HETA 88-108-2146
OCTOBER 1991
ASARCO NEW MARKET/YOUNG MINES
MASCOT, TENNESSEE

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 from the International Chemical Worker's Union (ICWU) The requestor asked NIOSH to evaluate exposures to asbestos, silica, and diesel emissions at two zinc mines located in Tennessee. This survey was conducted at the two mines and mills.

On March 29 through April 1, 1988, NIOSH conducted a walk-through survey at two American Smelting and Refining Company's (ASARCO) zinc mines located in East Tennessee. On September 21-23, 1988 and September 26-27, 1988, medical and environmental evaluations were conducted at the New Market and Young zinc mines, respectively. The environmental evaluations consisted of personal breathing zone and area samples for coal tar pitch volatiles (CTPV), polynuclear aromatic hydrocarbons (PNA), diesel particulates, oxides of nitrogen ($NO + NO_2$), carbon monoxide, and silica.

At both mines, overexposures were found to nitrogen dioxide and coal tar pitch volatiles. Both contaminants are produced from the combustion of fossil fuels. Twenty-five passive dosimeters analyzed for nitrogen dioxide (NO_2) indicated that full-shift exposure levels ranged from below detectable limits to 1.8 parts per million (ppm). Twenty-four percent (6 of 25) were above the NIOSH recommended ceiling of one ppm. None of the NO_2 passive dosimeters exceeded the Mine Safety and Health Administration's (MSHA) ceiling standard of 5 ppm. A total of thirty-four CTPV samples were collected and analyzed for the benzene soluble fraction. Results of sampling for CTPV's ranged from below detectable limits to 2.8 milligrams per cubic meter (mg/m^3). At the New Market mine, 10 of 17 (59%) CTPV sample concentrations were above the MSHA standard of 0.2 mg/m^3 and 12 of 17 (71%) CTPV's were above the NIOSH recommended exposure limit (REL) of 0.1 mg/m^3. At the Young mine, 11 of 17 (65%) CTPV sample concentrations were above the NIOSH REL and 10 of 17 (59%) were above the MSHA standard. NO_2 and CTPV's were not detected on any of the environmental samples taken outside of the mine.

Eighty-nine percent of the PNA samples collected had quantifiable amounts of naphthalene, acenaphthylene, fluorene and phenanthrene; however, all were at/near the limit of detection of the analytical procedure. Exposure to diesel particulates ranged from 0.24 to 1.06 mg/m^3, with a mean concentration of 0.55 mg/m^3. The mean exposures for respirable dust in the underground operation at the New Market mine was 1.0 mg/m^3 and 0.8 mg/m^3 at the Young mine with a range from below detectable limits to 2.16 mg/m^3. The mean exposure for respirable dust at the surface operations of New Market and Young were 0.21 and 0.33 mg/m^3 respectively, with a range from below detectable limits to 0.72 mg/m^3. None of the 52 respirable dust samples collected exceeded the calculated MSHA Standard or NIOSH REL for free silica exposure. Results of long and short term samples for carbon monoxide indicated that concentrations were below the evaluation criteria.

The medical evaluation consisted of a Medical Research Council (MRC) questionnaire on respiratory symptoms, smoking habits, demographic information, and work history. The employees who participated were also given chest x-rays, and pulmonary function tests. Eighty-three (21%) of the approximate 400 current employees and one retired employee participated in the medical evaluation. There was little difference between the surface and underground workers for prevalence of chronic symptoms (cough and phlegm), except for the smokers. It is uncertain whether this increased prevalence of cough and phlegm is associated with dust exposure or the effects of tobacco smoking. Review of 84 radiographs revealed seven underground employees with small opacity readings of $\geq$ 1/0. Pulmonary function tests indicated four employees with moderate airway obstruction, 17 with mild obstruction and two with mild restriction of lung volume. Three of the employees with obstructive lung disease pattern also had positive radiographs for pneumoconiosis.

On the days of the NIOSH surveys, employee overexposures to coal tar pitch volatiles and nitrogen dioxide (products of diesel combustion) were measured in excess of NIOSH and/or MSHA criteria/standards. Radiographic evidence of pneumoconiosis found in 8 percent of the miners along with a reduction in the mean percent predicted FEV_1 in non-smoking underground miners suggest a chronic respiratory health effect that may be related to cumulative workplace exposures. Recommendations for reducing these exposures and developing a medical surveillance program can be found in section VII of this report.

KEYWORDS: SIC 1031 (Lead and Zinc Ores), Diesel exhaust, Coal tar pitch volatiles, Oxides of Nitrogen, Silica.

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 employee exposures (medically and environmentally) to asbestos, silica, and diesel emissions at two zinc mines located in Tennessee. This survey was conducted at both mines and mills. NIOSH was also requested to evaluate the potential synergistic effects of combined exposures to asbestos/diesel and silica/diesel. The synergistic effects were not evaluated because of insufficient numbers of study participants with exposures to the substances of concern. On March 29 through April 1, 1988, NIOSH conducted walk-through surveys at two of American Smelting and Refining Company's (ASARCO) zinc mines in East Tennessee. Based on the walk-throughs, medical and environmental protocols were developed. The medical and environmental evaluations were conducted on September 21-23 and September 26-27 at the New Market and Young mines, respectively.

III. Background

Zinc mining in the east Tennessee area dates back to the 1850's. The zinc ore deposits in this area span a distance of 30 miles from the Knoxville area towards Jefferson City. More zinc is mined in Tennessee than any other state in the United States. The zinc ore is contained within layers of limestone and dolomite rock (calcium magnesium carbonate) known as the Mascot and Kingsport formations. Zinc sulfide is the primary ore present. The ore is low grade, averaging about 3% zinc. The ore body ranges from 10 to 150 feet thick, 15 to 800 feet wide and 200 to 1000 feet long.

Economic mining of the zinc ore by ASARCO is possible because of their extraction and processing methods. About 80% of the mined material is converted into commercial products such as: zinc concentrates, construction aggregates, and agricultural lime. The zinc is mined by the "room and pillar" extraction method. This method results in large rooms being formed called "stopes". The pillars in these "stopes" are ore bodies that support the rooms and range from 30 to 40 feet wide and 30 to 50 feet apart to 150 feet high.

Ore is extracted in five stages: 1) drilling, 2) blasting, 3) scaling and roof bolting, 4) mucking, and 5) hauling. To start the extraction process, two jumbo drills are used to bore holes into the ore body. At the end of the shift the holes are filled with explosives and detonated.

After a blast, the area is cleared by ventilation and checked by mine supervisory personnel before a miner is permitted to enter. The blasted ore is scooped (mucked) up by diesel load-haul-dump (LHD) vehicles. These vehicles are capable of carrying eight to nine cubic yards (7.5 tons) of ore at a time. Once loaded, the ore is dumped at designated locations into ten foot diameter holes called ore passes. These ore passes connect the working levels with the main haulage ways, where the ore is gravity fed into rail cars. The rail cars are pulled by a small diesel locomotive which transports the ore to the main pass where the ore is hoisted to the surface in buckets called skips. At the New Market mine, the ore is crushed underground (to less than five inches in size) and then hoisted to the surface.

The New Market and Young Mines both work three underground shifts. Each mine employs approximately 95 to 105 workers. The mines use diesel equipment exclusively; however, some mining equipment, such as the drilling rig, uses diesel for transportation and compressed air for drilling. Both mines had at least 10 to 12 pieces of diesel equipment underground; but, only five to eight pieces were actively working the stopes. The remaining equipment was in the shop for repairs.

From the walk-through evaluations at both mines, diesel emissions were considered to be a primary health concern. The ICWU request indicated asbestos and silica were also potential problems. The requestor cited potential asbestos exposure problems from vehicle brake shoes and the hoist brake pads. It was discovered during the walk-through evaluation that semi-metallic brakes and/or torque converters are used on most of the equipment and non-asbestos material was used in the hoist brakes. Free silica, on the other hand, while not a component of Dolomite rock, is frequently encountered during mining. Mine Safety and Health Administration (MSHA) records for the years 1972 to 1984 indicated no overexposures to either silica or asbestos. Diesel emissions, monitored by MSHA for Nitric Oxide (NO), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), and Carbon Dioxide (CO_2) were not in excess of applicable standards for these gases.

In August 1986, the Young Mine participated in a NIOSH retrospective mortality study to estimate exposures to diesel exhaust contaminants. During this study, the mine was evaluated for total and respirable dusts, NO, NO_2, CO and CO_2. Of these compounds, only NO_2 was detected at concentrations in excess of the NIOSH REL. Fifty-three samples were collected for NO_2 with five (9%) samples exceeding NIOSH's REL. None of the NO_2 samples exceeded the MSHA TLV.(2)

IV. Methods

A. Environmental

During the initial site visits to the Young and New Market mines in March 1988, the NIOSH investigator conducted walk-through evaluations of the underground areas to observe various types of diesel equipment in operation and learn about mining processes. On the surface, the hoist house was visited to observe work activities and potential exposures.

On September 22-23 and September 26-27, 1988, environmental samples were collected at both mines and mills. Samples were collected on the day shift for potential exposures to CTPV's, PNA's, diesel particulates, NO, NO_2, CO, and free silica. At both mines, full-shift, personal samples were collected for NO/NO_2 and diesel particulates. Full-shift, area samples for CTPV, PNA's, and respirable free silica were collected on the equipment. These area samples were placed on the equipment adjacent to the operator and within three feet of his breathing zone. In underground mine areas, partial-shift samples for carbon monoxide were collected using long-term detector tubes positioned on the mining equipment for a period of four hours. On the surface, full- shift, personal and area samples were collected for respirable free silica. Most of the area samples on the surface were placed in work areas.

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

The diesel particulates were collected using a 2-stage, dichotomous impactor that is inserted into a respirable dust cyclone. The effective cut-off diameter (ECD) for the impactor at a 2.0 lpm flow rate 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.

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

Carbon monoxide was monitored using a sampling pump calibrated at 20 cubic centimeters per minute in-line with a Drager long-term detector tube.

The respirable free silica was collected with a sampling pump calibrated at a flow rate of 1.7 lpm in-line with a 10 mm nylon cyclone. A 37 mm PVC filter with a 5.0 um pore size was used.

The methods used to analyze the mine and mill environment are summarized in Table I.[3,4,5,6,7]

B. Medical

All current employees at the ASARCO zinc mines in East Tennessee were invited to participate in the medical portion of the health hazard evaluation. The local union was contacted to help notify and schedule workers for the medical examination. A mobile trailer equipped with spirometers and an x-ray machine was used for the study. The trailer was parked at the local union hall for this evaluation. After each miner received an explanation of the tests to be performed and gave consent to participate, each volunteer had his height measured, a posteroanterior chest radiograph taken, performed spirometry, and answered a standardized questionnaire.

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 defined as having to stop for breath when walking at his/her own pace on level ground (Medical Research Council 1960).[8]

Spirometry was performed using a dry rolling-seal spirometer interfaced to a computer terminal with tape and disk storing capabilities. At least five maximal expiratory maneuvers were recorded for each person. All values were corrected to body temperature, ambient pressure, saturated with water vapor (BTPS). The largest forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and peak flow (PF) were selected for analysis regardless of the curves on which they occurred. The spirometer and methods met the quality control recommendations of the American Thoracic Society (ATS).[9]

Each chest radiograph was read independently by three certified pneumoconiosis "B" readers who, without knowledge of the subjects' ages, occupations, or smoking histories, classified the films according to the 1980 International Classification of Radiographs of Pneumoconioses.[10] 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 were recorded. 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. The median profusion of the three readings was used in the analysis.

To evaluate any 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 prevalences expected if the workers at the Zinc mines had the same symptom prevalences reported by a group of nonexposed blue-collar workers.[11] Knowledge of each employee's smoking history was used to calculate the expected prevalences of these respiratory symptoms. Percent predicted pulmonary function values were calculated using Knudson's prediction equations.[12] 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 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. An analysis of covariance was used to determine if age, height, and smoking-adjusted mean pulmonary function values were significantly different between surface and underground groups.

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's (MSHA's) 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 (The MSHA Standards are adopted from the 1973 American Conference of Governmental Industrial Hygienist, Threshold Limit Values). Often, the NIOSH REL's are lower than the corresponding MSHA Standards. NIOSH REL's are usually based on the most recent information available and on the concerns related to the prevention of occupational disease.

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

B. Toxicology

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

Coal Tar Pitch Volatiles/Polynuclear Aromatic Hydrocarbons

Coal tar pitch volatiles (CTPV's) and polynuclear aromatic hydrocarbons (PNA's) are terms frequently encountered when dealing with coal tar and petroleum products. CTPV's are products from the combustion of petroleum products or the destructive distillation of bituminous coal. CTPV's contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily, thereby increasing the amounts of carcinogenic compounds in working areas.[13] Epidemiological evidence suggests that workers exposed to the products of combustion or distillation are at an increased risk of cancer at such sites as the respiratory tract, kidney, bladder and skin.[13] Coke oven workers, for which the CTPV standard was developed, have been found to be at the highest risk for lung and kidney cancer if employed for 5 or more years. While the agents responsible for cancers among coke oven workers are unidentified, it is suspected that several of the PNA's in CTPV's are involved. The primary hydrocarbons that are suspect human carcinogens are chrysene and benzo (a) pyrene.[14,15] These hydrocarbons are small in size, readily inhaled and typically represent 15-65% of the diesel exhaust particulates emitted from diesel powered vehicles.[16]

Diesel Particulates

Emissions from diesel engines consist of both gaseous and particulate fractions. The gaseous constituents include carbon dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, oxides of sulfur, and polynuclear aromatic hydrocarbons. Particulates in diesel exhaust are composed of solid carbon (soot) which tend to form clusters during combustion. As much as 15 to 65% of the diesel emissions are made up of organic compounds adsorbed onto the surface of particulates.[17] More than 95% of these particulates are less than one micron in size.[18] It has been suggested that the diesel exhaust acts as a carrier for the gaseous fractions of diesel emissions and, based on the small size of diesel particles, penetration to the gas exchange regions of the lung is possible. Animal studies, toxicology studies, and epidemiological findings suggest that a potential health risk exists from exposure to diesel exhaust.[17] These studies serve as the basis for the current NIOSH position 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.[19] Animal experimental data indicates that nitric oxide is about one-fifth as toxic as nitrogen dioxide.[20] At 175 ppm, guinea pigs lived for an indefinite period, while at 322 ppm, methemoglobinemia was produced in 60% of the guinea pigs.[19] Methemoglobinemia results when oxygen in the blood can not combine with the hemoglobin thus impairing the transport of oxygen to tissues. Information suggests that in mixtures of 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.[20]

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 in a few hours upon cessation 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.[21] There have been several studies on the effects of continuous exposure at low concentrations.[20] 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 exposures of 0.5 ppm for 6, 18, and 24 hours daily for three to twelve months, produced 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, mild and acute changes in the lungs at weeks end.[20]

Industrial data on human exposures have not been conclusive; however, animal research has developed several important principles. First, intermittent NO_2 exposures result in considerably less toxic effects 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.[19] 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.[21] There is a noted reduction in pulmonary function among normal adult males exposed to 4-5 ppm NO_2 for 10-15 minutes. Studies on individuals with bronchitis exposed to NO_2 concentrations above 1.5 ppm (not at or below this level) resulted in increased airway resistance.[21]

Carbon Monoxide

Carbon monoxide is 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.[22] High concentration 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.[2,13]

Respirable Dust/Free Silica

Crystalline silica, referred to as free silica, is silicon dioxide (SiO_2) commonly in the forms of quartz, and to a lesser extent as tridymite, or cristobalite.[23] Overexposure to free silica can result in the development of silicosis. This form of pneumoconiosis is characterized by a nodular pulmonary fibrosis caused by the inhalation and pulmonary deposition of dust containing crystalline silicon dioxide. In silicosis, as in many other pneumoconioses, the various stages of progression of silicotic lesions are related to the degree of exposure to free silica, the duration of exposure, and the length of time the dust is permitted to react with the lung tissue. Clinical symptoms of silicosis may include a cough, sputum production, shortness of breath, wheezing, and nonspecific chest infection. There may be little or no symptoms or decrements in pulmonary function when only discrete nodular (simple) silicosis is present. The two main complications of simple silicosis are the development of complicated forms of disease and tuberculosis. Simple silicosis has a definite tendency to progress, even in the absence of tuberculosis or further exposure to dust containing free silica.[23]

VI. Results and Discussion

A. Environmental

At both facilities, environmental sample duration averaged 7.4 hours for the surface operations and 6.7 hours for the underground operations. During the morning hours at both mines, the humidity levels underground ranged between 80 to 100% resulting in foggy conditions. The foggy conditions resulted from the volumes of water used underground for dust control combined with the fluctuating warm and cold air temperatures flowing through the mine. After 10:00 am, the fog conditions disappeared. On the surface, the relative humidity levels ranged from 40 to 65 percent.

Company measurements show the New Market mine had an average of 285,000 cubic feet per minute (cfm) of airflow through the mine; and 390,000 cfm at the Young mine. Visual assessment of the diesel exhaust in the mine environment indicated that the air volumes flowing through the mine were sufficient to remove the diesel exhaust from most of the immediate work areas. There were several dumping locations where diesel exhaust was observed to accumulate. One such location, at the Young mine, was the 63F mill hole where the blue haze of diesel exhaust was observed. Short-term detector tube readings at this location indicated 1.5 to 2.0 ppm of $N0_2$. These concentrations exceeded the NIOSH REL for NO_2, 1 ppm as a ceiling exposure level. As soon as a loader would leave the dump point, the diesel exhaust would clear. Neither mine had a lot of diesel equipment and typically no more than one diesel vehicle was observed working in a room at a time.

Coal Tar Pitch Volatiles/Polynuclear Aromatic Hydrocarbons

At the New Market mine and mill, seventeen area samples were collected and analyzed for benzene soluble CTPV's. An ambient CTPV sample was taken to compare with the underground and surface samples. No CTPV's were found in the ambient (outdoor) sample. Results of sampling for CTPV's ranged from below detectable limits (ND) to 2.0 mg/m^3. Ten (59%) of the seventeen sample concentrations were above the MSHA Standard of 0.2 mg/m^3 and twelve (71%) of the seventeen samples were above the NIOSH REL of 0.1 mg/m^3. The limit of detection (LOD) for the CTPV's was 0.06 mg/m^3. Results can be found in Table III.

At New Market, eleven (58%) of nineteen area samples collected for PNA's were analyzed. The eleven samples were taken on operator driven equipment working in areas considered to have the potential for high exposures. Of 16 different PNA's analyzed on each sample, only naphthalene, acenaphthylene, fluorene were detected.

Naphthalene[1] ranged from 0.02 to 0.12 mg/m^3, well below the MSHA Standard of 50 mg/m^3. The other two PNA concentrations ranged from ND to 0.002 mg/m^3 and were close to the limit of detection (LOD) of 0.001 mg/m^3. No PNA's were detected on the outdoor samples (Table V). The PNA concentrations found in Table V are the sum of the gaseous state PNA's collected on the back-up sorbent tube. No particulate PNA's were collected on the filter samples. Of the three PNA's detected, none are considered carcinogenic.(14,15,17)

At the Young mine/mill, seventeen area samples were collected and analyzed for the benzene soluble CTPV's. Results of sampling for CTPV's ranged from ND to 2.8 mg/m^3. Eleven (65%) of the seventeen sample concentrations were above the NIOSH REL and ten (59%) were above the MSHA Standard. The limit of detection (LOD) for the CTPV's was 0.06 mg/m^3. The results can be found in Table IV.

Also at the Young mine, eight area samples were collected and analyzed for PNA's. Of 16 different PNA's analyzed on each sample, four (naphthalene, acenaphthylene, fluorene, phenanthrene) were detected. Naphthalene ranged from ND to 0.09 mg/m^3 and was below the MSHA Standard. Acenaphthylene, fluorene and phenanthrene ranged from ND to 0.004 mg/m^3. Of the four PNA's that were detected, phenanthrene is considered to be a suspect carcinogen.(14,15,17) However, phenanthrene air concentrations were low, near the detection limits for the analytical method. The LOD for the PNA's found was 0.001 mg/m^3. The results can be found in Table VI. An outdoor sample taken at the Young mine was below detectable limits for CTPV and PNA's.

Diesel Particulate

At the New Market mine, a total of 18 personal samples were collected for the diesel particulate. Sampling for diesel particulates was done to determine the diesel fraction in the mine dust. This diesel fraction of airborne dusts is in the submicrometer size range and has the potential for reaching the lower airways of the lung. The diesel fraction is composed of solid carbon (soot) with organic compounds adsorbed onto its surface. Only eight of the 18 samples were analyzed because ten samples did not contain enough particulate material for analysis by low temperature ashing (LTA). In Table VII, the diesel fraction ranged from 0.11 mg/m^3 to 0.86 mg/m^3 and the organic content of the diesel fraction ranged from 46 to 86 percent of the total respirable particulate weight.

At the Young mine, nine personal samples were collected and three samples were not weighed/ashed due to low particulate weights. In Table VIII, the diesel fraction ranged from 0.09 to 0.82 mg/m^3 and the organic content ranged from 21 to 88 percent of the total respirable particulate weight. There is currently no occupational standard for exposures to diesel particulates.

[1]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 is reported with PNA compounds.

Nitric Oxide

Seventeen personal, full-shift samples for nitric oxide were collected at the New Market mine on heavy equipment operators. The time-weighted average (TWA) concentrations ranged from 0.12 to 14.3 ppm. None of the samples exceeded the MSHA or NIOSH recommended exposure limit of 25 ppm. The results are shown in Table IX.

At the Young mine, eight personal, full-shift samples for nitric oxide were collected from heavy equipment operators. The TWA sample concentrations ranged from 1.6 to 13.6 ppm. Again, none of the samples exceeded the MSHA Standard or the NIOSH REL of 25 ppm. The results are shown in Table X.

Review of MSHA data for the years 1976 to 1986 revealed no overexposures to nitric oxide at either mine.

Nitrogen Dioxide

At the New Market mine, seventeen full-shift personal samples for nitrogen dioxide were collected on the equipment operators. These 17 personal samples ranged from ND to 1.8 ppm with a mean exposure of 0.68 ppm. The results indicate that, at some point over the shift, exposures exceeded the NIOSH ceiling limit of 1 ppm (see Table IX). Five short-term $N0_2$ detector tube readings taken in various working areas, ranged from 0.5 to 3.0 ppm (see Table XI). Three of the five detector tube readings exceeded the NIOSH REL. None of the short term detector tubes exceeded the MSHA Standard.

At the Young mine eight full-shift, personal samples for nitrogen dioxide were collected on the equipment operators. The eight samples ranged from 0.2 to 1.8 with a mean exposure of 0.69 ppm (see Table X). Four short term $N0_2$ detector tube readings taken in the haulage ways and stopes ranged from 1.5 to 2.0 ppm (see Table XI). All four samples exceeded the NIOSH REL. None of the short term samples exceeded the MSHA Standard.

Review of MSHA data for New Market for the years 1976 to 1986 indicated that MSHA had taken 89 short term detector tube readings for $N0_2$. Of these 89 samples, six(7%) exceeded the MSHA Standard of 5 ppm and 45 (51%) of the samples were at or exceeded the NIOSH REL of 1 ppm. The MSHA sample data ranged from 0.25 to 10 ppm. At the Young mine for the same years, MSHA collected 78 samples for $N0_2$. Five(6%) of the 78 samples exceeded MSHA's Standard and 42 (54%) were at or exceeded NIOSH's REL. The MSHA samples ranged from 0.25 to 20 ppm.

Carbon Monoxide

Thirteen long-term detector tubes were collected at New Market in various working areas of the mine. Samples were taken for a period of four hours. The long term CO sampling results ranged from 1.0 to 9.0 ppm with a mean of 5 ppm. Short term detector tubes ranged from 2.0 to 3.0 ppm (see Table XII).

At the Young mine, nine long-term detector tubes were collected throughout the mine. The CO samples were collected over a five to seven hour period. It was felt that the low

CO levels seen at the New Market mine would also be found at the Young mine, consequently, the sampling time for CO was extended for the duration of the shift. Carbon monoxide concentrations ranged from 3 to 21 ppm with a mean of 6.5 ppm. Five short term detector tubes were collected in the stope areas where heavy equipment was operating. Two of these five samples revealed carbon monoxide levels of 3 ppm (see Table XIII).

Respirable Free Silica

Fifteen underground samples and eleven mill or surface samples were collected over the two day period at New Market. Of the 26 samples, only three had any detectable levels of quartz. These three samples did not exceed the MSHA Standard or NIOSH REL (Table XIV).

Review of the MSHA free silica data from 1981 to 1986 at the New Market Mine revealed one sample out of 25 exceeded the NIOSH REL and none exceeded the MSHA Standard. From the MSHA and NIOSH data, it appears that exposures to free silica at the New Market mine/mill are minimal. It is not known what exposures existed prior to 1981, but if the same ores were processed prior to 1981, then free silica exposures were probably minimal.

Nineteen underground and seven mill samples were collected for free silica analysis at the Young mine. Only two of 26 samples had detectable levels of quartz. The levels found were below NIOSH's REL and MSHA Standard (Table XV).

Review of MSHA data for the period 1976 to 1985 at the Young mine revealed that four of 68 free silica samples ranged from 0.050 to 0.103 mg/m^3 and exceeded the NIOSH REL of 0.05 mg/m^3. None of the samples exceeded the MSHA Standard.

B. Medical

Eighty-three males (21%) with an average age of 45 participated in the medical study. The mining tenure for this group ranged from eight to 41 years with the mean tenure at 20 years. Forty-four percent of the participants were current smokers, 35 percent were ex-smokers, and 21 percent had never smoked cigarettes (Table XVIII).

Current employment in jobs underground did not significantly increase the prevalence of cough and phlegm relative to the surface jobs. However, the prevalences of chronic cough, chronic phlegm, and chronic shortness of breath reported at the zinc mines were significantly different than those reported in the nonexposed blue-collar workers ($p < .01$)[11] (Table XIX). Height, age, and smoking-adjusted mean values of pulmonary function for underground and surface workers indicated no differences between the two groups. Percent predicted pulmonary function values by current job and smoking status also showed no significant mean differences between the surface and underground groups (Table XX).

Questionnaire results indicated increased prevalences of chronic cough, chronic phlegm, and chronic shortness of breath among the workers. Because only 21% of the current employees participated, the applicability of the HHE results to the entire work force is unclear. When asked about acute symptoms related to their work, the responses for "often" were quite similar between the surface and underground workers, except for eyes tearing and headache. The underground workers complained more of these symptoms (Table XXI).

Of the 84 chest films, seven (8%) had a median reading of $\geq$ 1/0 profusion of small opacities, and all seven of these workers were currently employed underground (Table XXII). In five of the workers the opacities were predominantly irregular and concentrated in the lower lobes, except for one who had equal distribution over all lobes. In the remaining two, the opacities were rounded, with one more predominant in the upper lobes and the other in the lower lobes. Their mean age was 53 years and they had an average tenure of 29 years in mining.

VII. Conclusions/Recommendations

A. Environmental

The environmental data collected at both the New Market and Young mines, indicate overexposures to nitrogen dioxide and coal tar pitch volatiles. Both contaminants are produced from the combustion of fossil fuels and their presence indicates inadequate dilution ventilation. Nitrogen dioxide is also a by-product of explosions. Short-term detector tubes taken for NO_2 underground at the end of a shift (when explosives are used) were below detectable limits. Exposures to NO_2 and CTPV's should be reduced below the NIOSH REL by increased dilution ventilation.

The presence of CTPV's at both mines is significant in that the only sources of its production are the diesel engines. CTPV's contain PNA's and some PNA's are suspect carcinogens. NIOSH detected one suspect PNA carcinogen (Phenanthrene) in air samples. Based on long term animal inhalation studies using whole diesel exhaust (gas and particulate), a causal relationship between diesel exhaust and cancer was observed.(17) On the basis of the results of animal studies and review of toxicological and epidemiologic studies, NIOSH considers diesel exhaust to be a potential occupational carcinogen.(14,15,17) It should be noted that there is no threshold concentration established for carcinogens at this time. Diesel emissions are a complex mixture of compounds that vary with fuel and engine type, load cycle, engine maintenance, tuning and exhaust treatment. This is compounded further by the myriad of environmental conditions in which diesel equipment is operated. Because of limitations in diesel technology, NIOSH can not confidently recommend applicable control measures that would completely eliminate carcinogenic risks. However, several recommendations can be made that will help minimize the risk. These recommendations are: (1) Continue to restrict the number of vehicles in a working stope to one vehicle at a time, (2) Increase the volume of air at both mines, use brattice curtains and/or portable fans with brattice cloth extensions to direct the flow of air to working areas, (3) Continue engine maintenance, and (4) Install engineering controls (scrubbers, filters, catalytical purifiers) on mine equipment to help reduce the pollutants emitted.

B. Medical

Results indicate very little difference between surface and underground workers for prevalence of chronic symptoms except for smokers. Among the smokers, the rates of chronic cough and phlegm were almost double those of ex- and nonsmokers. Thus, a question may be raised as to whether this increased prevalence in symptoms of cough and phlegm is actually associated with dust exposure or reflects the effects of tobacco smoking. It should be noted, however, that the reported symptoms among these workers were almost triple those of the nonexposed blue-collar workers in all categories, including nonsmokers (Table XIX). This increased prevalence may have resulted from a self-selection bias, since the participation rate was very low.

Radiographic evidence of pneumoconiosis was found in eight percent (7/83) of the current workers which compares to a 0.2 percent (3/1422) overall prevalence found among currently employed blue-collar workers with a minimal history of occupational exposure to respiratory hazards.[25] All seven positive radiographs were on underground workers with mining tenures ranging from 23 to 37 years and a mean age of 53.

Pulmonary function results showed four workers with moderate obstruction, 17 with mild obstruction, and two with a mild restrictive pattern. In a group of nonexposed blue-collar workers, an obstructive lung disease pattern was observed in 8.1% of the workers compared to 25.3% observed in these workers.

A moderate obstruction is defined as a FEV_1/FVC ratio between 45 and 60%, with normal being greater than 70%. The mild obstructive pattern has a ratio between 61 and 69%. A restrictive pattern has a normal FEV_1/FVC ratio, but the FVC falls below the predicted value for that individual. In the case of mild restrictive disease, the FVC observed/FVC predicted percent would fall in the 66 to 79 range. Both cases of restriction occurred in current smokers above the age of 40. All but one case of obstruction occurred in workers over age 40, the one younger case was in the 30-39 age group. All but three of the workers with obstructive pattern were either current or ex-smokers. Three of the workers with obstructive disease also had positive radiographs for pneumoconiosis. They were all over 50 years of age and had mining tenure of 20 plus years.

Although the participation rate was low (21%), there was evidence of an increase in radiographic evidence of pneumoconiosis (7/83, 8 percent) and an obstructive lung disease pattern in 3 of the 7 miners with evidence of pneumoconiosis. In addition, the underground miners (non-smokers and ex-smokers) had mean percent predicted FEV_1's statistically significantly lower than 100 percent. These findings suggest that a chronic respiratory health effect may have occurred as a result of cumulative workplace exposures in miners with the longest tenure.

Pneumoconiosis is a condition characterized by the deposition of dust in the lungs and the reaction of the lung tissue to this dust. The screening method that is generally available to recognize pneumoconiosis is the chest x-ray. The chest radiograph is reproducible, acceptable, and widely available. Equipment, expertise, and experience to obtain and interpret chest x-rays satisfactory for the detection of pneumoconiosis is readily available. An international classification for evaluating chest x-rays for the presence of pneumoconiosis exists and includes standard x-ray example films. To increase the x-ray reader's expertise in interpretation, NIOSH has developed teaching materials and an examination (B reader) to document a reader's ability in this area. Recommended methodology for x-ray surveillance would follow NIOSH guidelines for obtaining the x-rays and use NIOSH certified "B" readers, or radiologists with comparable expertise, to interpret the films. Agreement among two or three readers is suggested.

Periodic medical examinations should be made available to all workers subject to dust exposure. Examinations shall include as a minimum:

1. A medical and occupational history to elicit data on worker exposure to dust, and signs and symptoms of respiratory disease.
2. A chest radiograph (posteroanterior 14" x 17") classified according to the 1980 ILO International classification of Radiographs of Pneumoconioses. Repeat chest x-ray is recommended at 5-year intervals.
3. Pulmonary function tests including forced vital capacity (FVC) and forced expiratory volume at one second (FEV_1) to provide a baseline for evaluation of pulmonary function and to help determine the advisability of the workers using negative- or positive-pressure respirators. Repeat spirometry is recommended at yearly intervals and at termination of potential exposure or of employment.
4. Body weight.
5. Height.
6. Age.

If positive findings are found on the chest x-ray or spirometry test or both, the worker should be notified and be referred for further clinical evaluation to establish whether the condition is work-related. If workplace-related airways obstruction or pneumoconiosis is confirmed by the clinical evaluation, the workplace environment should be evaluated, and the worker should no longer be exposed to the inciting agent(s).

VIII. References

1. ASARCO. The Tennessee Mines, ASARCO Inc., Mascot, Tennessee.

2. 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.

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

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

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

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

7. 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.

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

9. American Thoracic Society: Standardization of Spirometry update. Am Rev Respiratory Disease 1987; 136:1285-1298.

10. International Labour Office. Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconiosis. Revised 1980. Geneva, Switzerland: ILO Occupational Safety and Health Series No. 22, 1980.

11. Petersen MR, Castellan RM. Prevalence of Chest Symptoms in Nonexposed Blue-Collar Workers. J Occupational Med. 26:367-374, 1984.

12. 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.

13. NIOSH/OSHA. Occupational Health Guidelines for Chemical Hazards. U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control, U.S. Dept. of Labor. January 1981.

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

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. 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.

18. 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.

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

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

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

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

23. NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Crystalline Silica, DHEW (NIOSH) Publication No. 75-120.

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

25. Castellan RM, Sanderson WT, Peterson MR,: Prevalence of Radiographic Appearance of Pneumoconiosis in an Unexposed Blue-Collar Population. Am Rev Respir Dis 131:684-686.

IX. Authorship and Acknowledgments

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

X. Distribution and Availability 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 45226. To expedite your request, include a self-address mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. ASARCO Safety Director, Mascot, Tennessee
2. ICWU Local 700
3. ICWU Local 701
4. ICWU, Akron, Ohio
5. MSHA, Knoxville, Tennessee
6. ASARCO Inc, Salt Lake City, Utah
7. 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.

TABLE I

SAMPLING AND ANALYTICAL TECHNIQUES
ASARCO NEW MARKET AND YOUNG MINES
MASCOT, TENNESSEE

RDHETA 88-108

Agent/Substance Sampled	Sample Flow Rate(LPM)	Sampling Media	Analytical Method and Reference
Coal Tar 5023 Using Pitch volatiles	2.0	PTFE Laminated Membrane Filter	NIOSH Method Benzene as Extractor[5]
Polynuclear 5515/Gas Aromatic FID[5] Hydrocarbons	2.0	PTFE Filter/Orbo-43 Solid Sorbent Tube	NIOSH Method Chromatography
Diesel Particulate 7500[5]	2.0	PVC Filter (Cyclone/Impactor)	Gravimetric/LTA[7] NIOSH Method
Oxides of Nitrogen ($N0_x$, NO, NO_2) Spectrophotometry[3,4]	Passive Sampler	Chromic acid disc Triethanolamine (Passive Dosimeter)	Visible Absorption
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]
Respirable Free 7500/0500, Silica	1.7	PVC Filter/Cyclone X-Ray Diffraction[5]	NIOSH methods

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

TABLE II

ENVIRONMENTAL EVALUATION CRITERIA
ASARCO NEW MARKET AND YOUNG MINES
MASCOT, TENNESSEE

RDHETA 88-108

Substance	NIOSH REL[8]	MSHA STANDARD[2]
Coal Tar Pitch Volatiles	0.1 mg/m^3 (TWA)	0.2 mg/m^3 (TWA)
PNA's	None	None
Diesel Particulates	None	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)
Respirable Free Silica (Quartz)	0.05 mg/m^3 (TWA)	$\frac{10\ mg/m^3}{\%\ Resp.\ Quartz + 2}$

NOTE: References are listed in Section VIII of this report.
Note: C (ceiling), TWA (time-weighted average)

TABLE III

COAL TAR PITCH VOLATILES
ASARCO NEW MARKET MINE
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Date	Location	Job(A)	Concentration (mg/m^3)
9/22/88	3P1 Drift	Roof Bolter	0.14
	8K	Trimmer	ND
	8F	Driller	2.0
	3P15 Drift	Wagner #1	0.29
	14N	Wagner #4	0.60
	---	Wagner #3	0.26
	13F	IMCO #2	0.13
	Maint. Shop	Cabinet	0.06
9/23/88	13F/G	Wagner #4	1.1
	---	Locomotive	0.45
	Maint. Shop	Cabinet	0.44
	13F	IMCO #2	ND
	All Over	Grader	0.06
	13G	Roof Bolter	1.0
	13F	Powder Wagon	0.60
	3P18	Wagner #1	0.34
	Outdoors	North Side Main Bldg	ND
	Limit of Detection (LOD)(mg/m^3)		0.06

ND (not detected), Mg/M^3 (milligrams per cubic meter)

Location - Where there is a blank, a work area was not identified with the piece of equipment

A - All samples were area samples.

TABLE IV

COAL TAR PITCH VOLATILES

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Date	Location	Job(A)	Concentration (mg/m^3)
9/26/88	Maintenance Shop	Shelf	ND
	8409	Roof Bolter	0.44
	8113	Rock Breaker	1.1
	8414	Driller	2.8
	170 level	Loader #7	0.14
	8461	Loader #9	0.47
	6912	Trimmer	0.07
	Outdoors	Outside Office	ND
9/27/88	1636	Driller	1.6
	----	Grader	0.30
	----	Loader #2	0.64
	7530	Loader #1	0.71
	8461	Loader #9	ND
	8114	Trimmer	0.08
	----	IMCO #8	0.23
	Maintenance Shop	Shelf	ND
	8113	Rock Breaker	0.29
	Limit of Detection (LOD) (mg/m^3)		0.06

Location - Where there is a blank, a work area was not identified with a piece of equipment.

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

A - All samples were area samples.

TABLE V

POLYNUCLEAR AROMATIC HYDROCARBONS
ASARCO NEW MARKET MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Date	Job/Location (A)	Naphthalene (mg/m^3)	Acenaphthylene (mg/m^3)	Fluorene (mg/m^3)
9/22/88	Driller	0.04	ND	ND
	Wagner #1	0.04	ND	ND
	Wagner #4	0.03	ND	ND
	Wagner #3	0.02	ND	ND
	IMCO #2	0.04	0.001	ND
9/23/88	Powder Wagon	0.05	ND	ND
	Maintenance Shop	0.06	0.001	ND
	Wagner #4	0.06	0.001	0.002
	Locomotive	0.12	0.001	0.001
	Wagner #1	0.07	ND	0.001
	Outdoors	ND	ND	ND
	Limit of Detection (LOD) (mg/m^3)	0.001	0.001	0.001

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

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

TABLE VI

POLYNUCLEAR AROMATIC HYDROCARBONS

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Date	Job/Location(A)	Naphthalene (mg/m^3)	Acenaphthylene (mg/m^3)	Fluorene (mg/m^3)	Phenanthrene (mg/m^3)
9/26/88	Maintenance Shop	0.09	0.002	0.001	0.001
	Outdoors	ND	ND	ND	ND
	Loader #7	0.03	0.003	0.002	ND
	Loader #9	0.06	0.004	0.003	0.001
	Loader #2	0.05	0.003	0.002	ND
9/27/88	Loader #1	0.02	0.004	0.003	0.001
	Loader #9	0.08	0.004	0.002	0.001
	IMCO #8	0.03	0.003	0.001	ND
	Limit of Detection (LOD) (mg/m^3)	0.001	0.001	0.001	0.001

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

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

TABLE VII

DIESEL PARTICULATE/FRACTION
ASARCO NEW MARKET MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Date	Job (P)	Total Respirable Particulate (TWA) (mg/m_3)	Diesel Fraction (mg/m_3)	Fraction Percent
9/22/88	Loader	0.72	0.62	86
	Loader	0.84	0.59	70
9/23/88	Loader	0.36	0.18	50
	Locomotive	1.06	0.86	81
	Loader	0.34	0.27	78
	Roof Bolter	0.25	0.11	46
	Driller	0.68	0.41	61
	Blaster	0.66	0.53	80
	Limit of Detection(LOD) (mg/m^3)		0.06	

P (personal sample), mg/m^3 (milligrams per cubic meter)

TABLE VIII

DIESEL PARTICULATE/FRACTION
ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Date	Job (P)	Total Respirable Particulate (TWA) (mg/m$_3$)	Diesel Fraction (mg/m$_3$)	Fraction Percent
9/26/88	Loader	0.98	0.82	88
	Rock Breaker	0.44	0.09	21
9/27/88	Loader	0.44	0.36	81
	Grader	0.43	0.38	88
	Trimmer	0.32	0.13	42
	Driller	0.24	0.09	38
	Limit of Detection (LOD) (mg/m^3)		0.06	

P (personal sample), mg/m^3 (milligrams per cubic meter)

TABLE IX

OXIDES OF NITROGEN
ASARCO NEW MARKET MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Date	Job (P)	NO_x Conc. TWA (ppm)	NO_2 Conc. TWA (PPM)	NO Conc. TWA (ppm)
9/22/88	Drill Operator	7.9	0.93	5.4
	Loader Operator	20.4	1.80	14.3
	Trimmer	2.3	0.12	1.7
	Roof Bolter	4.3	0.23	3.1
	Loader Operator	4.0	0.32	2.8
	Roof Bolter	3.8	0.23	2.7
	Skip Tender	0.15	ND	0.12
	Loader Operator	8.0	0.65	7.4
	Loader Operator	5.9	0.42	5.5
	Trimmer	2.8	0.22	2.0
9/23/88	Blaster	19.4	1.60	13.7
	Loader Operator	9.0	0.67	6.4
	Roof Bolter	3.9	0.23	2.8
	Drill Operator	10.6	1.40	7.1
	Grader Operator	8.2	0.78	5.7
	Loader Operator	4.7	0.31	3.4
	Locomotive Operator	12.5	1.60	8.4

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

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

TABLE X

OXIDES OF NITROGEN

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Date	Job (P)	NO_x Conc. TWA (ppm)	NO_2 Conc. TWA (ppm)	NO Conc. TWA (ppm)
9/26/88	Rock Breaker	6.7	0.53	4.7
	Loader Operator	4.8	0.42	3.4
	Roof Bolter	12.3	0.31	9.2
	Trimmer	3.5	1.15	1.8
	Loader Operator	19.5	1.80	13.6
9/27/88	Loader Operator	8.2	0.56	5.9
	Driller Operator	2.3	0.20	1.6
	Grader Operator	5.0	0.54	3.4

NOTES: P (personal samples), NO_x (total oxides of nitrogen), NO_2 (nitrogen dioxide), NO (nitric oxide), PPM (parts per million)

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

TABLE XI

SHORT TERM NITROGEN DIOXIDE CONCENTRATIONS
ASARCO NEW MARKET AND YOUNG MINES
MASCOT, TENNESSEE

SEPTEMBER 22-27, 1988
RDHETA 88-108

Date/Time	Location	Short-term Detector Tube Reading (ppm)
9/22/88		
	NEW MARKET MINE	
0938	14N Stope	0.5
0954	13G	1.5
1004	13F	3.0
1330	14N Stope	0.5
1310	13F	2.0
9/26/88		
	YOUNG MINE	
0818	8113	2.0
0847	8811	1.5
9/27/88		
0859	63F	1.5
0905	63F	2.0

NOTE: Nitrogen dioxide samples at New Market were taken only on September 22 and at the Young mine on September 26-27.

ppm - parts per million.

TABLE XII

CARBON MONOXIDE
ASARCO NEW MARKET MINE
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Date	Time	Location	Job(A)	Short Term Conc. (ppm)	Long Term Conc. (ppm)
9/22/88	0938	14N Stope	Area	3.0	NT
	1330	14N Stope	Area	3.0	NT
	0725-1055	14N Stope	Wagner #4	NT	6.0
	0756-1111	3P15	Wagner #1	NT	3.0
	1354	3P15	Area	2.0	NT
	0745-1105	3P1 Drift	Roof Bolter	NT	1.0
	0837-1135	8F	Driller	NT	5.0
	0728-1050	9M	IMCO #4	NT	5.0
	1145-1400	9M	IMCO #4	NT	9.0
9/23/88	0730-1050	13F	IMCO #2	NT	1.0
	0740-1052	13G	Roof Bolter	NT	7.0
	0732-1100	13F/G	Wagner #4	NT	7.0
	0717-1030	3P18	Wagner #1	NT	8.0
	0723-1010	All Over	Grader	NT	6.0
	0730-1050	Main Haulage	Locomotive	NT	7.0
	0725-1045	Support Column	Maint. Shop	NT	3.0

ND (not detected), NT (none taken), PPM (parts per million)

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

TABLE XIII

CARBON MONOXIDE

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Date	Time	Location	Job(A)	Short Term Conc. (ppm)	Long Term Conc. (ppm)
9/26/88	0818	8113	Area	3.0	NT
	0729-1428	8113	Rockbreaker	NT	3.0
	0757-1358	6912	Trimmer	NT	3.0
	0725-1330	170 Level	Loader #7	NT	4.0
	0830-1410	8409	Roof Bolter	NT	4.0
	0737-1358	1636	Driller	NT	4.0
	0720-1424	8461	Loader #9	NT	6.0
	0847	8811	Area	ND	NT
9/27/88	0815	8461	Area	3.0	NT
	0706-1359	8461	Loader #9	NT	7.0
	0859	63F	Area	ND	NT
	0901	63F	Area	ND	NT
	0710-1417	8114	Loader #2	NT	21.0
	0717-1412	7530	Loader #1	NT	ND
	0710-1425	All Over	Grader	NT	7.0

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

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

TABLE XIV

RESPIRABLE DUST/FREE SILICA
ASARCO NEW MARKET MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Job	Location	Respirable Dust TWA (mg/m^3)	MSHA STANDARD (mg/m^3)	Percent Silica	Respirable Free Silica-TWA (mg/m^3)
Secondary Crusher Operator (P)	Mill	0.48	1.25	6	0.03
Secondary Crusher Operator (P)	Mill	0.72	1.25	6	0.04
Maintenance Shop (A)	Cabinet	0.52	5.0	ND	ND
Maintenance Shop (A)	Cabinet	0.49	5.0	ND	ND
IMCO #2 (A)	13F	1.61	5.0	ND	ND
IMCO #2 (A)	13F/G	0.82	5.0	ND	ND
Loader Operator (P)	Mill	0.04	5.0	ND	ND
Loader Operator (P)	Mill	0.19	5.0	ND	ND
Outdoors (A)	Surface	ND	5.0	ND	ND
Outdoors (A)	Surface	0.10	5.0	ND	ND
Wagner #4 (A)	14N	0.57	5.0	ND	ND
Wagner #4 (A)	13F/G	1.93	2.5	2	0.03
Roof Bolter (A)	13G	1.49	5.0	ND	ND
Roof Bolter (A)	3P Drift	0.40	5.0	ND	ND
Concentrate Operator (P)	Mill	0.11	5.0	ND	ND
Concentrate Operator (P)	Mill	0.10	5.0	ND	ND
Wagner #1 (P)	3P18	2.16	5.0	ND	ND
Wagner #3 (A)	3P15	0.65	5.0	ND	ND
Millwright (P)	Mill	0.04	5.0	ND	ND
Control Booth (A)	Mill	0.31	5.0	ND	ND
Grader (A)	Shop	0.78	5.0	ND	ND
Trimmer (A)	8K	0.42	5.0	ND	ND
Yardman (P)	Mill	0.17	5.0	ND	ND
Powder Wagon (A)	13F	1.46	5.0	ND	ND
Driller (A)	8F	0.04	5.0	ND	ND
Locomotive (A)	Main Haulage	1.69	5.0	ND	ND

Evaluation Criteria: MSHA STANDARD $= \frac{10\ mg/m^3}{\%\ Resp.Quartz + 2}$ 0.05 mg/m^3 (NIOSH)

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

TABLE XV

RESPIRABLE DUST/FREE SILICA

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Job		Location	Respirable Dust TWA (mg/m^3)	MSHA STANDARD mg/m^3	Percent Silica	Respirable Free Silica-TWA (mg/m^3)
Secondary Crusher Operator	(P)	Mill	0.44	5.0	ND	ND
Secondary Crusher Operator	(P)	Mill	0.15	5.0	ND	ND
Rock Breaker	(A)	8113	0.77	5.0	ND	ND
Rock Breaker	(A)	8113	0.77	5.0	ND	ND
Loader #9	(A)	8461	1.38	5.0	ND	ND
Loader #9	(A)	8461	0.91	5.0	ND	ND
Maintenance Shop	(A)	Shelf	0.39	5.0	ND	ND
Maintenance Shop	(A)	Shelf	1.50	5.0	ND	ND
Concentrate Operator	(P)	Mill	0.47	5.0	ND	ND
Concentrate Operator	(P)	Mill	0.39	5.0	ND	ND
Yardman	(P)	Mill	0.11	5.0	ND	ND
Yardman	(P)	Mill	0.55	5.0	ND	ND
Trimmer	(A)	6912	0.59	5.0	ND	ND
Trimmer	(A)	8114	ND	5.0	ND	ND
Chute Puller	(P)	UG	0.15	5.0	ND	ND
Chute Puller	(P)	UG	0.55	5.0	ND	ND
Loader Operator	(P)	Mill	0.21	5.0	ND	ND
Driller	(A)	8414	0.62	5.0	ND	ND
Driller	(A)	1636	ND	5.0	ND	ND
Grader	(A)	All Over	ND	5.0	ND	ND
Loader #1	(A)	7530	1.60	5.0	ND	ND
Loader #7	(A)	170 Level	1.70	5.0	ND	ND
Loader #2	(A)	8811	1.80	2.5	2	0.03
Skip Tender	(P)	Skip	0.95	1.66	4	0.04
Roof Bolter	(A)	8409	0.59	5.0	ND	ND
IMCO #8	(A)	UG	0.81	5.0	ND	ND

Evaluation Criteria: $\text{MSHA STANDARD} = \dfrac{10\ mg/m^3}{\%\ \text{Respirable Quartz} + 2}$ 0.05 mg/m^3 (NIOSH)

NOTE: UG (underground), A (area sample), P (personal sample), ND (not-detected), mg/m^3 (milligrams per cubic meter), mg/m^3 (milligrams per cubic meter).

TABLE XVI

SUMMARY SHEET
ASARCO NEW MARKET MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 22-23, 1988
RDHETA 88-108

Agent	Number of Samples	Concentration Range	MSHA STANDARD	NIOSH REL
Coal Tar Pitch Volatiles (UG)	17	ND to 2.0 mg/m^3	0.2 (TWA)	0.1 (TWA)
Polynuclear Aromatic Hydrocarbons (UG)	11	ND to 0.12 mg/m^3	none	none
Diesel Particulates (UG)	8	0.25 to 0.93 mg/m^3	none	none
Nitric Oxide (UG)	17	0.12 to 14.3 ppm	25 (TWA)	25 (TWA)
Nitrogen Dioxide (UG)	17	ND to 1.80 ppm	5(C)	1(C)
Nitrogen Dioxide (UG)(ST)	4	0.5 to 3.0 ppm	5(C)	1(C)
Carbon Monoxide (UG)(LT)	13	1.0 to 9.0 ppm	50 (TWA)	35 (TWA)
Carbon Monoxide (UG)(ST)	4	2.0 to 3.0 ppm	50 (TWA)	35 (TWA)
Respirable Free Silica (UG)	15	0.03 to 0.04 mg/m^3	*	0.05 (TWA)
Respirable Free Silica (S)	11	0.03 mg/m^3	*	0.05 (TWA)

Note: ND - none detected
LT - long term tube
ST - Short term tube
UG - underground
S - surface
C - ceiling
* - $\frac{10\ mg/m^3}{\%\ Resp.Quartz + 2}$
ppm - parts per million
mg/m^3 - milligrams per cubic meter

TABLE XVII

SUMMARY SHEET

ASARCO YOUNG MINE/MILL
MASCOT, TENNESSEE

SEPTEMBER 26-27, 1988
RDHETA 88-108

Agent	No. of Samples	Concentration Range	MSHA STANDARD	NIOSH REL
Coal Tar Pitch Volatiles (UG)	17	ND to 2.8 mg/m^3	0.2 (TWA)	0.1 (TWA)
PNA's (UG)	8	ND to 0.09 mg/m^3	none	none
Diesel Particulates (UG)	6	0.24 to 0.93 mg/m^3	none	none
Nitric Oxide (UG)	8	1.6 to 13.6 ppm	25 (TWA)	25 (TWA)
Nitrogen Dioxide (UG)	8	0.20 to 1.8 ppm	5(C)	1(C)
Nitrogen Dioxide (UG)(ST)	4	1.5 to 2.0 ppm	5(C)	1(C)
Carbon Monoxide (UG)(LT)	9	ND to 21.0 ppm	50 (TWA)	35 (TWA)
Carbon Monoxide (UG)(ST)	5	ND to 3.0 ppm	50 (TWA)	35 (TWA)
Respirable Free Silica (UG)	19	0.03 to 0.04 mg/m^3	*	0.05 (TWA)
Respirable Free Silica (S)	7	ND	*	0.05 (TWA)

ND - none detected, LT - long term detector tube, ST - short term detector tube, UG- underground, S - surface, C - ceiling, PPM - parts per million, Mg/m^3 - milligrams per cubic meter.

$$* \quad \frac{10 \ mg/m^3}{\% \ Resp.Quartz + 2}$$

TABLE XVIII

DEMOGRAPHIC CHARACTERISTICS BY SMOKING AND CURRENT JOBS

ASARCO ZINC MINES/MILLS
EAST TENNESSEE

SEPTEMBER 21-23, 1988
RDHETA 88-108

	SMOKERS		EX-SMOKERS		NON-SMOKERS	
	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE
	N = 32 MEAN (SD)	N = 5 MEAN (SD)	N = 23 MEAN (SD)	N = 5 MEAN (SD)	N = 16 MEAN (SD)	N = 2 MEAN (SD)
AGE *	49 (9.7)	35 (9.5)	47 (8.6)	52 (7.0)	49 (9.8)	46 (2.8)
HEIGHT (CM)	174 (6.4)	177 (3.6)	176 (5.6)	177 (7.9)	176 (7.4)	174 (4.2)
	%	%	%	%	%	%
RACE WHITE	91	100	100	100	100	100
BLACK	9	-	-	-	-	-
SEX MALE	100	100	100	100		
FEMALE	-	-	-	-	-	-

*The mean ages are not equal between smoking categories (p=.0059).

TABLE XIX

PERCENTAGE REPORTING CHRONIC SYMPTOMS BY SMOKING STATUS

ASARCO ZINC MINES/MILLS
EAST TENNESSEE

SEPTEMBER 21-23, 1988
RDHETA 88-108

	ASARCO ZINC MINES			BLUE COLLAR STUDY		
	SMOKERS	EX-SMOKERS	NONSMOKERS	SMOKERS	EX-SMOKERS	NONSMOKERS
Chronic Cough	51 (19/37)	14 (4/29)	33 (6/18)	19.5	8.2	7.8
Chronic Phlegm	62 (23/37)	25 (7/28)	39 (7/18)	17.7	13.1	7.6
Chronic Shortness of Breath	16 (6/37)	7 * (2/28)	17 (3/18)	3.4	3.4	1.6

* 1 Disabled Worker

TABLE XX

PERCENT PREDICTED PULMONARY FUNCTION VALUES BY CURRENT JOB
AND SMOKING STATUS
MEAN (STD)

ASARCO ZINC MINES/MILLS
EAST TENNESSEE

SEPTEMBER 21-23, 1988
RDHETA 88-108

	SMOKERS		EX-SMOKERS		NON-SMOKERS	
	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND	SURFACE
N	32	5	23	5	16	2
FVC (%)	106.2 (14.4)	96.9 (9.4)	104.0 (13.2)	108.3 (20.1)	100.7 (18.5)	103.0 (11.2)
FEV_1	96.0 (14.9)	9	91.9 (14.7)*	96.8 (12.4)	93.0 (9.3)*	99.7 (16.7)

* Mean value statistically < 100% (t-test; $p < 0.05$)

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

ASARCO ZINC MINES/MILLS
EAST TENNESSEE

SEPTEMBER 21-23, 1988
RDHETA 88-108

	SURFACE WORKERS N=12	UNDERGROUND WORKERS N=71
ACUTE SYMPTOMS	N (%)	N (%)
COUGH	3 (25)	14 (20)
NOSE TICKLED/IRRITATED	2 (17)	16 (23)
SNEEZE	2 (17)	15 (21)
EYES ITCH/BURN	2 (17)	16 (23)
TEARING OF THE EYES	0 (0)	11 (15)
SORE THROAT	2 (17)	5 (7)
DIFFICULT/LABORED BREATHING	3 (25)	11 (15)
TIGHT/CONSTRICTED CHEST	2 (17)	10 (14)
UPSET STOMACH	4 (33)	12 (17)
CHEST WHEEZING/WHISTLING	2 (17)	8 (11)
HEADACHE	1 (8)	16 (23)

TABLE XXII

CHEST RADIOGRAPHS
CUMULATIVE MEDIAN PROFUSION CATEGORY

ASARCO ZINC MINES/MILLS
EAST TENNESSEE

SEPTEMBER 21-23, 1988
RDHETA 88-108

	FREQUENCY	PERCENT	MEAN MINING TENURE (YEARS)
0/0	71	85	18
0/1	6	7	25
1/0	4	5	29
1/1	3	4	29

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 ....
	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.							

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

C. SYMPTOMS (Continued)

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

IDENTIFICATION NO.

C. SYMPTOMS (Continued)

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? 1 ☐ Yes 2 ☐ No 9 ☐ NA
If so, how many ....

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

D. TOBACCO SMOKING (Continued)

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?

____

____