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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 (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 14, 1988, NIOSH conducted a walk-through survey at the Morton Salt Mine and Mill located on Weeks Island, Louisiana. Medical and environmental evaluations were conducted on December 1-2, 1988 at the mine and mill.

The environmental evaluations consisted of personal breathing zone and area air samples collected for sub-micron particulate, solvent soluble portion of airborne particulate, polynuclear aromatic hydrocarbons (PNAs), oxides of nitrogen (NO, NO_2), carbon monoxide, and asbestos.

Sub-micron particulate exposures ranged from 0.31 to 1.32 milligrams per cubic meter of air (mg/m^3). Low temperature ashing of these samples and observation of activities taking place during the sampling period indicates that the most significant source of these particulate was diesel exhaust. Thirteen area air samples of particulate were collected and subsequently analyzed for solvent soluble portion. Three of those 13 samples were found to be below the limit of detection for the analytical method. The remaining 10 sample concentrations ranged from 0.13 to 1.4 mg/m^3. These data indicate that there was exposure to diesel exhaust and therefore a potential health hazard since NIOSH considers diesel exhaust to be a potential carcinogen. There were no overexposures per MSHA standards.

None of the 20 personal breathing zone and area air samples collected in the mill exceeded the NIOSH REL or MSHA Standard for asbestos (0.1 and 2 fiber per cubic centimeter of air (fiber/cc), respectively). However, amosite and chrysotile asbestos were identified in one bulk sample collected from the transite siding on the boiler building.

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. All employees of the Morton Salt Mine and Mill were given the opportunity to participate in the medical portion of the health hazard evaluation. Of the approximately 208 employees, 61 (29%) participated. Thirty-nine (64%) were underground workers and the remaining 22 worked on the surface. The underground workers were slightly younger with a mean age of 39, compared to 44 for the surface workers. There were an equal number of smokers and non-smokers, 26 in each group. Nine ex-smokers (15%) accounted for the remainder of the group.

The prevalence of chronic cough (23%) and chronic phlegm (32%) reported at the Morton Salt Mine were statistically different exceeding those reported by a group of non-exposed blue-collar workers ($p < .04$). One worker complained of shortness of breath. Questionnaire results indicated increased prevalence of chronic cough and phlegm among smokers. Chronic symptoms were reported by underground workers in all smoking categories, but only by those surface workers who smoked. There were more complaints of eye irritation and tearing of the eyes in underground workers which is consistent with exposure to diesel by-products. Smoking status and current job location had no effect on mean percent predicted FVC and FEV_1. Pulmonary function results showed four workers with mild obstructive lung disease, and one with

moderate obstructive lung disease. There were also three workers with mild restriction of lung volume. Of the 61 chest films taken, none were read positive for pneumoconiosis.

A potential hazard from exposure to diesel exhaust was identified. Asbestos exposures in the mill were below detectable limits. There were no overexposures per MSHA Standards. 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, 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 (HHE) from the project director, 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 exposures to asbestos/diesel. The synergistic effects were not evaluated because of insufficient numbers of people with exposures to the substances of concern. On April 14, 1988, NIOSH conducted a walk-through survey at the Morton Salt Mine and Mill located on Weeks Island, Louisiana. 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 December 1-2, 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 methods used by Morton Salt at its Weeks Island operation is rock salt mining and vacuum pan evaporation. Next to solar salt evaporation (another method), mining is the second oldest method and safest.

At Morton Salt's Weeks Island Operation, 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 Weeks Island, the room height was 75 feet, and the haulage ways for transport vehicles was 25 to 35 feet wide. The volume of air moving through the mine during this survey, per management measurements, was 256,000 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 ten 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 ten feet or more and explosives are inserted. At the end of the work shift, the explosives are detonated. Morton Salt works three shifts, five days a week, with approximately 25 miners per shift. During the survey, Morton Salt had six pieces of diesel equipment operating. During the walk-through evaluation in April 1988, eight of the 28 pieces of diesel equipment in the mine were operating. Jeeps make up a large portion of this total number and are primarily used to transport personnel. The Load Haul Dumps (LHD's) are the primary pieces of equipment used to haul salt to the underground crusher/feeders, which in turn dump 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 area until it is ready to be hoisted to the surface. The salt is hoisted to the surface in "skips" (large bins). On the surface, the skip dumps the salt onto a conveyor belt which transports the salt for further processing.

Processing of the rock salt above ground consists of sorting the mined salt, which is 99% pure, into various marketable sizes. When sized, the salt is packaged for shipment by rail, trucks and barges.

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 in 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. Salt made from this process is used as table salt, in food processing, as a chemical, and for water softening.

IV. Methods

A. Environmental

On December 1-2, 1988, environmental samples were collected at the mine and mill on the day shift for exposures to the solvent soluble portion of airborne particulate, polynuclear aromatic hydrocarbons (PNAs), submicron 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 submicron particulates. Full-shift area samples for the solvent soluble portion of particulate (reference NIOSH method #5023 for Coal Tar Pitch Volatiles) 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 breathing zone 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 diesel particulate samples were collected at the same flow rate as the PNA samples and with the same type filter, except that it did not include the sorbent tube.[(2)] The submicron particulates 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 micron 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, 90^o 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 of the employees at the Morton Salt Company on Weeks Island, Louisiana 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 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 (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 person had 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, ambient 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 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 evaluate the potential for acute respiratory effects from occupational exposures, the workers were divided into surface and underground groups based on the location of their current job. 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 and current job location on the mean percent predicted 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 criteria in 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 Particulates/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. Particulates in diesel exhaust are composed of solid carbon (soot) which tend to form clusters during combustion. More than 95% of these particulates 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 absorbed onto diesel exhaust particulates.(14) This absorbed 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 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.(18) 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 cessation of 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 tissue. 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 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 by 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 underground at Morton Salt, Weeks Island was minimal when compared to the total number (28) of vehicles which could have been operating. Six pieces of equipment were monitored during the survey; three LHD's, the scaler, condor 100 and roof bolter #2. Samples were also collected in the maintenance shop (2WC) area where the diesel equipment was being repaired.

Temperatures in the mine during the survey averaged 82° F, with a relative humidity of 27%. The volume of air moving through the mine haulage ways and work areas, per management measurements, averaged 256,000 cfm. The room height throughout the areas monitored was approximately 75 feet, and the haulage ways ranged between 25 to 35 feet high. Because of the larger physical dimensions of dome salt mining, greater volumes of air are needed to move the air to the working sections in order to dilute/remove contaminants. Since this mine was monitored with a minimal amount of equipment operating, Morton Salt will need to re-evaluate its ventilation requirements when the diesel equipment usage increases.

Three short-term nitrogen dioxide detector tube measurements taken underground over the shift between 7(OE), 12(OE), and 9(EN) found levels ranging from 0.5 to 0.8 ppm. Long-term detector tube measurements were taken for carbon monoxide and found to range from below detectable limits to 7.3 ppm. The short-term samples are good indicators to determine if the ventilation in the immediate working area is effectively diluting/removing a contaminant. The personal passive dosimeters used for nitrogen dioxide are good for assessing the full-shift exposures since the worker is in and out of work areas and travelling throughout the mine. The NO_2 dosimeters measured nitrogen dioxide levels ranging from 0.62 to 0.83 ppm. None of the nitrogen dioxide (NO_2) or carbon monoxide levels exceeded NIOSH/MSHA evaluation criteria.

Solvent Soluble Portion of Particulate and PNA'S

At the Morton Salt Mine and Mill, thirteen area samples were collected and analyzed for the solvent soluble portion of airborne particulate. Three of the samples were below detectable limits (ND) and the remaining ten samples ranged from 0.13 to 1.4 mg/m^3. These samples were collected on loaders #1 through #5, roof bolter #2, the maintenance shop and a loader on the surface. The results can be found in Table III and summary Table X.

Thirteen area PNA samples were also collected in the same locations (Table IV). Of 16 different PNA analyzed on each sample, five were present at detectable levels in the samples collected underground. These PNA were naphthalene, acenaphthylene, acenaphthene, flourene and phenanthrene. Naphthalene concentrations ranged from ND (approximately 0.001 mg/m^3) to 0.05 mg/m^3, well below the MSHA Standard of 50 mg/m^3. The other PNA concentrations ranged from ND (approximately 0.001 mg/m^3) to 0.03 mg/m^3. The PNA levels (while low) did reveal quantifiable levels at or higher than the limit of detection (LOD) of the analytical procedure.

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 five PNAs detected, phenanthrene is considered a suspect carcinogen.[15,21] However, phenanthrene concentrations in air were low, at the detection limit for the analytical method (0.001 mg/m^3).

Sub-micron Particulate

Eight personal breathing zone samples which measured particulate matter less than 1 micrometer in diameter were collected from the operations of the loaders, scaler, and roof bolter. Diesel particulate has been shown to be in the submicrometer range, thus having the potential for reaching the lower airways of the lung.[3] Measurements for respirable diesel particulate ranged from 0.31 to 1.32 mg/m^3 (Table V). 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] Low temperature ashing of the filter indicated that the particulate collected was predominantly organic/diesel particulate and not inorganic dust since in all but one case more than 80% of the particulate weight was lost after ashing.

Nitric Oxide

Six personal full-shift samples for nitric oxide were collected underground at the Morton Salt mine. The personal time-weighted average (TWA) concentrations ranged from 3.8 to 6.1 ppm. None of the samples exceeded the MSHA or NIOSH evaluation criterion of 25 ppm. The results are found in Table VI and Table X. No outdoor samples were collected.

Nitrogen Dioxide

At Morton Salt, six full-shift personal samples for nitrogen dioxide were collected on the equipment operators. These six personal samples ranged from 0.62 to 0.83 ppm, with a mean exposure of 0.7 ppm. The low levels found by the dosimeters and short-term detector tubes would seem to indicate that over the shift that the contaminants are being diluted/removed from the worker. None of the samples exceeded NIOSH/MSHA evaluation criteria. The results are in Table VI and summary Table X.

Carbon Monoxide

Eight long-term detector tube measurements were taken in various locations that equipment was operating; results ranged from ND to 7.3 ppm. None of the sample results exceeded NIOSH/MSHA evaluation criteria. The results are found in Table VII and the summary Table X.

Asbestos

Twenty airborne samples, thirteen personal and seven area, were collected throughout the mill from mechanics, boiler and pan operators, loader operators, hoist #3, and the hoist house. Eleven bulk samples of material thought to contain asbestos were collected from the shop, evaporators, dryers, pipe insulation, transite siding, boiler room ledge, and evaporator control room. The airborne samples were analyzed by transmission electron microscopy (TEM) which counts and identifies all of the fibers in a sample. The concentration of fibers on the personal and area samples ranged from 0.004 to 0.01 fibers per cubic centimeter (f/cc). Four samples were void because of interference from particulate material other than fibers. The airborne samples contained primarily cellulose and fiberglass. Of the eleven bulk samples, six were vacuum samples and five were bulk pieces of material. Asbestos was not detected in any of the vacuum samples. Only one bulk sample (transite siding) contained asbestos (chrysotile/amosite) and this was to be expected because the material is already known to contain asbestos. This siding is used to cover exterior surfaces on the buildings at Morton Salt. The asbestos appeared to be in good condition throughout the mill area. The results can be found in Tables VIII and IX.

B. Medical

Sixty-one employees, 56 males and 5 females, participated in the medical survey. Thirty-nine (64%) were underground workers and the remaining 22 worked on the surface. The underground workers were slightly younger, with a mean age of 39 compared to 44 for the surface workers. There were an equal number (26) of smokers and non-smokers. Ex-smokers accounted for 15% of the group with nine workers (Table XI).

The prevalence of chronic cough and chronic phlegm reported at the Morton Salt Mine were statistically different than those reported by a group of non-exposed blue-collar workers ($p < .04$) (Table XII). One worker complained of shortness of breath. Questionnaire results indicated increased prevalence of chronic cough and phlegm among smokers. Chronic symptoms were reported in all smoking categories in underground workers and in surface workers who smoke. When asked about acute symptoms related to their work, the responses for "often" were quite similar between surface and underground workers, except for sneezing, eye irritation and tearing of the eyes. The underground workers complained more of these symptoms (Table XIII).

Table XIV shows the mean pulmonary function results by smoking status. Smoking status and current job location were not associated with mean percent predicted FVC and FEV_1 (Table XV). Pulmonary function results showed 4 workers with mild obstructive lung disease pattern, and one with moderate obstructive pattern. There were also three workers with mild restriction of lung volumes. A mild obstruction was defined as a FEV_1/FVC ratio between 61 to 69%. The moderate obstruction had a FEV_1/FVC ratio between 45 and 60%. In the cases of mild restriction, the FVC observed/FVC predicted percent were in the 66 to 79% range.

Of the 61 chest films taken, none had a positive reading for pneumoconiosis. The ILO says that radiographs should have profusion categories of 1/0 or greater to be classified as pneumoconiosis.[9]

VII. Conclusions/ Recommendations

A. Environmental

A potential health hazard from exposure to diesel exhaust was identified. Because of studies which have been conducted with animals and humans at various concentrations and review of toxicological and epidemiologic evidence,[14,15,21] it is NIOSH's position that materials contained in diesel exhaust can cause lung and skin cancer.[14,21] There were no overexposure per MSHA standards.

Because of the limitations in diesel technology, we can not confidently recommend control measures that would completely eliminate the exposures to diesel exhaust. However, the following recommendations should minimize those exposures and any related occupational health risks: (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.

B. Medical

Results indicate very little difference between surface and underground workers for prevalence of chronic cough and phelgm among workers who currently smoke. There were more complaints of eye irritation and tearing of the eyes in underground workers which is consistent with exposure to diesel by-products.

No radiographic evidence of pneumoconiosis was found in those participating.

Pulmonary function results showed 4 cases of mild obstructive lung disease, and 1 case of moderate obstructive disease. There were three cases of mild restriction of lung volumes. In a group of non-exposed blue-collar workers, the prevalence of an obstructive lung disease pattern was 8.1% compared to 8.2% (5/61) observed in these workers. All mean FVC and FEV_1 percent predicted values (Table XIV) were above 100% for all smoking categories.

Considering the observed complaints of chronic cough, chronic phlegm, and nasal and eye irritation, 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.

VIII. References

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IX. Authorship and Acknowledgements

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X. Distribution of Report

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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
Weeks Island, Louisiana

HETA 88-391

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 ($N0_x$, 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
Weeks Island, Louisiana

HETA 88-391

Substance	NIOSH[23]	MSHA STANDARD[12]
Diesel Exhaust	Lowest feasible limit	None
PNAs	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	2.0 f/cc (all forms)

NOTE: References are listed in Section VIII of this report.
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
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Date	Location	Job(A)	Concentration (mg/m^3)
12/01/88	Mill	Loader (Cat.966)	0.32
	Outdoors	Control	ND
	12 QE	Roof bolter #2	1.1
	1300 Bench	Loader #5	0.21
	Top 14 TE	Loader #3	0.73
	Maint.Shop (table near fan)	Area	0.13
	1300 Bench	Loader #4	1.4
12/02/88	Outdoors	Control	ND
	12 TE/13 NE	Loader #1	0.15
	10 UE (intersection)	Roof bolter #2	0.56
	11 OE	Loader #2	0.23
	11 OE (Bench)	Loader #5	0.41
	Maint.Shop (2 WC)	Area	ND
	Limit of Detection (LOD) (mg/m^3)		0.06

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
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Date	Vehicle or Location (A)	Naphthalene (mg/m^3)	Acenaphthylene (mg/m^3)	Acenaphthene (mg/m^3)	Fluorene (mg/m^3)	Phenanthrene (mg/m^3)
12/01/88	Cat.Loader (Mill)	0.004	0.002	ND	ND	ND
	Outdoors	ND	ND	ND	ND	ND
	Roof bolter	0.04	0.02	0.01	0.002	0.001
	Loader $5	0.03	0.02	0.01	0.002	0.001
	Loader #3	0.04	0.03	0.01	0.003	0.001
	Maint.Shop	0.03	0.02	0.01	0.002	ND
	Loader #4	0.03	0.01	0.01	0.001	0.001
12/02/88	Outdoors	ND	ND	ND	ND	ND
	Loader #1	0.05	0.02	0.01	0.002	0.001
	Roof Bolter #2	0.04	0.02	0.01	0.002	ND
	Loader #2	0.02	0.02	0.01	0.002	0.001
	Loader #5	ND	ND	ND	ND	ND
	Maint.Shop (2WC)	0.03	0.01	0.01	0.001	ND
	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 PNAs analyzed on each sample, five 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
Weeks Island, Louisiana

December 1-2, 1988
HETA 88- 391

Date	Job (P)	Submicron Particulate (TWA) (mg/m^3)	% of Measured Particulate Lost After LTA
12/01/88	Loader Oper.	0.35	90
	Loader Oper.	0.31	100
	Loader Oper.	0.60	66
	Scaler Oper.	0.40	100
12/02/88	Roof Bolter	1.32	81
	Loader Oper.	1.03	88
	Loader Oper.	0.70	100
	Loader Oper.	0.50	100
	Limit of Detection(LOD) (mg/m^3)	0.06	

Note: P(personal sample), mg/m^3 (milligrams per cubic meter)
LTA - Low Temperature Ashing

TABLE VI

NITRIC OXIDE/NITROGEN DIOXIDE
Morton Salt Company
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Date	Job (P)	NO_x Conc. TWA (ppm)	NO_2 Conc. TWA (ppm)	NO Conc. TWA (ppm)
12/01/88	Loader Oper.	6.0	0.65	4.1
	Loader Oper.	8.2	0.71	5.8
	Loader Oper.	6.2	0.76	4.2
	Scaler Oper.	5.6	0.62	3.8
12/02/88	Roof Bolter	7.9	Lost	---
	Loader Oper.	8.7	0.83	6.1
	Loader Oper.	5.7	0.66	3.9

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
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Date	Time	Location	Job(A)	Long Term Conc. (ppm)
12/01/88	1750-2250	12 QE	Roof bolter	3.3
	1730-2230	14 TE	Loader #3	4.1
	1655-2255	1300 Bench	Loader #5	ND
	1657-2320	Maint.Shop	------	ND
	1710-2255	1300 Bench	Loader #4	ND
12/02/88	1710-2240	12 TE/13 NE	Loader #1	ND
	1730-2255	11 OE	Loader #2	6.2
	1650-2255	11 OE (Bench)	Loader #5	7.3

ppm (parts per million), ND (none detected).

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

TABLE VIII

Airborne Asbestos Exposures

Morton Salt Company
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Date	Location	Job	Ambient Concentration f/cc	Fiber Identification
12/01/88	Mill (Grind/Cut)	Mechanic (P)	0.02	Cellulose/Fiberglass
	Mill (Grind/Cut)	Mechanic (P)	0.01	Cellulose
	Mill (Grind/Cut)	Mechanic (P)	0.01	Cellulose
	Mill	Pan Oper.(P)	0.01	Cellulose/Fiberglass
	Mill	Boiler Oper.(P)	0.01	Cellulose/Fiberglass
	Mill	Evaporators/ Dryers (A)	0.03	Cellulose/Fiberglass
	Hoist House	Area	0.003	Cellulose
	Mill	Loader Oper.(P)	0.01	Cellulose
	Mill	Loader Oper.(P)	Void	Void
	Mill	Loader Oper.(P)	Void	Void
	Outdoors	Area	0.004	Cellulose
	Maint.Shop	Table (A)	0.004	Not Analyzed
12/02/88	Outdoors	Area	0.003	Not Analyzed
	Mill (Cut/Weld)	Mechanic (P)	0.01	Not Analyzed
	Mill (Cut/Weld)	Mechanic (P)	0.01	Not Analyzed
	Mill (Cut/Weld)	Mechanic (P)	Void	Void
	Mill	Pan Oper.(P)	0.04	Cellulose/Fiberglass
	Mill	Boiler Oper.(P)	0.01	Cellulose/Fiberglass
	Mill	Evaporators/ Dryers (A)	Void	Void
	Mill	Production Hoist #3 (A)	0.01	Cellulose

Limit of Quantitation (LOQ) 0.003 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).
P (personal sample), A (area sample).

Not Analyzed (because duplicate samples were collected in same general location and laboratory results did not identify asbestos fibers, the duplicate sample was assumed to have no asbestos and not analyzed).

TABLE IX

Bulk Asbestos Analysis

Morton Salt Company
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Location	Type Sample	Type Asbestos/ Material	Approximate Percent
Shop (Mill)	Vac	ND	ND
Evaporators	Vac	ND	ND
Dryers	Vac	ND	ND
Boiler Room	Vac	ND	ND
Evaporator/Dryers	Bulk	ND	ND
Pipe Insulation	Bulk	ND	ND
Boiler Room Pipe	Bulk	ND	ND
Evaporator/Dryer Office	Bulk	ND	ND
Transite Siding (Boiler Bldg)	Bulk	Amosite	5 to 10
	Bulk	Chrysotile	30 to 40
Boiler Room Ledge	Vac	ND	ND
Evaporator/Dryer Control Room	Vac	ND	ND

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

TABLE X

SUMMARY SHEET
Morton Salt Company
Weeks Island, Louisiana

December 1-2, 1988
HETA 88-391

Agent	Number of Samples	Concentration Range	MSHA TLV	NIOSH REL
Soluble Particulate (UG)	13	ND to 1.4 mg/m^3	none	none
PNAs (UG)	13	ND to 0.05 mg/m^3	none	LFL
Diesel Particulates (UG)	8	0.31 to 1.32 mg/m^3	none	LFL
Nitric Oxide (UG) (PD)	6	3.8 to 6.1 ppm	25 (TWA)	25 (TWA)
Nitrogen Dioxide (UG) (PD)	6	0.62 to 0.83 ppm	5(C)	1(C)
Nitrogen Dioxide (UG)(ST)	3	0.5 to 0.8 ppm	5(C)	1(C)
Carbon Monoxide (UG)(LT)	8	ND to 7.3 ppm	50 (TWA)	35 (TWA)
Carbon Monoxide (UG)(ST)	O	NT	50 (TWA)	35 (TWA)
Asbestos (S)	20	0.003 to 0.04 f/cc	2.0 f/cc (TWA)	0.1 f/cc (TWA)

Note: ND - none detected
NT - none taken
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 AND CURRENT JOB

Morton Salt Company
Weeks Island, Louisiana

HETA 88-391

	SMOKERS		EX-SMOKERS		NONSMOKERS	
	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE
	N = 17 MEAN (SD)	N = 9 MEAN (SD)	N = 8 MEAN (SD)	N = 1 MEAN (SD)	N = 14 MEAN (SD)	N = 12 MEAN (SD)
AGE	38 (7.7)	46 (11.0)	41 (11.4)	47 (-)	38 (11.8)	42 (9.4)
HEIGHT (cm)	170 (7.9)	173 (4.8)	178 (10.1)	174 (-)	173 (5.4)	175 (7.8)
	%	%	%	%	%	%
RACE						
WHITE	53 (1H)	67 (1H)	38	--	50	25
BLACK	47 (1H)	33 (1H)	62	100	50	75
SEX						
MALE	76	100	88	100	100	100
FEMALE	24	--	12	--	--	--

H denotes Hispanic origin

TABLE XII

PERCENTAGE REPORTING CHRONIC SYMPTOMS BY SMOKING STATUS

Morton Salt
Weeks Island, Louisiana

HETA 88-391

	MORTON SALT MINE			BLUE COLLAR STUDY		
	SMOKERS	EX-SMOKERS	NONSMOKERS	SMOKERS	EX-SMOKERS	NONSMOKERS
CHRONIC COUGH	24 (6/25)	33 (3/9)	19 (5/26)	19.5	8.2	7.8
CHRONIC PHLEGM	44 (11/25)	22 (2/9)	23 (6/26)	17.7	13.1	7.6
CHRONIC SHORTNESS OF BREATH	4 (1/26)	0 (0/9)	0 (0/26)	3.4	3.4	1.6

TABLE XIII
NUMBER AND PERCENTAGE OF ACUTE SYMPTOMS REPORTED "OFTEN" BY CURRENT JOB CATEGORY

MORTON SALT
Weeks Island, Louisiana

DECEMBER 1-2, 1988
HETA 88-391

	SURFACE WORKERS N=22		UNDERGROUND WORKERS N=39	
ACUTE SYMPTOMS	N	(%)	N	(%)
COUGH	0	(0)	1	(3)
NOSE TICKLED/IRRITATED	2	(9)	6	(15)
SNEEZE	1	(5)	7	(18)
EYES ITCH/BURN	1	(5)	6	(15)
TEARING OF THE EYES	0	(0)	4	(10)
SORE THROAT	0	(0)	1	(3)
DIFFICULT/LABORED BREATHING	0	(0)	0	(0)
TIGHT/CONSTRICTED CHEST	0	(0)	0	(0)
UPSET STOMACH	0	(0)	2	(5)
CHEST WHEEZING/WHISTLING	0	(0)	0	(0)
HEADACHE	3	(14)	5	(13)

TABLE XIV

PULMONARY FUNCTION TEST RESULTS VS SMOKING STATUS

Morton Salt Company
Weeks Island, Louisiana

HETA 88-391

	SMOKING STATUS					
	NEVER N=26		EX N=9		CURRENT N=26	
	MEAN	SD	MEAN	SD	MEAN	SD
FVC (l)	4.59	0.71	4.62	0.94	4.31	0.93
FEV_1 (l)	3.82	0.59	3.69	0.83	3.40	0.74
FEV_1/FVC RATIO (%)	83.4	5.6	80.1	7.9	79.2	8.1

NUMBER OF WORKERS: 61

TABLE XV

PERCENT PREDICTED PULMONARY FUNCTION VALUES BY CURRENT JOB AND SMOKING STATUS

Morton Salt Company
Weeks Island, Louisiana

HETA 88-391

	SMOKERS		EX-SMOKERS		NONSMOKERS	
	UNDERGROUND N=17 MEAN (SD)	SURFACE N=9 MEAN (SD)	UNDERGROUND N=8 MEAN (SD)	SURFACE N=1 MEAN (SD)	UNDERGROUND N=14 MEAN (SD)	SURFACE N=12 MEAN (SD)
FVC (%)	106.0 (15.1)	112.5 (29.5)	108.3 (17.0)	119.3 (-)	106.5 (12.0)	109.3 (9.2)
FEV_1 (%)	101.2 (15.5)	106.7 (27.4)	105.6 (21.4)	116.9 (-)	109.5 (12.8)	107.8 (11.9)

Identification No. ______________________

APPENDIX 1

I, ____, voluntarily agree to participate in this Health Hazard Evaluation conducted by the National Institute for Occupational Safety and Health (NIOSH). I understand that I will be asked some questions about my work history, health and use of tobacco. I will also have my height and weight measured, a chest x-ray taken, and perform a simple pulmonary function test. I will receive my individual test results and, if I want, a copy of my results will be sent to my doctor. I have the right to ask questions of NIOSH and am free to terminate my consent and discontinue participation at any time without prejudice to myself.

Every effort will be made to safeguard the confidentiality of information collected in this survey, in accordance with the Privacy Act of 1974. The information will be used for statistical purposes and will not be disclosed in a manner which will identify me as an individual, except with my written permission or as requested by law to protect me and others.

Signature: ______________________________ Date: ______________

Investigator: ______________________________

REQUEST AND AUTHORIZATION FOR RELEASE OF INFORMATION:

I ______________________________, hereby request and authorize the Project Director to inform the following physician whose name and address I have entered below of any significant findings.
(Do not leave blank. Write "NO" if you do not wish to give a name and address)

Dr. ______________________________

Street: ______________________________

City/State: ______________________________

SIGNATURE: ______________________________ DATE ______________

A. IDENTIFICATION

1. NAME (Last) (First) (Middle Initial)	3. PHONE NUMBER	4. SOCIAL SECURITY NUMBER**
2. CURRENT ADDRESS (Number, Street, or Rural Route, City or Town, County, State, Zip Code)	5. BIRTHDATE (Month, Day, Year)	6. AGE LAST BIRTHDAY
	7. SEX 1 ☐ MALE 2 ☐ FEMALE	8. STANDING HEIGHT .... (cms.) / 9. WEIGHT .... (k
	10. RACE ☐ White ☐ Black ☐ Asian/Pac. ☐ Am. Indian/Eskimo ☐ Other Hispanic Origin Y/N	

ID #			
Date	MO	DAY	YR
Interviewer #			
PFT #			
X-ray #			
Before/After Shift, Neither	B	A	N

IDENTIFICATION NO.

B. OCCUPATIONAL HISTORY TABLE

Complete the following table showing the entire work history of the individual from present to initial employment. Sporadic, part-time periods of employment, each of no significant duration, should be grouped if possible.

INDUSTRY & LOCATION	TENURE OF EMPLOYMENT		SPECIFIC OCCUPATION	CODE	IF OCCUPATION IS MINING, INDICATE:				
	From 19—	To 19—			ORE	TRANS	MAINT	MISC.	NON ORE
		Pr.							

B. OCCUPATIONAL HISTORY (Continued)

IDENTIFICATION NO

Record on lines the number of years in which subject has worked in any of the below listed industries.
Have you ever worked:

9. In any other type of mine? 1 ☐ Yes 2 ☐ No No. Yrs. ......
10. In a quarry? 1 ☐ Yes 2 ☐ No No. Yrs. ......
11. In a foundry? 1 ☐ Yes 2 ☐ No No. Yrs. ......
12. In a pottery? 1 ☐ Yes 2 ☐ No No. Yrs. ......
13. In a cotton, flax or hemp mill? 1 ☐ Yes 2 ☐ No No. Yrs. ......
14. With asbestos? 1 ☐ Yes 2 ☐ No No. Yrs. ......
15. In any other dusty job? 1 ☐ Yes 2 ☐ No No. Yrs. ......
    (Specify) ......

TOTAL
NUMBER OF YEARS ......

C. SYMPTOMS

I am now going to ask you some questions, mainly about your chest. I would like you to answer "YES" or "NO" whenever possible.

COUGH

1. Do you usually cough first thing in the morning (on getting up*) in the winter? 1 ☐ Yes 2 ☐ No

   Count a cough with first smoke or on first going out of doors.

   Exclude clearing throat or a single cough.

2. Do you usually cough during the day (or at night*) in the winter? 1 ☐ Yes 2 ☐ No

   Ignore an occasional cough.

   If "No" to both questions 1 and 2, go to question 4.

   If "Yes" to either question 1 or 2:

3. Do you cough like this on most days (or nights*) for as much as three months each year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

PHLEGM

4. Do you usually bring up any phlegm from your chest first thing in the morning (on getting up*) in the winter? 1 ☐ Yes 2 ☐ No

   Count phlegm with first smoke or on first going out of doors.
   Exclude phlegm from the nose. Count swallowed phlegm.

*For individuals who work at night.

IDENTIFICATION NO

PHLEGM (Continued)

5. Do you usually bring up any phlegm from your chest during the day (or at night*) in the winter? 1 ☐ Yes 2 ☐ No

Accept twice or more.

If "No" to both questions 4 and 5, go to question 7.

If "Yes" to either question 4 or 5:

6. Do you bring up phlegm like this on most days (or nights*) for as much as three months each year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

7. In the past three years have you had a period of (increased**) cough and phlegm lasting for three weeks or more? 1 ☐ Yes 2 ☐ No

If "No" to question 7, go to question 9.

If "Yes" to question 7:

8. Have you had more than one such period? 1 ☐ Yes 2 ☐ No 9 ☐ NA

9. Have you ever coughed up blood? 1 ☐ Yes 2 ☐ No

If "No" to question 9, go to question 11.

If "Yes" to question 9:

10. Was this in the past year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

BREATHLESSNESS

11. Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill? 1 ☐ Yes 2 ☐ No ☐ *** Disabled

If "No" or "Disabled" to question 11, go to question 14.

If "Yes" to question 11:

12. Do you get short of breath walking with other people of your own age on level ground? 1 ☐ Yes 2 ☐ No 9 ☐ NA

If "No" to question 12, go to question 14.

If "Yes" to question 12:

13. Do you have to stop for breath when walking at your own pace on level ground? 1 ☐ Yes 2 ☐ No 9 ☐ NA

WHEEZING

14. Does your chest ever sound wheezing or whistling? 1 ☐ Yes 2 ☐ No

If "No" to question 14, go to question 16.

If "Yes" to question 14:

15. Do you get this most days — or nights? 1 ☐ Yes 2 ☐ No 9 ☐ NA

*For individuals who work at night.

**For individuals who usually have phlegm.

***Disabled from walking by any conditions other than heart or lung disease.

IDENTIFICATION NO.

WHEEZING (Continued)

16. Have you ever had attacks of shortness of breath with wheezing? 1 ☐ Yes 2 ☐ No

If "No" to question 16, go to question 18.

If "Yes" to question 16:

17. Is was your breathing absolutely normal between attacks? 1 ☐ Yes 2 ☐ No 9 ☐ NA

WEATHER

18. Does the weather affect your chest? 1 ☐ Yes 2 ☐ No
Only record "Yes" if adverse weather definitely and regularly causes chest symptoms.

If "No" to question 18, go to question 21.

If "Yes" to question 18:

19. Does the weather make you short of breath? 1 ☐ Yes 2 ☐ No 9 ☐ NA

20. What kind of weather? .... 9 ☐ NA

NASAL DRAINAGE

21. Do you usually have a stuffy nose or drainage at the back of your nose in the winter? 1 ☐ Yes 2 ☐ No

22. Do you have this in the summer? 1 ☐ Yes 2 ☐ No

If "No" to both questions 21 and 22, go to question 24.

If "Yes" to either question 21 or 22:

23. Do you have this on most days for as much as three months each year? 1 ☐ Yes 2 ☐ No 9 ☐ NA

CHEST ILLNESSES

24. During the past three years have you had any chest illness which has kept you from your usual activities for as much as a week? 1 ☐ Yes 2 ☐ No

If "No" to question 24, go to question 27.

If "Yes" to question 24; ask questions 25 and 26.

25. Did you bring up more phlegm than usual in any of these illnesses? 1 ☐ Yes 2 ☐ No 9 ☐ NA

If "No" to question 25, go to question 27.

If "Yes" to question 25:

26. How many illnesses like this have you had in the past three years? ____________ 9 ☐ NA

C. SYMPTOMS (Continued)

IDENTIFICATION NO.

HAVE YOU EVER HAD (Insert proper code, questions 27 through 36)

27. An injury or operation affecting your chest? ☐

28. Heart trouble? ☐

29. Bronchitis? ☐

30. Pneumonia? ☐

31. Pleurisy? ☐

32. Pulmonary tuberculosis? ☐

33. Bronchial asthma? ☐

34. Emphysema? ☐

35. Bronchiectasis? ☐

36. Other chest trouble? ☐

Code 0 = No 1 = Once; 2 = Twice 9 = Nine or more times Codes only 0 or 1 for questions 27 28, 32, 33, 34 and 35

37. Have you ever been exposed regularly to irritating gas or chemical fumes? 1 ☐ Yes 2 ☐ No

38. Have you ever been exposed (within 30 feet) to the smoke of an underground cable fire? If so, how many .... 1 ☐ Yes 2 ☐ No 9 ☐ NA

D. TOBACCO SMOKING

1. Do you now smoke cigarettes? 1 ☐ Yes 2 ☐ No

   If "Yes" to question 1, go to question 4.

   If "No" to question 1:

2. Have you ever smoked cigarettes? 1 ☐ Yes 2 ☐ No 9 ☐ NA

   If "Yes" to question 2, go to question 4.

   If "No" to question 2:

3. Have you smoked at least as many as five packs of cigarettes, that is, 100 cigarettes during your entire life? 1 ☐ Yes 2 ☐ No 9 ☐ NA

   If "Yes" to question 3, go to question 4.

   If "No" to question 3, go to question 9.

4. How old were you when you started smoking cigarettes regularly? .... (Age in years)

   If an ex-cigarette smoker, ask:

5. How old were you when you last gave up smoking cigarettes? .... (Age in years)

5a. During the years that you smoked, did you ever quit for a year or more? 1 ☐ Yes 2 ☐ No

   If yes, how long? ....

6. How much do/did you smoke on the average? .... (Cigarettes a day)

7. Do/did you inhale the cigarette smoke? 1 ☐ Yes 2 ☐ No

8. What do/did you mostly smoke? 1 ☐ Filters 2 ☐ Non-Filters — 1 ☐ Regular 2 ☐ King Size 3 ☐ 100 Millimeter

IDENTIFICATION NO.

9. Do you now smoke a pipe? 1 ☐ Yes 2 ☐ No

If "Yes" to question 9, go to question 11.

If "No" to question 9:

10. Have you ever smoked a pipe? 1 ☐ Yes 2 ☐ No 9 ☐ NA

11. How many bowlsful a week do/did you smoke? ____________

12. Do you now smoke cigars? 1 ☐ Yes 2 ☐ No

If "Yes" to question 12, go to question 14.

If "No" to question 12:

13. Have you ever smoked cigars? 1 ☐ Yes 2 ☐ No 9 ☐ NA

If "Yes" to question 13, go to question 14.

If "No" to question 13, end interview.

14. How many cigars a week do/did you smoke? ____________

Use "did" only for ex-smokers.

Identification No.

E. ACUTE SYMPTOMS

1. While at work in your present job, how often do you have any of the following symptoms? (Circle only ONE number per line)

	Never or Rarely	Sometimes	Often
Cough	1	2	3
Nose Tickled or Irritated	1	2	3
Sneeze	1	2	3
Eyes Itch or Burn	1	2	3
Tearing of the Eyes	1	2	3
Sore Throat	1	2	3
Difficult or Labored Breathing	1	2	3
Tight or Constricted Feeling in the Chest	1	2	3
Upset Stomach	1	2	3
Chest Sound Wheezing or Whistling	1	2	3
Headache	1	2	3

2. Do you have any other medical complaints related to your job?

____

____