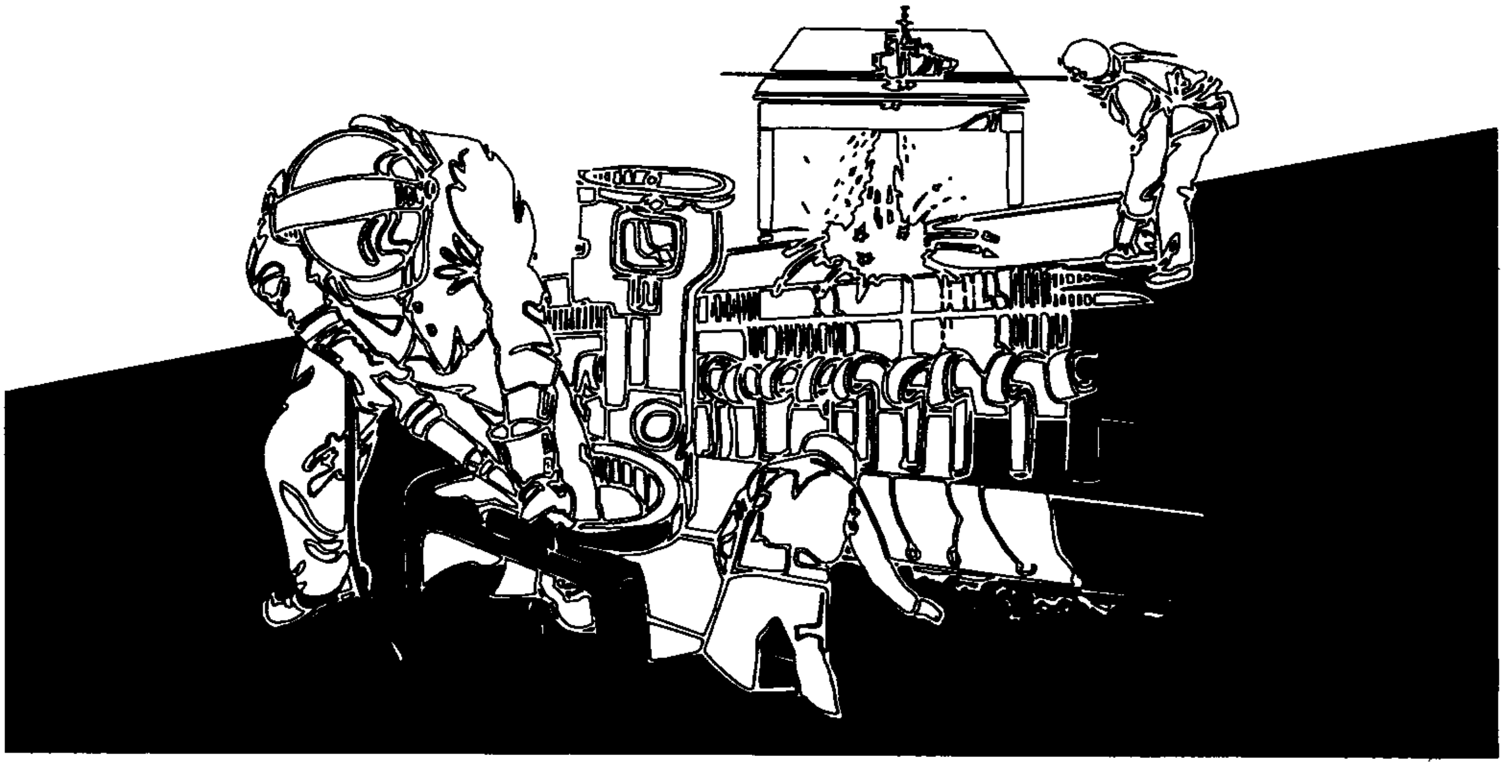
NIOSH

HEALTH HAZARD EVALUATION REPORT

RDHETA 88-390-2148
AMERICAN SALT COMPANY
LYONS, KANSAS



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

CDC
CENTERS FOR DISEASE CONTROL

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 and 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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AMERICAN SALT COMPANY
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I. Summary

In January 1988, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH), received a request for a health hazard evaluation from the International Chemical Workers Union (ICWU). NIOSH was requested to evaluate exposures to asbestos and diesel emissions at four salt mines located in Kansas, Texas and Louisiana. On April 7, 1988, NIOSH conducted a walk-through survey at the American Salt mine and mill located in Lyons, Kansas. On October 25-26, 1988, medical and environmental evaluations were conducted at the American Salt mine and mill. The environmental evaluations consisted of personal breathing zone and area air samples collected for coal tar pitch volatiles (CTPV), polynuclear aromatic hydrocarbons (PNA's), diesel particulates, oxides of nitrogen (NO,NO_2), carbon monoxide and asbestos.

At American Salt, the only detectable overexposure was to nitrogen dioxide. Nitrogen dioxide is a contaminant produced from the combustion of fossil fuels. Five passive dosimeters analyzed for nitrogen dioxide (NO_2) indicated full-shift exposure levels ranging from 0.71 parts per million (ppm) to 1.4 ppm. Four of these NO_2 exposures were in excess of NIOSH's recommended ceiling of one ppm. None of the NO_2 passive dosimeter samples exceeded the Mine Safety and Health Administration's (MSHA) ceiling standard of five ppm.

Five coal tar pitch volatile (CTPV) samples, analyzed for the benzene soluble fraction were below detectable levels. None of the CTPV's exceeded the MSHA/NIOSH evaluation criteria. Six PNA samples had quantifiable amounts of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene and Phenanthrene. Diesel particulate exposure ranged from 0.02 to 0.19 mg/m^3 with a mean of 0.1 mg/m^3. There is currently no occupational standard for exposure to diesel particulates.

Carbon monoxide was detected, but well below NIOSH/MSHA evaluation criteria. Fourteen air samples analyzed by transmission electron microscopy (TEM) for asbestos had no detectable asbestos concentrations. Bulk and settled dust samples collected for asbestos analysis near the 1-A turbines, evaporator building and hoist house contained amosite and chrysotile asbestos.

The medical evaluation consisted of a Medical Research Council (MRC) questionnaire on respiratory symptoms, smoking habits, demographic information and work history; chest x-rays; and pulmonary function tests. Forty-seven employees, 39 males and 8 females, participated in the medical evaluation. Of these employees, only two worked underground. Because of the small numbers, surface and underground workers could not be compared. Radiographic evidence of pneumoconiosis was nonexistent among the employees evaluated. Pulmonary function test results showed four employees with mild obstruction, one with severe obstruction and two with mild restriction of lung volume. When compared to a group of nonexposed blue-collar workers the prevalences of chronic cough (28%) and phlegm (29%) were significantly different.

According to NIOSH evaluation criteria, overexposures to nitrogen dioxide (NO_2) existed during the survey. There was no NO_2 exposures exceeding the MSHA standard. In the evaporator building and hoist house, there were no detectable airborne asbestos exposures. However, chrysotile and amosite was identified in the evaporator building in bulk materials and settled dust samples. Recommendations for reducing occupational exposure to these workplace contaminants and to conduct a follow-up medical questionnaire survey can be found in section VII of the report.

KEYWORDS: SIC 1479 (Salt Mines), Diesel exhaust, Coal tar pitch volatiles, PNA's, Asbestos and Oxides of Nitrogen.

II. Introduction

In January 1988, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH), received a request for health hazard evaluation from the project director, International Chemical Workers Union (ICWU) located in Akron, Ohio. The requestor wanted NIOSH to evaluate exposures (medically and environmentally) to asbestos and diesel emissions at four salt mines located in the states of Kansas, Texas, and Louisiana. NIOSH was also asked to evaluate the synergistic effects of asbestos/diesel. The synergistic effects were not evaluated because of insufficient numbers of people with exposures to the substances of concern. On April 7, 1988, NIOSH conducted a walk-through at the American Salt mine and mill located in Lyons, Kansas. The walk-through was used to help determine potential exposures and to assist in the planning of the medical and environmental evaluations at the mine and mill. The environmental and medical evaluations were conducted at American Salt on October 25-26, 1988.

III. Background

American Salt Company located in Lyons, Kansas, mines and processes salt for commercial and consumer use. The salt that is mined is 96 to 97% pure. The mine and mill at the time of the survey were operating only the day shift. The company previously operated (based on production) 5 to 7 days and ran two shifts, but was gearing its production down due to a decrease in market demands. At American Salt, the salt exists in veins and is mined in a room and pillar fashion similar to coal mining. Normally, salt deposits are found in domes 30,000 to 40,000 feet high and from hundreds of yards to miles in diameter.

Both vein and dome salt is commonly mined by the room and pillar method. Salt removed by the room and pillar method has the appearance of a square checkerboard pattern with some salt left as pillars for room support. Vein salt can vary in height from 8 feet to 40 feet. Vein or dome salt underground transportation/haulage ways are commonly 40 to 70 feet wide. At American Salt, haulage ways were approximately 40 feet wide and the ceiling height was 16 feet. Mine temperatures averaged 73° F with 52% relative humidity.

The first step in the mining process is undercutting. Undercutting is accomplished by cutting at least a 10 foot deep slot under the salt wall. Next, holes are drilled into the salt wall and explosives are inserted in these holes. At the end of the work shift, the explosives are detonated. A front end loader then loads the salt into a shuttle car for transportation to a crusher/feeder. After crushing, the salt is conveyed through several screening stations for sizing and then to storage bins. The salt is hoisted to the surface by skips (bins) which dump the salt onto conveyors to mill bins for further processing.

Mill processing consists of sorting the salt into marketable sizes by additional screening for use as a road salt, ice cream salt, water softeners or salt blocks for farm animals. Bulk salt is shipped by rail or truck to commercial users.

At the time of the survey, American Salt had four pieces of diesel equipment underground; a shuttle car, a load haul dump vehicle (LHD), a powder wagon that runs a maximum of four hours a day, and a small bobcat for clean up purposes. The vehicles are on a maintenance schedule. The amount of air supplied to a working section as measured by the company averaged 17,500 cubic feet per minute (CFM).

IV. Methods

A. Environmental

On October 25-26, 1988, environmental samples were collected at the mine and mill on the day shift for exposures to coal tar pitch volatiles (CTPV), polynuclear aromatic hydrocarbons (PNA's), diesel particulates, nitric oxide (NO), nitrogen dioxide (NO_2), carbon monoxide (CO) and asbestos. At the mine, full-shift personal breathing zone samples were collected for NO/NO_2 and diesel particulates. Full-shift area samples for CTPV and PNA's were collected on the equipment. Partial-shift samples for carbon monoxide were collected on the equipment for four hours using solid sorbet tubes. Full-shift samples were normally placed on the equipment adjacent to the operator and within three feet of his breathing zone. On the surface, full-shift personal and area samples were collected for asbestos. Area samples were hung primarily in the immediate work area.

The PNA samples were collected using a sampling pump calibrated at a flow rate of 2.0 lpm in-line with a 37 mm PTFE laminated filter with a 2.0 micrometer (um) pore size.[1] Orbo-43 solid sorbent tubes were connected in-line following the filter. The CTPV samples were collected in the same manner as the PNA samples without the sorbent tube back-up.[1]

The diesel particulates were collected with a 2-stage, dichotomous impactor inserted into a respirable dust cyclone. The effective cut-off diameter (ECD) for the impactor is 1.0 um in aerodynamic diameter. The impactor consists of three parts. The first part is a 37 mm cassette with a modified orifice (0.1 cm diameter). The second part is a spacer and the third part consists of a greased pre-weighed aluminum foil impaction plate. Air is pulled through the cyclone, impactor and filter at a flow rate of 2.0 lpm.[2]

Nitric oxide and nitrogen dioxide were collected using the Palmes[3,4] passive dosimeter. The passive dosimeters are rigid, cylindrical, plastic tubes with a mesh screen at one end of the tube that is coated with triethanolamine. In the nitric oxide dosimeter, there is an impregnated filter containing chromic acid which is placed on top of the coated mesh screen.

Carbon monoxide was monitored using a sampling pump calibrated at 20 cubic centimeters (cc) per minute in-line with a Drager long-term tube.[5]

Asbestos was collected using a sampling pump calibrated at a flow rate of 2.0 lpm in-line with a 25 mm three piece cassette with a 50 mm electrically conductive extension cowl, mixed cellulose ester filter (0.45 to 1.2 um pore size), and a backup pad.[1] Settled dust samples for asbestos were collected from horizontal surfaces using a sampling pump calibrated at a flow rate of 4.0 lpm in-line with a 37 mm mixed cellulose ester filter. Preceding the filter a plastic disposable syringe tip was used as a vacuum nozzle to collect the dust from plant surfaces. This tip was changed each time a sample was collected. The methods used to analyze the mine and mill environment are summarized in Table I.[1,2,3,4,5]

B. Medical

All employees at the American Salt Company were invited to participate in the medical portion of the health hazard evaluation. A mobile trailer equipped with spirometers and an x-ray machine was used for the study. The trailer was parked at the mine site. After each participant received an explanation of the tests to be performed and gave their consent to participate, each volunteer had standing height measured, received a posteroanterior chest radiograph, was administered a standardized questionnaire, and performed spirometry.

A modified version of the Medical Research Council (MRC) questionnaire on respiratory symptoms, supplemented with questions concerning smoking habits, demographic information, and occupational history, was administered by trained interviewers (Appendix I). In addition, participants were asked to classify the frequency of eleven acute symptoms experienced at work as "never/rarely", "sometimes", or "often". For purposes of this analysis, "chronic cough" was defined as a cough on most days for as much as three months each year. "Chronic phlegm" was defined as the production of phlegm on most days for as much as three months each year. A person was said to have "chronic shortness of breath" if he answered yes to having to stop for breath when walking at own pace on level ground (MRC 1960).[6]

Spirometry was performed using a dry rolling-seal spirometer interfaced to a computer terminal with tape and disk storing capabilities. At least five maximal expiratory maneuvers were recorded for each person. All values were corrected to body temperature, ambient pressure, saturated with water vapor (BTPS). The largest forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and peak flow (PF) were selected for analysis regardless of the curves on which they occurred. The spirometer and methods met the quality control recommendations of the American Thoracic Society (ATS).[7]

Each chest radiograph was read independently by certified pneumoconiosis "B" readers who, without knowledge of the subjects' ages, occupations, or smoking histories, classified the films according to the 1980 International Classification of Radiographs of Pneumoconioses.[8] It is now extensively used internationally for epidemiological research, for the surveillance of those in dusty occupations and for clinical purposes. Parenchymal and pleural abnormalities are recorded. A chest radiograph was defined as positive for pneumoconiosis if at least two of three "B" readers categorized small opacity profusion as 1/0 or greater. The median profusion of the three readings was used in the analysis.

To examine respiratory effects of possible exposures, the workers were divided into surface and underground groups based on the location of their current job. However, since there were only two underground workers that participated in the study, a comparison between surface and underground workers could not be statistically performed.

Likelihood ratio tests for goodness-of-fit were used to compare the responses to questions about chronic cough and chronic phlegm to the prevalences expected if the workers at the American Salt Mine had the same symptom prevalences reported by a group of nonexposed blue-collar workers. Chronic shortness of breath prevalence could not be statistically compared due to the small numbers observed. Knowledge of each employee's smoking history was used to calculate the expected prevalences of these respiratory symptoms. Percent predicted pulmonary function values were calculated using Knudson's prediction equations.[9] The observed lung volume or flow rate converted to BTPS was divided by the predicted value and multiplied by 100 to obtain the percentage. In the absence of airway obstruction, a restrictive ventilatory impairment is present when the FVC is less than 80% of predicted. An obstructive ventilatory impairment is defined as an FEV_1 of less than 80% of predicted or an $FEV_1/FVC\%$ less than 70%. However, an occasional individual may be slightly below the normal value and not have a respiratory disorder.

V. Evaluation Criteria and Toxicology

A. Criteria

Evaluation criteria are used as guidelines to assess the potential health effects of occupational exposures to substances and conditions found in the work environment. These criteria are generally established at levels that can be tolerated by most healthy workers occupationally exposed day after day for a working lifetime without adverse effects. Because of variations in individual susceptibility, a small percentage of workers may experience health problems or discomfort at exposure levels below these criteria. Consequently, it is important to understand that these evaluation criteria are guidelines, not absolute limits between safe and dangerous levels of exposure.

The primary sources of environmental evaluation criteria used in this report are: (1) NIOSH Recommended Exposure Limits (REL's), and (2) the Mine Safety and Health Administration (MSHA) Standards. In evaluating the exposure levels and any recommendations for reducing the levels found in this report, it should be noted that the metal/non-metal surface and underground mining industry is mandated to meet MSHA Standards. Those MSHA Standards are adopted from the criteria established by the 1973 ACGIH TLV's.[10] Often, the NIOSH REL's are lower than the corresponding MSHA Standards. NIOSH recommended exposure limits are usually based on the most recent information available and on the concerns related to the prevention of occupational disease.

A time-weighted average (TWA) exposure in this report refers to the average airborne concentration of a substance during a normal eight to ten-hour workday. Some substances have recommended short-term exposure criteria or ceiling (C) values which are intended to supplement the TWA where there are recognized toxic effects from high exposures. These exposure criteria and standards are commonly reported as parts per million parts air (ppm), or milligrams per cubic meter of air (mg/m^3).

B. Toxicology

The following information describes the possible toxicological and physiological effects to workers exposed to the substances monitored during this survey. These effects are described so workers will be familiar with the symptoms and consequences of overexposure. The effects depend upon such factors as contaminant concentration, length of exposure, workload, individual susceptibility and synergistic or additive effects of more than one substance.

Coal Tar Pitch Volatiles/Polynuclear Aromatic Hydrocarbons

Coal tar pitch volatiles (CTPV's) and polynuclear aromatic hydrocarbons (PNA's) are terms frequently encountered when dealing with coal tar and petroleum products. CTPV's are products from the combustion of petroleum products or the destructive distillation of bituminous coal. CTPV's contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons convert readily, thereby increasing the amounts of carcinogenic compounds in working areas.[11] Epidemiological evidence suggests that workers intimately exposed to the products of combustion or distillation are at an increased risk of cancer at such sites as the respiratory tract, kidney, bladder and skin.[11] Coke oven workers, for which the CTPV standard was developed, have been found to be at the highest risk for lung and kidney cancer if employed for 5 or more years. While the agents responsible for cancers among coke oven workers are unidentified, it is suspected that several of the PNA's in CTPV's are involved. The primary hydrocarbons that are suspect human carcinogens are chrysene and benzo (a) pyrene.[12,13] These hydrocarbons are small in size, readily inhaled and typically represent 15-65% of the diesel exhaust particulates emitted from diesel powered vehicles.[14]

Diesel Particulates

Emissions from diesel engines consists of both gaseous and particulate fractions. The gaseous constituents include carbon dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, oxides of sulfur, and polynuclear aromatic hydrocarbons. Particulates in diesel exhaust are composed of solid carbon (soot) which tend to form clusters during combustion. As much as 15 to 65% of the diesel emissions are made up of organic compounds adsorbed onto the surface of particulates.[14] More than 95% of these particulates are less than one micron in size.[15] It has been suggested that the diesel exhaust acts as a carrier for the gaseous fractions of diesel emissions and, based on the small size of diesel particles penetration to the gas exchange regions of the lung is possible. Animal studies, toxicology studies and human epidemiological findings suggests that a potential health risk exists from exposure to diesel exhaust.[14] These studies serve as the basis for the current NIOSH conclusion that exposure to whole diesel exhaust is associated with the risk of cancer.

Nitric Oxide

Nitric oxide is a by-product of both combustion and the detonation of explosives. Nitric oxide (NO) is converted spontaneously in air to nitrogen dioxide, thus both gases are usually present together. At concentrations less than 50 ppm, this conversion is usually slow and can result in negligible quantities of nitrogen dioxide.[16] Animal experimental data indicate that nitric oxide is about one-fifth as toxic as nitrogen dioxide.[17] At 175 ppm, guinea pigs lived for an indefinite period, while at 322 ppm, methemoglobinemia was produced in 60% of the guinea pigs.[17] Methemoglobinemia results when oxygen in the blood can not combine with the hemoglobin thus impairing the transport of oxygen. Information suggests that in mixtures with carbon monoxide and nitrogen dioxide, an additive exposure effect can occur. At concentrations less than 25 ppm, there is very little concern with chronic effects in humans.[17]

Nitrogen Dioxide

Nitrogen dioxide is formed from nitric oxide, which is a by-product of combustion of petroleum based fuels. Nitrogen dioxide is an irritant to the mucous membranes and may cause coughing accompanied by a mild or transient headache. The symptoms will usually subside a few hours after removal from the exposure. If exposure is long enough and the concentrations high enough, dyspnea, persistent cough, cyanosis, bronchitis, and pulmonary edema can occur.[18] There have been several studies on the effects of continuous exposure at low concentrations.[17] One study found that rats exposed to 0.8 ppm had elevated respiratory rates and at 2.0 ppm, there were slight lung changes, but no effect on their life spans. Another study using mice exposed to 0.5 ppm for 6, 18, and 24 hours daily for three to twelve months, found an expansion in the alveoli of the lungs. Lesions appeared, consistent with the development of early focal emphysema. Several studies of higher concentrations have also been conducted. One study with rats using pure NO_2 at concentrations of 1, 5 and 25 ppm for 18 months showed no chronic effects. However, there were transient acute changes in the lungs at weeks end.[17]

Industrial data on human exposures have not been conclusive; however, animal research has developed several important principles. First, intermittent No_2 exposures are considerably less toxic than continuous exposure. Second, the hazard associated with NO_2 during continuous exposure is primarily determined by the peak and not by the average concentration.[16] The latter notion is supported by data that indicates an equivalent effect on the severity of respiratory infections from continuous exposures at 2.0 ppm and 0.5 ppm, with 1-hour peaks at 2.0 ppm, and that brief high-level exposures are more hazardous than longer exposures at low concentrations.[18] There is a noted reduction in pulmonary function among normal adult males exposed to 4-5 ppm NO_2 for 10-15 minutes. Studies on individuals with bronchitis exposed to NO_2 concentrations above 1.5 ppm (not at or below this level) resulted in increased airway resistance.[18]

Carbon Monoxide

Carbon monoxide (CO) can be formed from the incomplete combustion of fossil fuels. Exposure to CO decreases the ability of the blood to carry oxygen to the tissues. The typical early signs and symptoms of acute CO poisoning are headache, dizziness, fatigue and nausea.[18] Employee exposure to CO at less than the NIOSH/MSHA exposure limits should not result in any permanent impairment of health. High concentrations of CO may be rapidly fatal without producing significant warning symptoms. Exposure to this gas may aggravate heart disease and artery disease and may cause chest pain in those with pre-existing heart disease. The MSHA standard for CO is 50 ppm as a TWA. NIOSH recommends a TWA exposure limit of 35 ppm for CO to 1) prevent acute CO poisoning, 2) to prevent myocardial alterations by maintaining carboxy-hemoglobin at less than 5 percent, and 3) to prevent adverse behavioral effects.[2,13]

Asbestos

Increased health risk resulting from occupational exposure to asbestos has been well-documented in the scientific literature. Asbestos is associated with a chronic and debilitating lung disease which normally occurs following long-term exposures to high levels of asbestos fibers. More recently, asbestos has also been linked to several types of cancer, including mesothelioma and cancers of the lung, esophagus, stomach and colon. These cancers usually appear many years after the initial contact with asbestos, and sometimes result from short-term and/or low level exposures. The data show there may not be a "safe" level of exposure to asbestos for the elimination of cancer risk.[19,20] This risk is also greatly enhanced by cigarette smoking.

NIOSH currently recommends that occupational exposure to asbestos be kept to the lowest feasible level.[20,23] This recommendation is based on the proven human carcinogenicity of asbestos and on the absence of a known threshold exposure level below which there is no risk of cancer. For most industrial settings, the lowest feasible limit for reliable detection of asbestos corresponds to a level of 0.1 fibers/cc.

VI. Results and Discussion

A. Environmental

The operation of diesel equipment at American Salt was minimal. Only three of four pieces of equipment were operating during the survey. The fourth piece of equipment, a Bobcat, was primarily used for clean-up work. Because so few pieces of equipment were operating, it was convenient to monitor workers and designated sampling areas for the full shift. Normally, full-shift sampling is difficult when there is a lot of equipment or personnel to monitor. This is also compounded by the distance/time required to reach a working section.

As mentioned earlier, American Salt is a vein mining operation and the section where most of the environmental sampling was being conducted measured 16 by 40 feet. Management measurements indicate the volume of air moving through this mine averaged 17,500 cubic feet per minute (cfm). Visual assessment of the removal of diesel exhaust in the working sections and the results of short-term detector tube readings taken in the mine for CO/NO_2 indicated the air volume was sufficient to remove the contaminants of diesel exhaust from the working sections. The short-term detector tube readings for carbon monoxide were less than three parts per million (ppm) and 0.8 ppm for nitrogen dioxide. All of the short-term samples were below MSHA/NIOSH evaluation criteria presented in Table II. However, the personal NO_2 dosimeter samples worn by the equipment operators indicated overexposures as discussed later in this report.

Coal Tar Pitch Volatiles/Polynuclear Aromatic Hydrocarbons

At the American Salt company mine/mill, five area samples were collected and analyzed for the benzene soluble CTPV's. Two outdoor samples were taken as controls (upwind of the mill) and for comparison with the underground and surface samples. Both controls were below detectable limits for CTPV's. Results of the three underground samples for CTPV's were also below detectable limits (less than approximately 0.06 mg/m^3). One surface sample collected in the "A" frame warehouse was also below detectable limits (ND). The three underground samples were collected on: (1) the powder wagon working the 21 heading at the 25 crosscut, (2) a load-haul-dump vehicle, and (3) on top of the refrigerator in the maintenance shop. The results can be found in the summary Table IX.

Five PNA samples were also collected on operator driven equipment over the shift. Of 16 different compounds analyzed on each sample, only five PNA's (naphthalene[1], acenaphthylene, acenaphthene, fluorene and phenanthrene) were detected. Naphthalene ranged from ND to 0.2 mg/m^3, well below the MSHA TLV of 50 mg/m^3. The other PNA concentrations ranged from ND to 0.01 mg/m^3. No PNA's were detected outdoors. The PNA concentrations found in Table III are the sum of the gaseous state PNA's collected on the back-up sorbent tube. No particulate PNA's were collected on the filter samples. Of the five PNA's detected, phenanthrene is considered a suspect carcinogen.[11,12] However, phenanthrene concentrations in air were low, at the detection limit for the analytical procedure (0.001 mg/m^3).

Diesel Particulate

Three personal, breathing zone samples were collected from the operators of the powder wagon, bobcat, and shuttle car. Two area samples were collected on the powder wagon and in the maintenance shop. The reason for sampling for diesel particulates was to determine the diesel fraction of the mine dust. The diesel fraction has been found to be in the submicron range, thus having the potential for reaching the lower airways of the lung. The diesel fraction is composed of solid carbon (soot) with organic compounds adsorbed onto its surface. Two samples; one on the powder wagon and outdoors were not analyzed because there was not enough particulate material on the filter to be analyzed by low temperature ashing (LTA). The diesel fraction ranged from ND to 0.19 mg/m^3 and the organic content of the diesel fraction ranged from ND to 89%. There is currently no occupational standard for exposure to diesel particulates.

Nitric Oxide

Five personal full-shift samples for nitric oxide were collected on the equipment operators. The personal time-weighted average (TWA) samples ranged from 8.4 to 12.2 ppm with a mean exposure of 10 ppm. None of the samples exceeded NIOSH/MSHA evaluation criterion. Results are found in Table V and summarized in Table IX.

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[1] Naphthalene, technically, is not considered a PNA because it has only two fused benzene rings (a true PNA has three or more).[19] Because naphthalene is analyzed as a PNA, it is reported with PNA compounds.

Nitrogen Dioxide

At American Salt, five full-shift personal samples were collected on the equipment operators and found to range from 0.71 to 1.4 ppm with a mean exposure of 1 ppm. These results indicate that at some point over the shift, exposures exceeded the NIOSH ceiling (C) limit of one ppm (Table V). Four of the five personal samples (80%) for NO_2 exceeded the NIOSH REL. The only short-term detector tube for NO_2 was taken at the 23/17 cross-cut and measured 0.8 ppm; this short-term NO_2 detector tube did not exceed NIOSH/MSHA evaluation criteria. The personal NO_2 samples were collected throughout the full work shift, and contrasted short-term, area samples in that: (1) the personal samples were closer to the diesel engines over the work shift, (2) the personal samples were collected throughout the full-shift (short-term samples were collected only in the working area for less than 10 minutes), and (3) because the personal samples on equipment operators in the immediate work area are exposed to exhaust from the vehicle before it is removed from the work area.

Carbon Monoxide

Because of the limited use of diesel equipment at American Salt, only one of four short-term detector tubes indicated a contaminant level of three parts per million. Four long-term detector tubes collected for carbon monoxide for a period of four hours indicated levels ranging from ND to 7.3 parts per million. Sample results are found in Table VI and summarized in Table IX. None of the samples exceeded NIOSH/MSHA evaluation criteria presented in Table II.

Asbestos

Fourteen airborne samples, six personal and eight area, were collected throughout the evaporator building, outdoors, and in the hoist house for asbestos. Eight bulk/vacuum samples of material thought to contain asbestos were also collected. The airborne samples were analyzed by transmission electron microscopy (TEM) for both fiber counts and fiber identification in each sample. The concentration of fibers on the personal and area samples were ND (0.01 fibers per cubic centimeter - f/cc). Some samples were void because of interference with particulate matter (not fibers) and could not be analyzed. Asbestos fibers were not found on any of the filters analyzed by TEM, only cellulose fibers (Table VII).

The bulk/vacuum settled dust samples taken from the hoist house, the fourth floor area of the evaporator building, the 1-A turbine drive, the control room in the evaporator building, and from duct insulation, identified chrysotile and amosite asbestos fibers. Asbestos that is found in settled dust samples indicates that at some point in time, (1) that asbestos was friable and became airborne naturally, or (2) that there has been repair or removal of asbestos containing material that became airborne and settled on ledges, floors, light fixtures, etc. When disturbed by air currents or employees, this asbestos can become airborne and present a potential exposure hazard. The approximate percentages of asbestos materials in the bulk/settled dust samples are found in Table VIII.

B. Medical

Forty-seven employees, 39 males and 8 females, participated in the medical survey. Of these, only two worked underground. Thirty-four percent of the participants were current smokers and 21 percent were ex-smokers. Twenty-one (45%) of the workers claimed to have never smoked (Table X).

The prevalences of chronic cough (28%) and chronic phlegm (29%) reported by the workers were significantly different than those reported in the nonexposed blue-collar worker study ($p < .01$)(Table XI).[21] Questionnaire results indicated similar prevalences of chronic symptoms among all workers regardless of smoking status, except for shortness of breath. Nonsmokers reported no shortness of breath. When asked about acute symptoms related to their work the responses for "often" ranged from 2% for sore throat to 17% for nose irritation (Table XII).

Pulmonary function results did show four workers with mild obstructive lung disease pattern, one with severe obstructive pattern and two with a mild restriction of lung volume. A mild obstruction is defined as a FEV_1/FVC ratio between 61 and 69%. A severe obstruction falls below 45%. Normal is $\geq$ 70%. In restrictive pattern the ratio is normal, but the FVC falls below the predicted value for that individual. In the case of a mild restriction, the FVC observed/FVC predicted percent would fall in the 66 to 79% range. Normal would be $\geq$ 80%. Three cases of mild obstruction occurred in the 30 to 39 age group and the other case occurred in an individual over age 50. The one severe case was also in an individual over age 50. The two restrictive cases occurred in the age groups 30 to 39 and over 50.

Radiographic evidence of pneumoconiosis was for all practical purposes nonexistent. Of the 46 (one person had no x-ray because of pregnancy) chest films of participating workers, one had a median reading of 0/1 profusion of small opacities. This is the lowest possible category with only a suspicion of pneumoconiosis and would not be reported as positive for pneumoconiosis.

The overall prevalence found among currently employed blue-collar workers with a minimal history of occupational exposure to respiratory hazards was 0.2% (3/1422).[22]

VII. Conclusions/Recommendations

A. Environmental

Overexposures were found to nitrogen dioxide based on NIOSH evaluation criteria. American Salt did not have any exposures to the contaminants sampled during this survey above the MSHA standards. Because of studies which have been conducted with animals and humans at various concentrations, it is NIOSH's position that no worker be exposed to NO_2 above the NIOSH REL of one ppm.[17] NO_2 is a by-product from the combustion of fossil fuels, such as diesel. Its presence may indicate that more dilution ventilation is needed or better maintenance and tune-ups performed on the vehicles.

Because of the limitations in diesel technology, we can not confidently recommend control measures that would completely eliminate the exposures to diesel exhaust. On the basis of animal studies, NIOSH considers diesel exhaust to be a potential occupational carcinogen.[14] Recommendations to minimize exposure to diesel exhaust would include: (1) increase the volume of air in the working sections of the mine using portable fans with/without brattice cloth extensions to direct the air flow better and (2) continue scheduled engine maintenance and install engineering controls (scrubbers, filters, catalytical purifiers) to help reduce the pollutants emitted.

While the airborne samples collected in the evaporator building did not detect any asbestos fibers, vacuum samples of settled dust collected on ledges did identify the presence of chrysotile and amosite fibers. The presence of these fibers indicates that these fibers have become airborne possibly from repair or removal of asbestos containing material and that some clean up of the areas are needed. Consequently, it is recommended that surfaces such as light fixtures, ledges, railings, and ducts, etc. at/near the areas identified be examined for settled dust (especially in the control room of the evaporator building) and wet methods (accompanied by personal protective equipment) be utilized per OSHA/EPA guidelines to clean these surfaces. Since American Salt has an in-house asbestos abatement program and some employees trained in the removal/repair of asbestos, it should utilize these capabilities to provide some additional cleaning to these surfaces to minimize potential exposures.

B. Medical

When compared to a group of nonexposed blue-collar workers the prevalences of chronic cough (28%) and phlegm (29%) were significantly different.

No radiographic evidence of pneumoconiosis was found in the group tested.

Pulmonary function tests found four cases of mild obstructive lung disease, one case of severe obstructive lung disease, and two cases with mildly restricted volumes. In a group of nonexposed blue-collar workers, the prevalences of an obstructive lung disease pattern was 8.1% compared to 10.6% for these workers. The mean FVC and FEV_1 percent predicted values were over 100% for all smoking categories except for smokers who had a mean FEV_1 percent predicted value of 96.9% (Table XIII).

Considering the observed complaints of chronic cough and phlegm, and nasal irritation in workers, a medical questionnaire survey should be conducted after the implementation of exposure controls to determine if these symptoms have been resolved. If these symptoms have not resolved, then further environmental and medical evaluation is indicated.

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1. American Salt Safety Director, Lyons, Kansas
2. ICWU Local 278
3. ICWU, Akron, Oh.
4. MSHA District Office
5. Salt Institute, Alexandria, Virginia
6. NIOSH Region VIII

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

TABLE I

SAMPLING AND ANALYTICAL TECHNIQUES
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Agent/Substance Sampled	Sample Flow Rate(LPM)	Sampling Media	Analytical Method and Reference
Coal Tar Pitch volatiles	2.0	PTFE Laminated Membrane Filter	NIOSH Method 5023 Using Benzene as Extractor[1]
Polynuclear Aromatic Hydrocarbons	2.0	PTFE Filter/Orbo-43 Solid Sorbent Tube	NIOSH Method 5515/Gas Chromatography FID[1]
Diesel Particulate	2.0	Cyclone/Impactor PVC Filter	Gravimetric/LTA[2] NIOSH Method 7500[1]
Oxides of Nitrogen (NO_x, NO, NO_2)	---	Chromic acid disc Triethanolamine (Passive Dosimeter)	Visible Absorption Spectrophotometry[3,4]
Nitrogen Dioxide	100 cc/stroke	Short-Term Detector Tube	Direct Reading[5]
Carbon Monoxide	0.02	Long-Term Detector Tube	Direct Reading[5]
Carbon Monoxide	100 cc/stroke	Short-Term Detector Tube	Direct Reading[5]
Asbestos	2.0	Mixed Cellulose Esther Filter, Pore Size 0.8 um 25 mm Diameter	NIOSH Methods 7400/7402, Using "A" Rules[1]

Notes: LPM (Liters Per Minute)
NO_x, NO, NO_2 (Oxides of Nitrogen, Nitric Oxide, Nitrogen Dioxide)

TABLE II

EVALUATION CRITERIA
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Substance	NIOSH[23]	MSHA STANDARD[10]
Coal Tar Pitch Volatiles	0.1 mg/m^3 (TWA)	0.2 mg/m^3 (TWA)
PNA's	Lowest feasible limit	None
Diesel Particulates	Lowest feasible limit	None
Nitric Oxide	25 ppm (TWA)	25 ppm (TWA)
Nitrogen Dioxide	1 ppm (C)	5 ppm (C)
Carbon Monoxide	35 ppm (TWA)	50 ppm (TWA)
Asbestos	0.1 f/cc > 5 um in length	2.0 f/cc > 5 um in length

NOTE: References are listed in Section VIII of this report.
Note: C (ceiling), TWA (time weighted average), f/cc (fibers per cubic centimeter), um (microns), mg/m^3 (milligrams per cubic meter), ppm (parts per million)

TABLE III

POLYNUCLEAR AROMATIC HYDROCARBONS
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Date	Job/Location(A)	Naphthalene (mg/m^3)	Acenaphthylene (mg/m^3)	Acenaphthene (mg/m^3)	Fluorene (mg/m^3)	Phenanthrene (mg/m^3)
10/25/88	Outdoors	ND	ND	ND	ND	ND
10/26/88	Shuttle Car	0.2	0.004	0.007	0.002	0.001
	Maint. Shop	0.19	ND	0.01	0.002	0.001
	Outdoors	ND	ND	ND	ND	ND
	Powder Wagon	0.18	ND	0.01	0.002	0.001
	Limit of Detection (LOD) (mg/m^3)	0.001	0.001	0.001	0.001	0.001

Notes: A (area samples), ND (not detected), mg/m^3 (milligrams per cubic meter), PNA (polynuclear aromatic hydrocarbons)

Of 16 PNA's analyzed on each sample, five were detected. Only Naphthalene has an exposure limit of 50 mg/m^3 per the MSHA Standards. The 16 PNA's analyzed were: (1) Benz(a)anthracene, (2) chrysene, (3) benzo(b)fluoranthene, (4) benzo(k)fluoranthene, (5) benzo(e)pyrene, (6) benzo(a)pyrene, (7) indeno(1,2,3-cd)pyrene, (8) dibenz(a,h)anthracene, (9) naphthalene, (10) acenaphthylene, (11) acenaphthene, (12) fluorene, (13) phenanthrene, (14) anthracene, (15) fluoranthene, (16) pyrene.

Table IV
DIESEL PARTICULATE/FRACTION
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88- 390

Date	Job	Total Respirable Particulate (TWA) (mg/m^3)	Diesel Fraction (mg/m^3)	Fraction Percent
10/25/88	Powder Wagon Oper. (P)	0.18	0.02	89
	Bobcat Oper. (P)	0.20	0.19	5
	Shuttle Car Oper. (P)	0.35	0.14	61
10/26/88	Maint. Shop (A)	0.15	0.12	19
	Powder Wagon (A)	0.13	0.02	85
	Outdoors (A)	ND	ND	ND
	Limit of Detection (LOD) (mg/m^3)	0.06		

Note: P(personal sample), A (area sample), mg/m^3 (milligrams per cubic meter)
ND (not detected)

TABLE V

NITRIC OXIDE/NITROGEN DIOXIDE
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Date	Job (P)	NO_x Conc. TWA (ppm)	NO_2 Conc. TWA (PPM)	NO Conc. TWA (ppm)
10/25/88	Powder Wagon	8.4	0.71	5.9
	Shuttle Car Oper.	12.2	1.30	8.4
	Shuttle Car Oper.	11.7	1.40	7.9
10/26/88	Drill Operator.	8.8	1.00	6.0
	Shuttle Car Operator	10.2	1.10	7.0

NOTES: P (personal samples), NO_x (total oxides of nitrogen), NO_2 (nitrogen dioxide), NO (nitric oxide), ppm (parts per million), TWA (time weighted average).

Nitric oxide (NO) is calculated from the E.D. Palmes[4] formula: $NO=NO_x-NO_2 \div 1.3$.

TABLE VI

CARBON MONOXIDE
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Date	Time	Location	Job(A)	Short Term Conc. (ppm)	Long Term Conc. (ppm)
10/25/88	0815-1055	"A" Frame	Payloader	ND	0.05
10/26/88	0735-1139	Maint. Shop	Refrig. Top	ND	7.3
	0715	23 Crosscut @ 17 Heading	Area	3.0	ND
	0739-1141	25 Crosscut @ 21 Heading	Powder Wagon	ND	5.2

ND (not detected), PPM (parts per million)

A - All samples were collected on operated equipment or in areas where equipment was operating.

TABLE VII

AIRBORNE ASBESTOS EXPOSURES
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Date	Location	Job	Ambient Concentration (f/cc)	Fiber Identification (TEM)
10/25/88	Outdoors	Area	0.01	Cellulose
	Hoist House	Hoist Oper. (P)	0.01	Cellulose
	"A" Frame	Payloader (A)	Void	Void
	Mill	Welder (P)	0.01	Cellulose
	Mill	Welder (P)	Void	Void
	Rock Mill	Laborer (P)	Void	Void
	Outside of Control Room	Area	0.01	Cellulose
	1-A Turbine Drive	Area	0.08	Cellulose
10/26/88	Mill	Maint.(P)	0.02	Cellulose
	Weld Shop	Maint.(P)	Void	Void
	Outdoors	Area	0.01	Cellulose
	Hoist House Ledge	Area	0.10	Cellulose
	Evaporator Bldg. 4th Floor, South	Area	0.08	Cellulose
	1-A Turbine Drive	Area	0.02	Cellulose
	Limit of Quantitation (LOQ)		0.01 f/cc	

NOTES: Void (means the sample had an excess of particulate material other than fibers and a fiber count or identification could not be made).

F/cc (fibers per cubic centimeter greater than 5 um in length), TEM (transmission electron microscope), P (personal), A (area)

TABLE VIII

BULK ASBESTOS ANALYSIS
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Location	Type Sample	Type Asbestos	Approx. Percent
Control Room (EB)	Vac	Amosite	< 1
Hoist House Ledge	Vac	-------	ND
Near Control Room (EB)	Vac	-------	ND
1-A Turbine Drive (EB)	Vac	Chrysotile	5 to 10
Insulation "A" Filter (EB)	Bulk	Chrysotile	10 to 20
Insulation 1-A Turbine Drive	Bulk	Chrysotile	40 to 50
Transite Siding Hoist House	Bulk	Chrysotile	60 to 70
4th Flr. South Side (EB)	Vac	Chrysotile	< 1

Notes: Evaporator Building (EB), None Detected (ND), Vacuum Sample (VAC), Bulk Materials (BULK)

TABLE IX

SUMMARY SHEET
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

Agent	Number of Samples	Concentration Range	MSHA TLV	NIOSH REL
Coal Tar Pitch Volatiles (UG)	5	ND	0.2 (TWA)	0.1 (TWA)
PNA's (UG)	5	ND to 0.2 mg/m^3	none	none
Diesel Particulates (UG)	5	ND to 0.19 mg/m^3	none	none
Nitric Oxide (UG)(PD)	5	8.4 to 12.2 ppm	25 (TWA)	25 (TWA)
Nitrogen Dioxide (UG)(PD)	5	0.71 to 1.4 ppm	5(C)	1(C)
Nitrogen Dioxide (UG)(ST)	1	0.8 ppm	5(C)	1(C)
Carbon Monoxide (UG)(LT)	3	0.05 to 7.3 ppm	50 (TWA)	35 (TWA)
Carbon Monoxide (UG)(ST)	4	ND to 3.0 ppm	50 (TWA)	35 (TWA)
Asbestos (S)	14	0.01 to 0.1 f/cc	2.0 f/cc (TWA)	0.1 f/cc (TWA)

Note: ND - none detected
LT - long term tube
ST - Short term tube
UG - underground
S - surface
C - ceiling
TWA - time weighted average
F/cc - fibers per cubic centimeter greater than 5 um in length
Mg/m^3 - milligrams per cubic meter
PPM - parts per million
PD - passive dosimeter

Table X

DEMOGRAPHIC CHARACTERISTICS BY SMOKING AND CURRENT JOB

American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

	SMOKERS		EX-SMOKERS		NONSMOKERS	
	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE
	N = 1 MEAN (SD)	N = 15 MEAN (SD)	N = 0	N = 10 MEAN (SD)	N = 1 MEAN (SD)	N = 20 MEAN (SD)
AGE	28 (-)	45 (11.4)		44 (10.8)	37 (-)	36 (9.1)
HEIGHT (cm)	177 (-)	174 (5.6)		177 (4.7)	169 (-)	174 (10.6)
	%	%		%	%	%
RACE WHITE	100	100 (2H)		100	100	95 (2H)
BLACK	-	-		-	-	5
SEX MALE	100	93		90	-	75
FEMALE	-	7		10	100	25

H denotes Hispanic origin

Table XI

PERCENTAGE REPORTING CHRONIC SYMPTOMS BY SMOKING STATUS
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

	AMERICAN SALT COMPANY			BLUE COLLAR STUDY		
	SMOKERS	EX-SMOKERS	NONSMOKERS	SMOKERS	EX-SMOKERS	NONSMOKERS
CHRONIC COUGH	31 (5/16)	20 (2/10)	29 (6/21)	19.5	8.2	7.8
CHRONIC PHLEGM	21 (3/14)	40 (4/10)	29 (6/21)	17.7	13.1	7.6
CHRONIC SHORTNESS OF BREATH	6 (1/16)	10 (1/10)	0 (0/21)	3.4	3.4	1.6

Table XII

ACUTE SYMPTOMS
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

SYMPTOMS	NEVER/RARELY		SOMETIMES		OFTEN	
	N	%	N	%	N	%
COUGH	21	45	23	49	3	6
NOSE TICKLED/IRRITATED	15	32	24	51	8	17
SNEEZE	19	40	22	47	6	13
EYES ITCH/BURN	22	47	19	40	6	13
TEARING OF THE EYES	21	45	19	40	7	15
SORE THROAT	35	75	11	23	1	2
DIFFICULT/LABORED BREATHING	35	75	9	19	3	6
TIGHT/CONSTRICTED CHEST	39	83	5	11	3	6
UPSET STOMACH	37	79	8	17	2	4
CHEST SOUND WHEEZING/WHISTLING	39	83	5	11	3	6
HEADACHE	27	57	15	32	5	11

	YES	NO	% YES
OTHER MEDICAL COMPLAINTS RELATED TO JOB?	8	39	17

Number of Workers 47

Table XIII

PULMONARY FUNCTION TEST RESULTS VS SMOKING STATUS
American Salt Company
Lyons, Kansas

October 25-26, 1988
RDHETA 88-390

	SMOKING STATUS					
	NEVER N = 21		EX N = 10		CURRENT N = 16	
	MEAN	SD	MEAN	SD	MEAN	SD
FVC	4.91	1.10	5.21	0.71	4.59	0.96
% PREDICTED FVC	110.3	18.6	110.5	12.0	105.7	22.0
FEV_1	3.90	0.88	4.19	0.53	3.45	0.92
% PREDICTED FEV_1	105.0	15.6	108.6	11.2	96.9	27.8
FEV_1/FVC RATIO	79.7	5.7	80.5	4.2	74.2	10.3