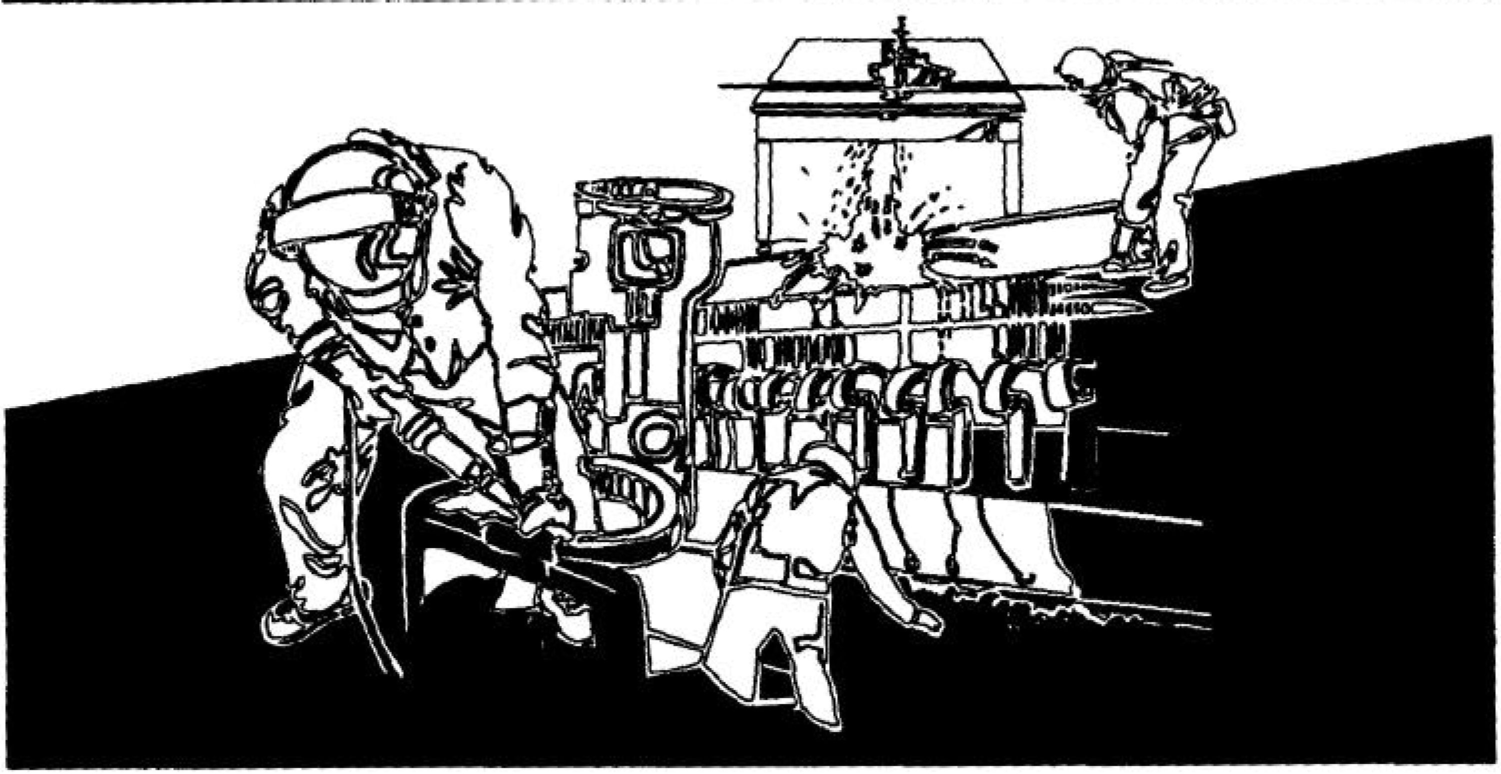
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 88-388-2155
MORTON SALT COMPANY
GRANDE SALINE, TEXAS

REVISED



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

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.

HETA 88-388-2155
MORTON SALT COMPANY
GRANDE SALINE, TEXAS
NOVEMBER 1991
REVISED APRIL 1993

NIOSH INVESTIGATORS
RICK P. FERGUSON, IHIT
ELIZABETH B. KNUTTI, RN

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 (HHE) 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 5, 1988, NIOSH conducted a walk-through survey at the Morton Salt Mine and Mill located in Grande Saline, Texas. On October 31 through November 1, 1988, medical and environmental evaluations were conducted at the mine and mill. The environmental evaluations consisted of personal breathing zone and area air samples collected for sub-micron particulate, the solvent soluble portion of airborne particulate, polynuclear aromatic hydrocarbons (PNAs), oxides of nitrogen (NO, NO_2), carbon monoxide, and asbestos.

Ten air samples of particulate were collected and subsequently analyzed for solvent soluble portions. Four of the ten samples were below detectable limits (ND). The remaining six sample concentrations ranged from 0.1 to 0.17 milligrams per cubic meter of air (mg/m^3). Three samples for sub-micron size particulate ranged from 0.20 to 0.27 mg/m^3. These data and observation of work activities indicate that there was exposure to diesel exhaust and, since NIOSH considers diesel exhaust to be a potential carcinogen, this work exposure represented a potential hazard. MSHA does not enforce a PEL for the solvent soluble portion of diesel particulate resulting from diesel combustion.

Seven full-shift personal NO_2 samples were collected on equipment operators. Concentrations ranged from 0.47 to 1.4 parts per million with a mean exposure level of 0.8 parts per million. Three of the seven full-shift samples exceeded NIOSH's ceiling REL of one part per million. None of the samples exceeded the MSHA Ceiling Standard, 5 ppm.

Airborne asbestos was not detected in 15 airborne samples collected in the mill area. However, chrysotile asbestos was identified in one of six bulk samples collected from various areas of the mill. The sample was taken from duct insulation.

The medical evaluation consisted of a Medical Research Council (MRC) questionnaire on respiratory symptoms, smoking habits, demographic information and work history; a chest x-ray; and pulmonary function test. Forty-eight employees, 44 males and 4 females, participated in the medical evaluation. All were employed in surface jobs. Fourteen employees were smokers, fourteen were ex-smokers, and 20 claimed to have never smoked. The prevalence of chronic cough (17%) and chronic phlegm (19%) reported by Morton Salt workers were not significant when compared to a group of non-exposed blue collar workers. Pulmonary function tests did show decreased FEV_1 values for current smokers. Pulmonary function results showed six workers with mild obstruction and two with

moderate obstruction. There were three cases of mild restriction of lung volume. Of 47 chest x-rays, one employee had a median reading of 1/1. This person also showed a moderate obstruction on the pulmonary function test.

A potential hazard from exposure to diesel exhaust and NO2 was identified. There were no overexposure per MSHA Standards. There were no airborne asbestos exposures detected in the mill, but asbestos was identified in some of the duct insulation. Recommendations to reduce these occupational exposures can be found in section VII of the report.

KEYWORDS: SIC 1479 (Salt Mines), Diesel Exhaust, PNAs, Asbestos, 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 a health hazard evaluation from the International Chemical Workers Union (ICWU) located in Akron, Ohio. NIOSH was requested 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 requested to evaluate the synergistic effects of exposure to asbestos/diesel. The synergistic effects were not evaluated because of insufficient numbers of people with exposures to the substances of concern. On April 5, 1988, NIOSH conducted a walk-through survey at the Morton Salt mine and mill located in Grande Saline, Texas. The walk-through was used to help determine potential exposures to the ICWU workforce and to assist in the planning of the medical and environmental evaluations to be conducted at the mine and mill. The environmental and medical evaluations were conducted at this mine and mill (Morton Salt) on October 31 through November 1, 1988.

III. Background

There are several methods of salt production and the one used depends on climate, the character of the deposit and the type salt required by the user. The three methods used by Morton Salt at its operations are solar evaporation, rock salt mining and vacuum pan evaporation.[1] Only the latter two methods are used at the Grande Saline facility. Solar salt is primarily used for agricultural products, water softening and ice control. Solar evaporation is the oldest method of salt production. The second oldest method and safest is mining.

At Morton Salt in Grande Saline, the salt is found in large domes. These salt domes were formed when the earth pressures forced salt up through the cracks from depths as great as 30,000 or 40,000 feet. Domes are circular in shape and from a few hundred yards to a mile across.

To enter a salt mine, miners go down a shaft to the salt bed. One side of this shaft is used to transport miners and the other side is used for materials and equipment and hoisting up mined salt. These shafts are usually 12 to 18 feet across. Salt is normally mined by the room and pillar method, where solid salt pillars are left for roof support. At Morton Salt, the room height was 85 to 90 feet and the haulage ways for transport vehicles was 25 to 40 feet wide. The volume of air moving through these rooms during this survey, per management measurements, was 200,000 cubic feet per minute (cfm).

The first step in the mining process is undercutting. Undercutting is accomplished by using an electrically driven machine to cut a 10 foot deep slot under a salt wall. This leaves a smooth floor for picking up the salt after blasting. Next, holes are drilled into the salt wall to a depth of 10 feet or more and explosives are tamped in. At the end of the work shift, the explosives are detonated. Morton Salt works two shifts five days a week; day and afternoon. There were 12 miners on the day shift and five on the afternoon shift. During the survey, Morton Salt had four pieces of diesel equipment operating. These included two loaders and two transport vehicles. The transport vehicles haul the salt to a combination crusher/feeder which puts the salt onto a conveyor belt. The conveyor belt carries the salt to a series of crushing and screening stations for sizing and then to a storage bin where salt is stored until it is hoisted to the surface. The salt is hoisted to the surface in "skips" (large bins) dumped onto a conveyor belt, and transported to surface bins/silos for storage until further processing.

The above ground processing of rock salt consists of sorting the mined salt which is 98% pure, into various marketable sizes. When sized, the salt is packaged for shipping by rail or trucks.

The last means of salt production used by Morton Salt is vacuum pan production. This is evaporation of a salt brine by steam heat using large commercial evaporators. Salt is mixed with water, making a salt brine. The brine is pumped into vacuum pans, which are closed vessels three stories high; they are arranged in a series of three to five, with each one in the series under a greater vacuum than the previous one. The principle of operation involves lowering the pressure, and thereby the temperature at which water boils. Consequently, each succeeding pan boils at a lower temperature because it has a lower pressure. The boiling brine from the first pan is then used in the second pan to start the brine boiling, then the third pan, and so forth. Boiled brine is then pulled off as a slurry through a filter dryer where heat removes the moisture and dries the salt. Evaporated salt from this process is used as table salt, in food processing, as a chemical, and for water softening.

IV. Methods

A. Environmental

On October 31 through November 1, 1988, environmental samples were collected at the mine and mill on the day shift for exposures to the solvent soluble portion of diesel particulate, polynuclear aromatic hydrocarbons (PNAs), diesel particulate, nitric oxide (NO), nitrogen dioxide (NO_2), carbon monoxide (CO) and asbestos. At the mine, full-shift personal samples were collected for NO/NO_2 and diesel particulate. Full-shift area samples for the solvent soluble portion of diesel particulate and PNAs were collected on the equipment. Partial-shift samples for carbon monoxide were collected on the equipment for four hours using solid sorbent 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 mainly 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.[2] Connected to the filter was an Orbo-43 solid sorbent tube. The solvent soluble portion of airborne particulate samples (reference NIOSH Method 5203 for Coal Tar Pitch Volatiles) were collected at the same flow rate as the

PNA samples and with the same type filter, except that this sampler did not include the sorbent tube.[2] The sub-micron particulate were collected with a 1-stage, single-jet impactor that is inserted into a respirable dust sampling train (cyclone followed by an impactor followed by a filter). 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 containing four holes approximately 0.64 cm in diameter at 90° apart, and 1.14 cm from the plate's center. Air is pulled through the cyclone, impactor and filter at a flow rate of 2.0 lpm.[3]

Nitric oxide and nitrogen dioxide were collected using the Palmes[4,5] 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 per minute in-line with a Drager long-term tube.[6]

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.[2] Settled dust samples for asbestos were collected using a sampling pump calibrated at a flow rate of 4.0 lpm in-line with a 37 mm, two piece cassette containing a mixed cellulose ester filter with a backup pad. Preceding the filter, a plastic disposable syringe tip was used as a vacuum nozzle to collect the dust. This syringe tip was changed each time a sample was collected. The methods used to analyze the mine and mill environment are summarized in Table I.[2,3,4,5,6]

B. Medical

All employees of the Morton Salt Company in Grande Saline, Texas were asked to participate in the medical portion of the health hazard evaluation.

A mobile trailer equipped with spirometers and an x-ray machine was parked at the mine site and used for the medical survey. After receiving an explanation of the tests and consenting 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 (see 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. "Chronic shortness of breath" was considered present if the subject answered yes to having to stop for breath when walking at his/her own pace on level ground [Medical Research Council 1960].[7]

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 BTPS (body temperature, pressure, saturated with water vapor). 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).[8]

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 ILO International Classification of Radiographs of the Pneumoconioses.[9] 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. If there was a disagreement between the first two readings, a third reading was obtained and the median profusion of the three readings was used for analysis. A chest radiograph was defined as positive for pneumoconiosis if at least two of the three "B" readers categorized small opacity profusion as 1/0 or greater.

To examine for the potential acute respiratory effects from occupational exposures at the Morton Salt Company, the participants were compared with workers in non-exposed blue-collar occupations. Likelihood ratio tests for goodness-of-fit were used to compare the responses to questions about chronic cough and chronic phlegm to the prevalence expected if the workers at the Morton Salt mine had the same symptom prevalence reported by the non-exposed blue-collar workers.[10] Knowledge of each employee's smoking history was used to calculate the expected prevalence of these respiratory symptoms. Percent predicted pulmonary function values were calculated using Knudson's prediction equations.[11] 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. The effect of smoking status on pulmonary function values was investigated using an analysis of variance.

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 the MSHA Standards. (These MSHA Standards are adopted from the 1973 ACGIH TLV's)[12]. 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 (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.

Diesel Particulate/Polynuclear Aromatic Hydrocarbons

Emission 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. Particulate in diesel exhaust are composed of solid carbons (soot) which tend to form clusters during combustion. More than 95% of these particulate are less than one micrometer in size.[13] It has been estimated that as many as 18,000 different substances from the combustion process can be adsorbed onto diesel exhaust particulate.[14] This adsorbed material contains 15% to 65% of the total particulate mass and includes such compounds as polynuclear aromatic hydrocarbons (PNAs). Among the PNAs are a number of known mutagens and carcinogens.[14] The primary hydrocarbons that are suspect human carcinogens are chrysene and benzopyrene.[15,16] It has been suggested that the diesel exhaust particulate 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 suggest 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 and both gases are usually present together. At NO concentrations less than 50 ppm, this conversion is usually slow and can result in negligible quantities of nitrogen dioxide.[17] Animal experimental data indicates that nitric oxide is about one-fifth as toxic as nitrogen dioxide. At 175 ppm, guinea pigs lived for an indefinite period, while at 322 ppm, methemoglobinemia was produced in 60% of the guinea pigs.[18] 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.[18]

Nitrogen Dioxide

Nitrogen dioxide is formed from nitric oxide, 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 after a few hours upon cassation of the exposure. If exposure is long enough and the concentrations high enough, dyspnea (shortness of breath), persistent cough, cyanosis, bronchitis, and pulmonary edema can occur.[19] There have been several studies on the effects of continuous exposure at low concentrations.[18] 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 found that at 0.5 ppm for 6, 18, and 24 hour daily exposures for three to twelve months, that there was an expansion in the alveoli of the lungs. Lesions appeared as would be 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.[18]

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.[17] 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.[19] 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) indicate that this exposure resulted in increased airway resistance.[19]

Carbon Monoxide

Carbon monoxide (CO) can be formed from the incomplete combustion of petroleum based fuels. Exposure to CO decreases the ability of the blood to carry oxygen to the tissues. Typical symptoms of acute CO poisoning are headache, dizziness, fatigue and nausea.[20] High concentrations of CO may be rapidly fatal without producing significant warning symptoms. Exposure to the 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 a carboxy-hemoglobin at less than 5 percent, and 3) to prevent adverse behavioral effects.[2,21]

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. This indicates that there may not be a "safe" level of exposure to asbestos for the elimination of all cancer risk. This risk is also greatly enhanced for cigarette smoking.[22]

NIOSH currently recommends that occupational exposure to asbestos be kept to the lowest feasible level that can reliably be determined.[22,23] 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 Morton Salt, Grande Saline was minimal. Four pieces of equipment were monitored; one loader, a powder wagon, a scaler and a driller. The driller/scaler is part electric and part diesel, with the diesel portion used primarily for transportation. The latter two are operated only for brief periods of time over the work shift. Samples were however, collected on the drill rig and also in the maintenance shop near diesel equipment being repaired.

Temperatures in the mine ranged from 71° to 79°F over the shift and the volumes of air flowing through the mine, as determined from company measurements, averaged 200,000 cfm. The room height throughout the areas monitored ranged between 85 to 90 feet and the haulage ways were commonly between 25 to 40 feet wide with some points even wider. Because of the larger physical dimensions of dome salt mining, greater volumes of air are needed to move air to working sections in order to dilute/remove contaminants.

A short-term detector tube reading taken underground for nitrogen dioxide (NO_2) during the morning at 4 South was 0.1 ppm and one taken at 5 North towards the end of the shift was 2.0 ppm. Short-term detector tubes for carbon monoxide were also taken during these times. The carbon monoxide results for the morning and afternoon were below detectable limits. Elevated NO_2 concentrations in the afternoon indicate that air was not being directed to a working section in volumes necessary to dilute NO_2 buildup. Long-term NO_2 concentrations from passive dosimeters worn by diesel equipment operators over the shift were ranged from 0.47 to 1.4 ppm. All of the short-term NO_2 detector tube readings were below the MSHA Standard. However, one NO_2 short-term detector tube was above the NIOSH REL, 1 ppm as a ceiling concentration. Of seven NO_2 passive dosimeters, three were above the NIOSH Ceiling REL. None of the NO_2 passive dosimeters exceeded the MSHA Ceiling Standard, 5 ppm.

Solvent Soluble Portion of Particulate and PNA's

At the Morton Salt Grande Saline mine/mill, ten area samples were collected and analyzed for the solvent soluble portion of diesel particulate. Two outdoor samples were taken as controls and for comparison with the underground and surface samples. Both outdoor samples were below detectable limits, less than 0.05 mg/m^3. Results of six underground samples collected on the equipment ranged from 0.1 to 0.17 mg/m^3. The samples collected in the maintenance shop were below detectable limits. These results can be found in Table III and Summary Table X.

Five PNA samples were also collected; three were personal samples collected from equipment operators, one sample was collected in the maintenance shop on a welding bench that was not being used and one sample was collected outdoors, upwind of the plant. Of 16 different PNAs analyzed on each sample, six were present at detectable levels on the underground samples. These were naphthalene, acenaphthylene, acenapthene, flourene, phenanthrene, and anthracene. Naphthalene concentrations ranged from ND to 0.05 mg/m^3, well below the MSHA Standard of 50 mg/m^3. The other PNA levels were near/at the limit of detection (LOD) of the analytical procedure. No PNAs were detected outdoors.

Naphthalene, technically, is not considered a PNA because it has only two fused benzene rings (a true PNA has three or more).[24] Because naphthalene is analyzed as a PNA, it's reported with PNA compounds. The PNA concentrations found in Table IV are the sum of the gaseous state PNAs collected on the back-up sorbent tube. No particulate PNAs were collected on the filter samples. Of the six PNAs detected, phenanthrene and anthracene are considered suspect carcinogens.[14,15,21] However, phenanthrene concentrations in air were low, near analytical detection limits. Two anthracene samples did show levels above the limit of detection of the analytical procedure (0.001 mg/m^3) and indicate potential for quantifiable exposure to a carcinogen.

Sub-micron Particulate

Three personal breathing zone samples which measured particulate matter less than 1 micrometer in diameter were collected from the operations of the driller, loader, and scaler. Diesel particulate has been shown to be in the submicrometer range, thus having the potential for reaching the lower airways of the lung. Measurements for sub-micron particulate ranged from 0.20 to 0.27 mg/m^3. In an attempt to determine or verify what percentage of the submicrometer particles collected was actually of organic/diesel origin, the filters were subjected to low temperature ashing (LTA) per NIOSH Analytical Method 7500.[2] Table V contains the results of sampling for sub-micron particulate.

Nitric Oxide

Seven personal, full-shift samples for nitric oxide were collected on equipment operators. The personal, time-weighted average (TWA) concentrations ranged from 2.3 to 7.0 ppm. None of the samples exceeded the MSHA Standard or NIOSH REL of 25 ppm. The results are found in Table VI and Table X.

Nitrogen Dioxide

At Morton Salt Grande Saline, seven full-shift personal samples for nitrogen dioxide were collected on the equipment operators. NO_2 concentration from these seven personal samples ranged from 0.47 to 1.4 ppm with a mean exposure of 0.8 ppm. The TWA sampling results indicate NO_2 concentrations exceeding NIOSH's ceiling REL of one ppm; three of the seven full-shift NO_2 samples exceeded the NIOSH ceiling limit (Table VI). A short-term detector tube reading taken for NO_2 in the afternoon (5 North) indicated an elevated reading (2.0 ppm) from the morning sample collected at the same location (0.1 ppm). None of the samples exceeded MSHA evaluation criteria, 5 ppm as a ceiling concentration.

Carbon Monoxide

Because of the limited use of diesel equipment at Morton Salt, only one short-term detector tube was taken for CO; no CO was detected. Seven long-term detector tubes collected for a period of four hours for carbon monoxide found levels ranging from 1.2 to 2.6 ppm. Sample results are found in Table VII and in Summary Table X. None of the samples exceeded NIOSH/MSHA evaluation criteria.

Asbestos

Fifteen airborne samples, seven personal and eight area, were collected for asbestos in the mill, outdoors, and in the hoist house. Six bulk samples of material thought to contain asbestos were also collected. The airborne samples were analyzed by transmission electron microscopy (TEM). The concentration of fibers on the personal and area samples ranged from 0.01 to 0.06 fibers per cubic centimeter (f/cc). Asbestos fibers were not found on any of the airborne samples, only brucite and cellulose fibers were detected. (Table VIII).

One of the six bulk asbestos samples, taken throughout the KCL (1st/3rd floor), contained asbestos; a less than 1% concentration of chrysotile asbestos was detected in a duct insulation sample.(Table IX).

B. Medical

About one-third of the workforce or forty-eight employees, 44 males and 4 females, participated in the medical survey. All were employed in surface jobs. Fourteen (29%) were smokers, 14 (29%) were ex-smokers, and 20 (42%) claimed to have never smoked (Table XI).

Questionnaire results indicated similar prevalence of chronic symptoms among the nonsmokers and ex-smokers, but smokers had three times the nonsmoker's complaints for chronic cough and chronic phlegm. All groups reported no problems with shortness of breath. The prevalence of chronic cough (17%) and chronic phlegm (19%) reported by the workers were not significantly different than those reported in a group of non-exposed blue-collar workers (Table XII). When asked about acute symptoms related to their work, the responses for "often" ranged from zero for sore throat to 15% for nose irritation (Table XIII).

Of the 47 chest films of participating workers, one had a median reading of 1/1 for irregular shaped opacities, and also showed a moderate obstruction on the pulmonary function test. However, this worker had a very short tenure with this company, so it is unlikely that the pneumoconiosis occurred from exposures at this plant.

Pulmonary function results showed six workers with mild obstruction and two with moderate obstruction. The cases were split evenly above and below age 40. There were three cases of mild restriction, all occurring in the over 40 age group. A moderate obstruction is defined as a FEV_1/FVC ratio between 45 and 60%; the mild obstructive pattern has a ratio between 61 and 69%. 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 restrictive, the FVC observed/FVC predicted percent would fall in the 66 to 79% range. Current smokers did have a significantly lower mean FVC and mean FEV_1/FVC ratio than nonsmokers and a significantly lower mean FEV_1 than ex and nonsmokers (Table XIV).

VII. Conclusions/ Recommendations

A. Environmental

A potential health hazard from exposure to diesel exhaust and NO2 was identified. There were no over exposures per MSHA Standards. No workers should be exposed to NO_2 above the NIOSH REL of one ppm.[18,19] Nitrogen dioxide is a by-product from the combustion of fossil fuels, such as diesel. Its presence above 1 ppm is indicative that more dilution ventilation is needed.

Because of the limitations in diesel technology, we can not confidently recommend control measures that would completely eliminate the exposures to diesel exhaust. It is NIOSH's position that diesel exhaust is a potential occupational carcinogen[14,15,21]. There is no safe or threshold concentration for occupational exposure to carcinogens at this time. However, the following recommendations should minimize these exposures and the related occupational health risk: (1) increase the volume of air in the working sections of the mine using portable fans with brattice cloth extensions to direct the air flow better, (2) continue scheduled engine maintenance, and (3) install engineering controls (scrubbers, filters, catalytical purifiers) to help reduce pollutants emitted.

Asbestos was not found in any of the airborne samples or settled dust samples and this indicates effective ongoing asbestos abatement programs, both in-house and through its private contractors. It was apparent from visual observations and the conditions of existing materials in the mill area that Morton Salt had gone through some extensive repair/removal in the past.

B. Medical

When compared to a group of non-exposed blue-collar workers the prevalence of chronic cough and phlegm reported by the workers were not significantly different. However, current smokers had three times the non- and ex-smokers complaints of chronic cough and phlegm.

Radiographic evidence of pneumoconiosis was found in one of the forty-seven participating workers. However, this worker had a very short tenure with this company, so it is unlikely that the pneumoconiosis occurred from exposures at this plant.

Three participants had a restricted volume. Eight participants showed an obstructive lung disease pattern or 16.7% of the participants, compared to 8.1% observed in a group of non-exposed blue-collar workers. Four of the participants with obstruction and one of the three with restriction were current smokers. Since four of the workers with ventilatory impairments had never smoked, the impairments cannot be attributed solely to tobacco exposure. All the mean FVC and FEV_1 percent predicted values were greater than 100% for all smoking categories except current smokers who had a mean FEV_1 percent predicted of 92.3%.

VIII. References

1. Morton Salt Company. Salt Today and Yesterday. Chicago, IL.

2. NIOSH (1986). NIOSH Manual of Analytical Methods, 3rd Edition, U.S. Dept. of Health and Human Services, PHS, CDC, NIOSH Pub. No. 84-1000.

3. Cocalis, J. et al., The Diesel Fraction of Respirable Dust in Underground Diesel Coal Mines. Proceedings of the 18th Annual Institute on Coal Mining Health, Safety and Research, pp.63-75, Blacksburg, Va., August 1987.

4. Palmes, E.D. et al, Personal Sampler for Nitrogen Dioxide, American Industrial Hygiene Association Journal, No. 37, 570-577, 1976.

5. Palmes, E.D., et al, Personal Sampler for NO_x, American Industrial Hygiene Association Journal, No. 40, 588-91, 1979.

6. Detector Tube Handbook, Air Investigations and Technical Gas Analysis With Drager Tubes, 6th edition, 1985.

7. Medical Research Council's Committee on the Etiology of Chronic Bronchitis (1960): Standardized questionnaire on respiratory symptoms. Br Med J 2:1665.

8. American Thoracic Society (1987): Standardization of Spirometry - 1987 update. Am Rev Respir Dis 1987; 136:1285-1298.

9. International Labour Office (1980): Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconiosis. Revised ed. 1980. Geneva, Switzerland: International Labour Office, 1980 (International Labour Office Occupational Safety and Health Series No. 22, Rev 80).

10. Petersen MR, Castellan RM (1984): Prevalence of Chest Symptoms in Non-Exposed Blue-Collar Workers. J. Occup. Med. 26:367-374.

11. Knudson RJ, Lebowitz MD, Holberg CJ, Burrows B. Changes in the Normal Maximal Expiratory Flow-Volume Curve with Growth and Aging. Am Rev Respir Dis 1983; 127:725-34.

12. ACGIH 1973. Threshold Limit Values for Chemical Substances in the Workroom Air Adopted by ACGIH for 1973, Cincinnati, OH. American Conference of Governmental Industrial Hygienists.

13. McCawley M, Cocalis J [1986]. Diesel Particulate Measurement Techniques for Use with Ventilation Control Strategies in Underground Coal Mines. In: Wheeler R, ed. International Conference on the Health of Miners. Annals of the American Conference of Governmental Industrial Hygienists 14:271-281.

14. NIOSH. Current Intelligence Bulletin #50: Carcinogenic Effects of Exposure to Diesel Exhaust. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, August 1988.

15. CRC. Handbook of Identified Carcinogens and Noncarcinogens, CRC Press, Vol. 1, 1984.

16. ACGIH. Health Effects of Diesel Exhaust - A Case Study in Risk Assessment. Annals of American Conference of Governmental Industrial Hygienists, Vol. 13, 1985.

17. Wade, H., Elkins, H., Rustolo, B. Archives Industrial Hygiene Occupational Medicine 1:81, 1950.

18. ACGIH. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th edition, 1986. Cincinnati, OH.

19. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Oxides of Nitrogen. DHEW Publication No. 76-149.

20. NIOSH. Occupational Diseases: A Guide to their Recognition, Publication No. 77-181, June 1977.

21. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Coal Tar Products. DHEW (NIOSH) Publication No. 78-107.

22. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Asbestos. Cincinnati, OH. NIOSH Publication No. 77-169, 1977.

23. NIOSH. Recommendations for Occupational Safety and Health - Compendium of Policy Documents and Statements. U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, January, 1992.

24. Rom, W., et al, Environmental and occupational Medicine. 2nd ed., Little, Brown and Company, Boston, 1983.

IX. Authorship and Acknowledgements

Evaluation Conducted and Report Prepared by:	Rick Ferguson, IHIT Elizabeth Knutti, RN
Statistical Analysis:	Kathleen B. Kinsley
Originating Office:	Respiratory Disease Hazard Evaluation and Technical Assistance Clinical Investigation Branch Division of Respiratory Disease Studies National Institute for Occupational Safety and Health Morgantown, West Virginia 26505

X. Distribution of Report

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45526 (513) 533-8287. To expedite your request, please include a self-addressed mailing label with your written request. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161 (703) 487-4650. Information regarding its availability through NTIS can be obtained from NIOSH Publication Office at the Cincinnati address.

Copies of this report have been sent to:

Safety Director, Morton Salt Grande Saline, Texas
ICWU, Akron, Ohio
ICWU, Local # 3
MSHA District Office, Texas
Salt Institute, Alexandria, Virginia
NIOSH Regional Office IV

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.

Mention of brand names does not constitute endorsement by NIOSH, CDC, USPHS, or DHHS.

TABLE I

SAMPLING AND ANALYTICAL TECHNIQUES

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31 - NOVEMBER 1, 1990
HETA 88-388

Agent/Substance Sampled	Sample Flow Rate(lpm)	Sampling Media	Analytical Method and Reference
Soluble Particulate	2.0	PTFE Laminated Membrane Filter	NIOSH Method 5023 Using Benzene as Extractor[2]
Polynuclear Aromatic Hydrocarbons	2.0	PTFE Filter/Orbo-43 Solid Sorbent Tube	NIOSH Method 5515/Gas Chromatography FID[2]
Sub-micron Particulate	2.0	Cyclone/Impactor PVC Filter	Gravimetric/LTA[3] Cocalis, J. et al[3]
Oxides of Nitrogen (NO_x, NO, NO_2)	---	Chromic acid disc Triethanolamine (Passive Dosimeter)	Visible Absorption Spectrophotometry[4,5]
Nitrogen Dioxide	100 cc/stroke	Short-Term Detector Tube	Direct Reading[6]
Carbon Monoxide	0.02	Long-Term Detector Tube	Direct Reading[6]
Carbon Monoxide	100 cc/stroke	Short-Term Detector Tube	Direct Reading[6]
Asbestos	2.0	Mixed Cellulose Ester Filter, Pore Size 0.8 um 25 mm Diameter	NIOSH Methods 7400/7402, Using "A" Rules[2]

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

TABLE II

EVALUATION CRITERIA

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31 - NOVEMBER 1, 1988
HETA 88-388

Substance	NIOSH[23]	MSHA STANDARD[12]
Diesel Exhaust	Lowest feasible conc.	None
PNAs	Lowest feasible conc.	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	2.0 f/cc

NOTE: References are listed in Section VII of this report.
Note: C (ceiling), TWA (time weighted average), f/cc (fibers per cubic centimeter greater than 5 um in length).

TABLE III

SOLVENT SOLUBLE PORTION OF AIRBORNE PARTICULATE[1]

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31 - NOVEMBER 1, 1988
HETA 88-388

Date	Location	Job(A)	Concentration (mg/m^3)
10/31/88	Loader 0485	Beside Operator	0.10
	Loader 0182	Beside Operator	0.13
	Powder Wagon	Beside Operator	0.10
	Maint. Shop	Spot Weld Bench	ND
	Outdoors	Upwind of Plant	ND
11/01/88	Loader 0485	Beside Operator	0.17
	Loader 0182	Beside Operator	0.16
	Powder Wagon	Beside Operator	0.11
	Maint. Shop	On I-Beam	ND
	Outdoors	Upwind of Plant	ND
	Limit of Detection (LOD) (mg/m^3)		0.05

ND - (not detected), mg/m^3 (milligrams per cubic meter)

A - All samples were area samples.

[1] - This measurement was obtained by use of the NIOSH Analytical Method #5023 for Coal Tar Pitch Volatiles.

TABLE IV

POLYNUCLEAR AROMATIC HYDROCARBONS

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31 - NOVEMBER 1, 1988
HETA 88-388

Date	Job/Location(A)	Naphthalene (mg/m^3)	Acenaphthylene (mg/m^3)	Acenapthene (mg/m^3)	Fluorene (mg/m^3)	Phenanthrene (mg/m^3)	Anthracene (mg/m^3)
10/31/88	Outdoors (A)	ND	ND	ND	ND	ND	ND
	Maint. Shop (A) at Spot Weld Bench	0.03	0.002	0.001	0.01	0.001	0.01
11/01/88	Loader Oper.(P)	0.01	ND	ND	ND	ND	0.001
	Driller Oper.(P)	0.04	0.003	0.001	0.002	0.002	0.009
	Loader Oper.(P)	0.05	0.003	0.001	0.002	0.002	0.001
	Limit of Detection (LOD) (mg/m^3)	0.001	0.001	0.001	0.001	0.001	0.001

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

Of 16 PNAs analyzed on each sample, six were detected. Only Naphthalene has an exposure limit of 50 mg/m^3 per the MSHA Standard. The 16 PNAs 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 V

PARTICULATE

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31-NOVEMBER 1, 1988
HETA 88-388

Date	Job (P)	Sub-micron Particulate (TWA) (mg/m^3)	% of Measured Particulate Lost after LTA
10/31/88	Driller Operator	0.21	53
	Loader Operator	0.20	83
	Scaler Operator	0.27	48
	Limit of Detection (LOD) (mg/m^3)	0.06	

Note: P(personal sample), mg/m^3 (milligrams per cubic meter).
No samples were collected on 11/01/88.
LTA - Low Temperature Ashing

TABLE VI

NITRIC OXIDE/NITROGEN DIOXIDE

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31-NOVEMBER 1, 1988
HETA 88-388

Date	Job (P)	NO_x Conc. TWA (ppm)	NO_2 Conc. TWA (ppm)	NO Conc. TWA (ppm)
10/31/88				
	Loader Oper.	4.7	0.49	3.2
	Driller Oper.	4.1	0.50	2.8
	Scaler Oper.	5.4	0.61	3.7
	Loader Oper.	3.5	0.47	2.3
11/01/88				
	Loader Oper.	10.5	1.40	7.0
	Driller Oper.	6.5	1.00	4.2
	Loader Oper.	9.0	1.20	6.0

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[5] formula: $NO = NO_x - NO_2 \div 1.3$.

TABLE VII

CARBON MONOXIDE

MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31- NOVEMBER 1, 1988
HETA 88-388

Date	Time	Location	Job	Conc. (ppm) Short Term	Conc. (ppm) Long Term
10/31/88	0721	4th South	Area	ND	NT
	0740-1135	Maint.Shop	Area	NT	1.9
	0740-1140	Powder Wagon	Area	NT	2.1
	0735-1145	Loader 0182	Area	NT	1.6
	1130-1440	Loader 0485	Area	NT	2.6
11/01/88	0800-1500	Loader 0182	Area	NT	2.4
	0800-1500	Maint.Shop	Area	NT	1.2
	0800-1450	Powder Wagon	Area	NT	1.2

NT (none taken), ND (none detected), ppm (parts per million)

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

TABLE VIII

AIRBORNE ASBESTOS EXPOSURES

MORTON SALT COMPANY
GRANDE SALINE, TEXAS
OCTOBER 31-NOVEMBER 1, 1988
HETA 88-388

Date	Location	Job	Ambient Concentration f/cc	Fiber Identification (TEM)
10/31/88	Mill	Pan Oper.(P)	0.02	Cellulose
	Mill	Relief Oper.(P)	0.05	Cellulose
	Hoist House	Hoist Oper.(P)	0.01	Cellulose
	Outdoors	Front end Loader (A)	0.02	Cellulose
	Maint.Shop	Area	0.01	Cellulose
	Outdoors	Area	0.01	None Detected
	Mill (3rd Flr)	KCL Shaker (A)	0.01	Brucite
	Mill (1st Flr)	Lower KCL (A)	0.01	Cellulose
11/01/88	Brine Fill	Laborer (P)	0.02	Cellulose
	Mill	Boiler Oper.(P)	0.01	Cellulose
	Mill	Mechanic (P)	0.06	Cellulose
	Mill	Fan Room (A)	0.01	Cellulose
	Mill	Pan Oper. (P)	Void	Void
	Hoist House	Area	0.01	Cellulose
	Mill (1st Flr)	KCL (A)	Void	Void
	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), A (area), P (personal), TEM (transmission electron microscope).

TABLE IX

BULK ASBESTOS ANALYSIS
MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31-NOVEMBER 1, 1988
HETA 88-388

Location	Sample	Type Asbestos or Material	Approx. Percent
KCL (3rd Flr)	Vac	ND	ND
Fan Duct Insulation KCL (3rd Flr)	Bulk	ND	ND
Duct Insulation KCL (1st Flr)	Bulk	Chrysotile	<1
Repaired Pipe Insulation	Bulk	ND	ND
Repaired Pipe Insulation	Bulk	ND	ND
KCL (1st Flr)	Vac	ND	ND

ND (none detected), Vac (vacuum dust sample), Bulk (piece of material).

TABLE X

SUMMARY SHEET
MORTON SALT COMPANY
GRANDE SALINE, TEXAS

OCTOBER 31-NOVEMBER 1, 1988
HETA 88-388

Agent	Number of Samples	Concentration Range	MSHA TLV	NIOSH REL
Soluble Diesel Particulate (UG)	10	ND to 0.17 mg/m^3	none	none
PNAs (UG)	5	ND to 0.05 mg/m^3	none	LFL
Diesel Particulate (UG)	3	0.20 to 0.27 mg/m^3	none	LFL
Nitric Oxide (UG)(PD)	7	2.3 to 7.0 ppm	25 (TWA)	25 (TWA)
Nitrogen Dioxide (UG)(PD)	7	0.47 to 1.4 ppm	5(C)	1(C)
Nitrogen Dioxide (UG)(ST)	2	0.1 to 2.0 ppm	5(C)	1(C)
Carbon Monoxide (UG)(LT)	7	1.2 to 2.6 ppm	50 (TWA)	35 (TWA)
Carbon Monoxide (UG)(ST)	2	ND	50 (TWA)	35 (TWA)
Asbestos (S)	15	0.01 to 0.06 f/cc	2 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
LFL - lowest feasible level

TABLE XI

DEMOGRAPHIC CHARACTERISTICS BY SMOKING
MEAN (SD)

MORTON SALT COMPANY
GRANDE SALINE, TEXAS
HETA 88-388

	SMOKERS		EX-SMOKERS		NONSMOKERS	
	N - 14 MEAN (SD)		N - 14 MEAN (SD)		N - 20 MEAN (SD)	
AGE	39	(8.2)	45	(10.1)	34	(9.4)
HEIGHT (CM)	170	(8.3)	177	(5.7)	177	(7.9)
	%		%		%	
RACE WHITE BLACK	 93 7		 93 7		 100 (1 HISPANIC) --	
SEX MALE FEMALE	 71 29		 100 --		 100 --	

TABLE XII

PERCENTAGE REPORTING CHRONIC SYMPTOMS BY SMOKING STATUS

MORTON SALT COMPANY
GRANDE SALINE, TEXAS
HETA 88-388

	MORTON SALT MINE			BLUE COLLAR STUDY		
	SMOKERS	EX-SMOKERS	NONSMOKERS	SMOKERS	EX-SMOKERS	NONSMOKERS
CHRONIC COUGH	36 (5/14)	7 (1/14)	10 (2/20)	19.5	8.2	7.8
CHRONIC PHLEGM	36 (5/14)	14 (2/14)	10 (2/20)	17.7	13.1	7.6
CHRONIC SHORTNESS OF BREATH	0 (0/14)	0 (0/14)	0 (0/20)	3.4	3.4	1.6

TABLE XIII

ACUTE SYMPTOMS

MORTON SALT COMPANY
GRANDE SALINE, TEXAS
HETA 88-388

SYMPTOMS	NEVER/RARELY		SOMETIMES		OFTEN	
	N	%	N	%	N	%
COUGH	25	52	18	38	5	10
NOSE TICKLED/IRRITATED	26	54	15	31	7	15
SNEEZE	20	42	25	52	3	6
EYES ITCH/BURN	25	52	19	40	4	8
TEARING OF THE EYES	31	65	14	29	3	6
SORE THROAT	37	77	11	23	0	0
DIFFICULT/LABORED BREATHING	38	79	7	15	3	6
TIGHT/CONSTRICTED CHEST	38	79	9	19	1	2
UPSET STOMACH	39	81	8	17	1	2
CHEST SOUND WHEEZING/WHISTLING	39	81	5	10	4	8
HEADACHE	18	38	26	54	4	8

	YES	NO	% YES
OTHER MEDICAL COMPLAINTS RELATED TO JOB?	2	46	4

NUMBER OF WORKERS: 48

TABLE XIV

PFT RESULTS VS SMOKING STATUS

MORTON SALT COMPANY
GRANDE SALINE, TEXAS
HETA 88-388

	SMOKING STATUS					
	NEVER N = 20		EX N = 14		CURRENT N = 14	
	MEAN	SD	MEAN	SD	MEAN	SD
FVC	5.31	0.84	4.93	0.87	4.40	0.80
% PREDICTED FVC	105.3	13.1	104.6	19.2	103.3	11.9
FEV_1	4.25	0.68	4.02	0.73	3.25	0.68
% PREDICTED FEV_1	101.7	14.6	104.1	20.1	92.3	17.5
FEV_1/FVC RATIO	80.3	7.0	81.7	6.5	74.2	10.6

NUMBER OF WORKERS: 48