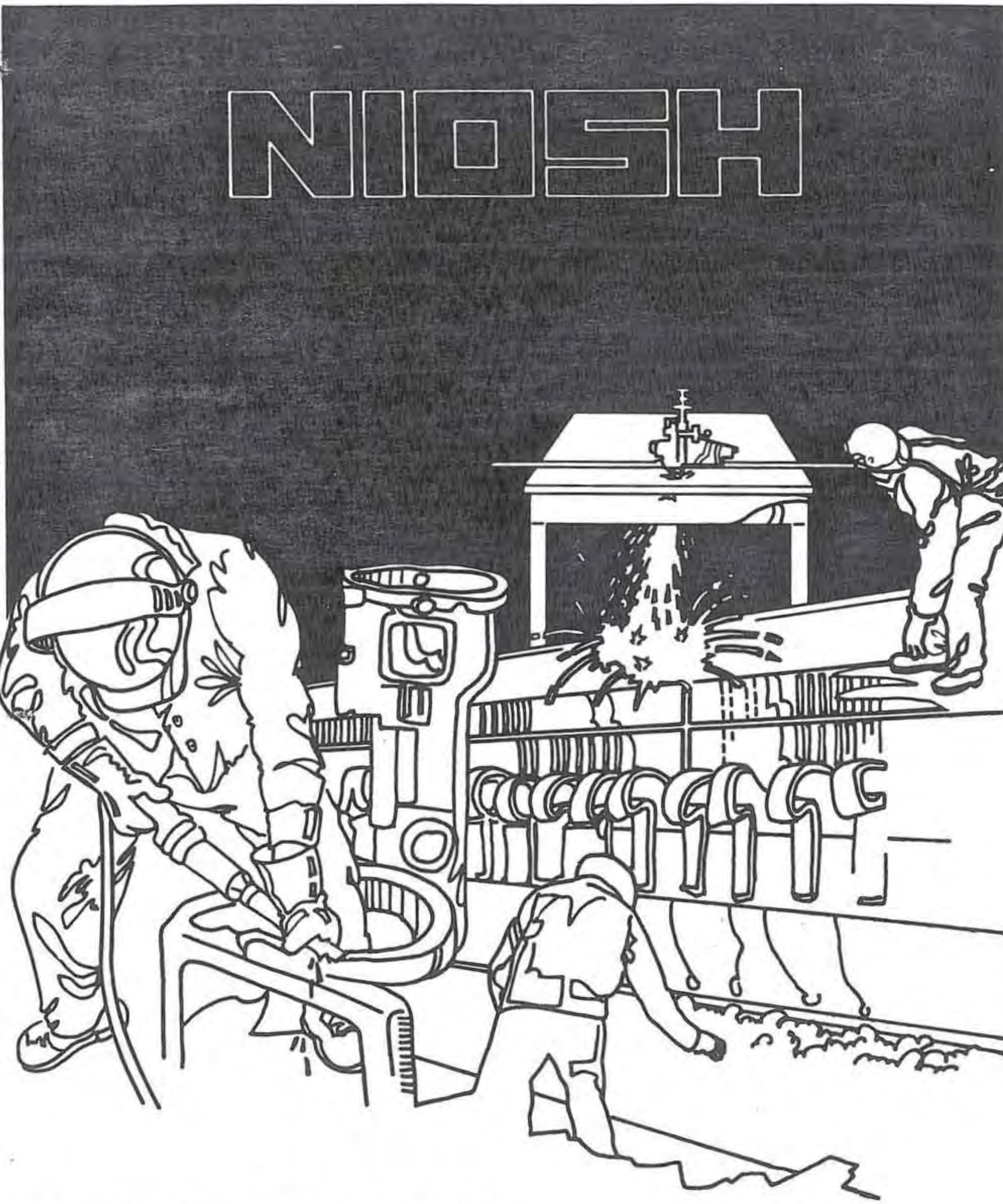
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-034,035-934
COLORADO SPRINGS PUBLIC UTILITIES
COLORADO SPRINGS, COLORADO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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I. SUMMARY

On October 16, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the City of Colorado Springs Department of Public Utilities for a "baseline" environmental evaluation of two coal-fired electrical power production facilities.

NIOSH industrial hygienists visited the Martin-Drake and R.D. Nixon power plants during February 9-20, 1981. Employees were monitored for exposures to airborne substances during normal electrical production at both plants, and during a period of scheduled maintenance shut-down at the Martin-Drake plant. These substances included fly ash, coal dust, free silica, flue gases, trace metals, and boiler feed-water chemicals.

Approximately 30% of the samples collected for respirable free silica (quartz) were found to be in excess of the NIOSH recommended standard. Results ranged from below the 0.03 milligram/sample analytical limit of detection to approximately 6 milligrams/cubic meter of air (mg/M^3). Excessive exposures to respirable free silica were measured during vacuum sweeping, pulverizer, fan, precipitator, and boiler maintenance, and during coal handling operations including the general coal yard area, coal dump, tripper deck, and conveyors. NIOSH currently recommends that exposures to all forms of respirable free silica be kept below 0.05 mg/M^3 on a time weighted average (TWA) basis.

Of 14 samples collected for determination of inorganic arsenic exposure, 3 obtained during maintenance operations indicated excessive exposure, with results ranging from 4.9 to 9.8 micro-grams (ug) /M^3. The NIOSH recommended standard for inorganic arsenic is 2.0 ug/M^3. Three of five measured exposures to sulfur dioxide were found to be in excess of the NIOSH recommended standard of 1.3 mg/M^3 during pulverizer and fan maintenance; the highest being 2.1 mg/M^3. One of two general area samples obtained during refractory repair which measured respirable free silica (cristobalite) was also in excess of the NIOSH exposure standard. Exposures to airborne hydrazine were measured at levels matching the Threshold Limit Value (TLV) of 0.1 ppm, during addition to dilution vessels at the Drake plant.

Based on the environmental data collected at the facilities, NIOSH has determined that a potential health hazard exists from over-exposure to fly ash and coal dust containing free silica at the both plants, and to inorganic arsenic, cristobalite, sulfur dioxide, and hydrazine at the Martin-Drake facility. Recommendations for control of excessive exposures are made in Section VII of this report.

KEY WORDS: SIC 4911 (Electric Power Generation)
Free Silica, Quartz, Christobalite, Fly-ash, Coal Dust, Nitric Oxide, Nitrogen Dioxide, Carbon Monoxide, Sulfur Dioxide, Arsenic, Hydrazine, Mercury, Trace Metals, Chlorine, Cyclohexylamine, Dimethylamine, Heat Stress.

II. INTRODUCTION

On October 16, 1980, a request for technical assistance was submitted by the Safety Director of the Colorado Springs Department of Public Utilities for an environmental evaluation of the Martin-Drake electric production facility located near down-town Colorado Springs and the R.D. Nixon facility located approximately 20 miles south of the city. The official request was for a "baseline" evaluation of numerous plant areas, including exposure conditions encountered during normal production and also during a maintenance shut-down phase. To comply with this request, NIOSH scheduled a visit which covered normal production at both plants and several days of the shut-down phase at the Martin-Drake plant. NIOSH industrial hygienists visited the facilities on February 9 through 20, 1981. The purpose of the surveys was to document the extent of employee exposures to potentially toxic substances encountered at these facilities and to supply this information to the Utility to aid their further development of a safety and health program.

III. BACKGROUND

The Martin-Drake plant consists of four separate electrical production systems. The original gas-fired system, built in 1925, is used only in emergency situations. The remaining three systems built in 1962, 1968, and 1972 (designated #'s 5, 6, and 7 units, respectively) are coal-fired and produce a total of 280 mega-watts (Mw) of electrical power.

Coal is received by rail, with the three units consuming about 850,000 tons a year when operating at full capacity. The newest unit, #7, will consume 72.5 tons of coal per hour. Coal reaches the power plants by train utilizing 73 rapid-unloading, 100-ton hopper coal cars. In full operation, 27 cars are dropped off at the Martin-Drake plant, with the rest proceeding to the Nixon plant. Coal is delivered on an average of three times per week. All coal for the power plants comes from Colorado mines near the Wyoming border: the Colowyo, Empire Energy, and Pittsburgh & Midway mines. Coal from these mines is of relatively low sulfur content.

Coal is unloaded through a grate positioned between the rail tracks, then conveyed to a crusher house and broken to "gravel size" pieces. The coal then proceeds to either the tripper-deck; a long narrow room located on the top (7th) floor of the facility which contains a mobile tripper mechanism for distribution of coal to the various unit bunkers, or to the surrounding plant areas to give a 60 to 90 day fuel supply. Coal is gravity fed from the in-plant bunkers to pulverizers where it is crushed to the consistency of powder. Number 5 unit utilizes a hammer mill pulverizer while #'s 6 and 7 units are of the rolling ball type. High capacity fans force air streams upward through the pulverizers, and once the coal is crushed to sufficiently small particles as to be entrapped in this air stream, it is forced into the boilers. Number 5 unit is air balanced; fans downstream of the boiler create negative pressure in the system. Numbers 6 and 7 units are under positive pressure (fans are upstream of the boilers) which causes combustion products to escape into the plant atmosphere through cracks or other openings.

Electrostatic precipitators are used on #'s 5 and 7 units to capture combustion products (fly ash), while #6 unit is equipped with a bag house. Due to the low sulfur content of the coal, sulfur trioxide must be added to the exhaust stream of the boilers utilizing the precipitators to increase system efficiency. Bottom ash (internal ash deposits which ultimately fall to the bottom of the boiler, or refractory area) is transported to a nearby "zero discharge plant" via water slurry where it is concentrated and subsequently disposed of by commercial carriers.

Boiler, feed, and main circulation water is chemically treated for scale, pH, and oxidation control from the basement level of the plant. Instrument inspections are usually made twice per shift. Chlorine is used as an algacide in the cooling towers, and is automatically fed to the water from inside the chlorine addition building (a small building located near the cooling towers). Instruments are monitored once or twice per shift in this building by a single worker. The building is equipped with a system to warn against the threat of chlorine leaks.

The R.D. Nixion plant began commercial production of electric power in April of 1980. This facility represents the state of the art in coal-fired electric power production. Coal is received by rail cars (the same as the Martin-Drake plant) and automatically unloaded via magnetically operated hopper doors. This single turbine plant operates in essentially the same manner as the Drake plant, except automation has replaced many of the worker tasks. Operating at full capacity, the Nixon plant produces approximatily 200 Mw of electric power, and uses 100 tons of coal/hr. Due to the inability of low-sulfur coal to efficiently operate electrostatic precipitators, the plant builders opted for a bag-house to control emissions. Fly ash is conveyed by vacuum to a storage silo and sold to a private firm.

The Drake plant employs a total of 50 production and maintenance workers while the more modern Nixon plant employs 22. Job classifications of workers with potential repeated exposures to airborne contaminants include Operators, Coal handlers, and Maintenance personnel. Within these classifications are numerous sub-catagories. Following are descriptions of these classifications and the catagories monitored during the environmental evaluations.

Operations - These workers are responsible for the surveillance of the hundreds of meters and gauges necessary for the production of electric power. Most of the work-shift is spent inside air-conditioned positive pressure control rooms. One or two times a shift, one or more of these workers conduct walk-downs of the entire facility for routine monitoring. Job classifications include Control Operators, Tenders, Helpers, and Auxiliary Helpers.

Maintenance - These workers are involved with the routine upkeep and emergency repairs of the facilities. During the time of the environmental survey, the following types of jobs were monitored for levels of exposure to airborne contanminants:

Janitors - General housekeeping duties including sweeping fly ash with brooms and vacuum sweepers.

Pulverizer maintenance - Routine repair and parts replacement of pulverizers.

Fan maintenance - Repair of primary air fans.

Soot blower maintenance - Routine repair and parts replacement of soot blowers.

Welders - welding I-beams, structural supports, and air fans.

Instrument technicians - Repair of various plant components including meters and gauges which may contain mercury; repairs conducted inside an enclosed repair shop.

Coal Handlers - Included in these operations are the unloaders, train operators, and tractor operators (all of which work in the coal yard), plus conveyormen and tripper deck operators which work inside the plant. Following is a list of the jobs monitored during the environmental evaluation:

Unloading rail cars - Assisted with the removal of coal from the rail cars which involved the use of shovels and bars to force the coal into metal grates.

Locomotive operator - Manipulated rail cars in the coal yard.

Equipment operator - Operated tractors to move the coal from the unloading point to the storage areas.

Car runner - Disconnects rail cars at desired locations.

Conveyorman - Surveillance of the crusher house and conveyor system.

Tripper Deck operator - Operated the tripper mechanism on the upper level of the plant.

During a scheduled maintenance period, an entire unit is brought off-line for inspection and repair. The following presents the types of jobs monitored during the environmental evaluation.

Boiler inspection - Usually conducted by 2 management employees, a physical inspection of all internal boiler components is made.

Precipitator inspection - An internal inspection is made by one management representative and one representative of the precipitator manufacturer.

Precipitator cleanout - Internal precipitator components are manually cleaned using brooms and shovels. Contract workers (usually 6-8) are used for this task.

Precipitator wash - The same contract workers enter the upper levels of the precipitator and wash the remaining fly ash toward the bottom hoppers.

Hopper maintenance - Sides of the fly ash hoppers are pounded to settle the fly ash to the bottom.

IV. METHODS AND MATERIALS

The environmental survey was scheduled to coincide with four days of normal production at the Martin-Drake and the Nixon plants and during four days of shut-down maintenance of the #7 unit at the Martin-Drake facility. A walk-through of both plants was conducted on February 9, 1981. Environmental sampling at the Drake plant was initiated on February 10, and continued through February 13 under normal production conditions. Sampling was conducted at the Nixon plant on February 12 for two shifts. Because of the apparent lack of appreciable exposures at this plant plus time and equipment constraints, the remainder of the survey focused on the Drake plant. Table 1 presents a list of sampled substances along with other pertinent data.

During periods of normal production, breathing zone samples were collected from the operators, maintenance workers, and coal-handlers, for determination of exposures to fly-ash, coal dust, free silica, sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), carbon monoxide (CO), trace metals, and hydrazine. General area samples were collected in the chemical addition room, the chlorine building, and the maintenance and repair shop for cyclohexylamine and dimethylamine, chlorine, and mercury, respectively.

Environmental monitoring for respirable and total particulates was conducted inside the plant and outside at the coal handling areas. All samples collected for fly ash or coal dust were also analyzed for free silica content. Sampling protocol called for a flow rate of 2.0 liters per minute (lpm) for coal dust samples, and 1.7 lpm for fly ash. Because there is no practical method for distinguishing between fly ash and coal dust particles on a particular sample, results were classified as fly ash or coal dust exposures dependent upon the work area of the sampled employee or the site of collection. Workers were questioned prior to their shift as to what type of job they would be performing, and accordingly sampled for fly ash or coal dust exposures.

Airborne exposures to trace metals are a result of the presence of metals in the coal. Worker exposures to arsenic were of concern based on results of environmental surveys of other power plants in the area, which reportedly showed arsenic exposures exceeding the OSHA standard. To determine the presence of other metal exposures, four of the filter samples were submitted for ICP (inductively coupled argon plasma) analysis which reports the possible content of a broad range of metals. From results of these four, thirteen other samples were analyzed via the less involved (and less expensive) Atomic Absorbtion technique.

Regular maintenance of pulverizers, soot blowers, and fans was monitored for exposures to flue gases containing SO_2, NO, NO_2, and CO, plus particulate exposures to free silica, coal dust, trace metals, or fly ash.

Chemicals used for water treatment which are of occupational health concern include dimethylamine, cyclohexylamine and hydrazine. The source of the amines are pressurized cylinders retained in the chemical addition room. The amines are automatically fed into the water system and require only periodic inspections. The source of hydrazine (an oxygen scanvenger) is a 20 gallon drum located in an open area of the basement level. Twice per shift, a measured amount of hydrazine (a few ounces) is manually obtained from the drum and poured into each of three water feeders. General area samples were collected in the chemical addition room for determination of airborne amine concentration. Short-term detector tube sampling was conducted during addition of hydrazine to the dilution vessels.

The maintenance schedule did not call for inspection or maintenance of the bag house during the NIOSH visit. However, because of the concern for excessive exposures during this operation, a "mock" inspection was conducted by a NIOSH investigator and a representative of the CSPU Safety Department. Environmental samples were collected for determination of exposures to fly ash, trace metals, SO_2 , NO, NO_2, and CO, plus heat stress conditions. Bag house inspections tend to be of short duration, but if a repair is needed, the time inside becomes greater.

Wet-bulb Globe Temperature (WBGT) measurements were obtained at several locations on the upper levels of the plants and during bag house inspection using a "WIBGET" model RSS-211D Heat Stress Monitor. Periodic surveillance and adjustment of guages requires maintenance personnel to spend limited time in extreamly hot areas. No work practices in these areas were observed.

The #7 Unit at the Martin Drake plant was shut down for routine maintenance on February 14. Typically, 2 or 3 days are allowed for boiler cool-down prior to entry. Boiler inspection is the initial maintenance phase, requiring 2 workers to enter and physically search the entire inside areas for breaks in steam lines or deposits of hardened fly ash (clinkers). The electrostatic precipitator is then examined for internal damage, usually by a company representative and a representative of management. Inspectors were monitored for fly ash, free silica and trace metal exposures.

Precipitator clean-out is conducted during a scheduled shut-down to remove internal fly ash deposits which collect on internal ledges, grates, and support structers. Normally, the electrically entrapped fly ash falls to the bottom of the precipitator, but these obstuctions require manual removal. During this operation, environmental samples were collected in determination of fly ash, free silica, and trace metal exposures.

V. EVALUATION CRITERIA

The environmental evaluation criteria used in this report as related to airborne exposures to toxic substances are 1) NIOSH recommended standards, 2) Federal Occupational Health Standards (as promulgated and enforced by the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor (29 CFR 1910.1000), and 3) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's).

Table 2 summarizes the evaluation criteria for sampled substances along with brief descriptions of their primary health effects. The following discussion pertains to those substances which were found to be in excess of the limits expressed in the evaluation criteria.

Silica

Crystalline silica, usually referred to as free silica, is defined as silicon dioxide (SiO_2) molecules arranged in a fixed pattern as opposed to a nonperiodic, random molecular arrangement defined as amorphous silica. The three most common crystalline forms of free silica encountered in industry are quartz, tridymite, and cristobalite, with quartz being by far the most common of these. NIOSH, in its recommendations for a free silica standard, has proposed that exposures to all forms of free silica be controlled so that no worker is exposed to respirable airborne concentrations greater than 0.05 mg/M^3, as averaged over a 10 hr. working day, 40 hr. workweek. This recommendation was designed to protect workers from silicosis; a pneumoconiosis due to the inhalation of silicon dioxide-containing dust. Exposures to free silica greater than one-half the recommended standard, or "action level", should initiate adherence to the environmental, medical, labeling, recordkeeping, and worker protection guidelines as contained in Chapter I of the NIOSH criteria document, "Occupational Exposure to Crystalline Silica". The current federal, or OSHA standard for respirable free silica exposure is an 8 hour time-weighted average based upon the 1968 ACGIH TLV formulas of 10 mg/M^3 divided by the percent SiO_2 plus 2 (10mg/M^3/%SiO_2 + 2) for respirable quartz. One-half this amount was established as the limit for cristobalite and tridymite. As can be seen from the calculation, the OSHA regulation is based on the percentage of free silica contained in the respirable particulate exposure, whereas the NIOSH recommended standard applies directly to the airborne concentrations of respirable free silica.

Coal Dust

Currently, NIOSH does not have a recommended standard for exposures to coal dust. The OSHA standard is 2.4 mg/M^3 (TWA) for coal dust with a respirable free silica fraction of less than 5%. If the respirable fraction of free silica is greater than 5%, then the previously described OSHA standard for free silica is applicable. The TLV is 2.0 mg/M^3 for a quartz content of less than 5%; for greater than 5%, the TLV is the same as the OSHA standard.

Arsenic

NIOSH has recommended that airborne concentrations of inorganic arsenic be controlled to prevent exposures in excess of 2.0 ug/M^3. For the purposes of the recommended standard, arsenic is defined as elemental arsenic and all of its inorganic compounds. To determine the extent of worker exposures, a 15 minute sampling period is advised for avoidance of spurious sampling results produced by natural "background" concentrations (not to be confused with the traditional "ceiling" designation occasionally assigned to some of the more toxic chemicals which require 15 minute exposure determinations). The recommended standard was designed to protect workers from the possible development of lymphatic and respiratory arsenic-related cancer. This relationship has been suggested by numerous studies of working populations.

The OSHA standard for inorganic arsenic is 10 ug/M^3, as averaged over an 8 hr. work-shift. The TLV for arsenic and its soluble compounds (except for arsenic trioxide, arsine, and lead arsenate which have individual TLV's) is 200 ug/M^3.

Sulfur Dioxide

NIOSH recommends that exposures to sulfur dioxide not exceed an 8-hr TWA of 1.3 mg/M^3, based on testimony presented to the Department of Labor in June of 1977. Severe skin and mucus membrane irritation may result from exposures to SO_2 due to the formation of sulfurous acid when it contacts moist surfaces. The TLV is 5 mg/M^3, while the current OSHA standard is at 13 mg/M^3.

Hydrazine

Although NIOSH has not as yet published a recommended standard for hydrazine, this substance has been classified within the ACGIH group of "Industrial Substances Suspect of Carcinogenic Potential for Man", and has been assinged a TLV of 0.13 mg/M^3. Substances are included in this category based on 1) limited epidemiological evidence, or 2) demonstration of carcinogenesis in one or more animal species by appropriate methods. This latter parameter was the basis for inclusion of hydrazine, which has demonstrated a dose-response relationship between various levels of exposures of laboratory animals and tumor incidence. The current OSHA standard is 1.3 mg/M^3.

VI. RESULTS AND DISCUSSION

Appendix A and B lists all results of environmental sampling conducted during the NIOSH visit. Also, various tables are presented which illustrate survey results by location/operation or by sampled substance.

The environmental survey was designed to measure numerous exposure situations toward a general characterization of the plant environment, rather than focussing on a single process for extensive, repeated sampling. As a consequence, the survey results are only suggestive of potential problem areas and do not give definitive degrees of over-exposure or, conversely, an absolute index of safe exposure. The results suggest that potential over-exposures exist on essentially a plant-wide basis, most notably to free silica contained in fly ash and coal dust.

When operating under limited time constraints, a complete environmental evaluation of maintenance tasks is nearly impossible at large facilities. Professional judgement should be used by the Utility Safety Department in extrapolating the recommendations contained in this report to similar maintenance jobs not monitored during the survey.

Table 3 presents a summary of analytical results of samples obtained during maintenance operations. Included in the maintenance job category were janitorial tasks and equipment repairs. The janitorial tasks which were monitored included removal of fly ash from the lower level floors with brooms and from the upper level structural supports and ledges with vacuum sweepers. Environmental samples were collected for determination of fly ash and free silica (quartz) exposures in these areas.

In many of the in-plant jobs, exposures are a result of worker motion in areas where fly ash has collected on exposed surfaces, and not a result of consistently excessive airborne concentrations. Surface collection presumably results from continual low-level expulsion of combustion products from cracks and imperfect seals on the #'s 6 and 7 units (positive pressure boilers).

Sweeping

All workers involved with fly ash removal wore some type of respiratory protection, either single use masks or half-face dual cartridge respirators. Therefore, sample results are indicative of potential employee exposures, not necessarily their actual exposures.

Results of samples collected during broom sweeping suggest that, at the time of the evaluation, exposures to fly ash and quartz were within their respective exposure guidelines (Table 3). Of the 5 breathing zone samples collected from workers while sweeping fly ash with vacuums, 4 were reported as below the analytical limit of detection for free silica. The fifth sample, however, was reported at 0.09 mg/M^3 (4% of the filter weight), or approximately twice the recommended standard. Concentrations of airborne fly ash ranged from 0.0 to 2.20 mg/M^3, averaging approximately 0.68.

One maintenance worker was sampled for exposures to total particulates (respirable plus non-respirable) during vacuum sweeping. Two consecutive breathing zone samples were obtained for a total of 7 hrs. with an average concentration of 16.02 mg/M^3 of total particulate. Free silica exposure (again, respirable plus non-respirable) ranged between 0.35 and 0.40 mg/M^3. The range is resultant of one of the two consecutive samples being reported below the 0.03 mg. detectable limit. Therefore the lowest (0.0) and the highest (0.029) possible free silica content was used in the weighted average calculation. A comparison of respirable vs. total particulate exposures suggests that the largest proportion of airborne particulates in this area are in the non-respirable range. However, the limited data warrants discretion when making this type of conclusion. The results suggest that a potential for over exposure to free silica exists for this operation.

Air Fans

Air fan maintenance workers were monitored for exposures to a mixture of fly ash and coal dust, free silica, SO_2, and NO_2 at the Drake plant, and coal dust and free silica at the Nixon plant. Of significance were results of 2 breathing zone particulate samples at the Drake plant (Table 3) indicating excessive exposures to free silica (3-4 X the NIOSH recommended standard) and the coal dust-fly ash mixture. As previously described, the OSHA standard and the TLV for coal dust with a quartz content greater than 5% (the range of these 2 breathing zone samples was 4.5-5%) is the same as the quartz standard; 10 mg/M^3 / % SiO_2 + 2. In this instance, the OSHA standard would be 10 / 5 + 2 or 1.43 mg/M^3, which indicates excessive exposures, when compared to the measured exposures of 3.33 and 4.62 mg/M^3. Observations of the work area revealed that exposures to airborne particulates were a mixture of fly ash and coal dust, which makes an evaluation of exposures somewhat more difficult. However, since exposures to free silica were measured in excess of the recommended standard, control of this substance should take presidence over other particulates.

The TWA exposure concentrations of SO_2, reported at 2.0 and 2.1 mg/M^3 were above the NIOSH recommended standard of 1.3 mg/M^3. Exposures to NO_2 were below the detectable limit at the Drake plant. Results of free silica and coal dust sampling at the Nixon plant for this job indicate that exposures were within their respective guidelines.

Pulverizers

Seven full shift breathing zone environmetnal air samples were collected during pulverizer maintenance over a 3 day period for determination of free silica and coal dust exposure concentrations. Three of the seven free silica samples were above the limit of detection, with one reported in excess of the NIOSH recommended standard. Quartz content averaged approximately 3%. Exposure to coal dust averaged 1.25 mg/M^3 with only one of 7 samples indicating excessive exposure (% quartz less than 5%; thus OSHA standard = 2.4 mg/M^2; TLV = 2.0 mg/M^3). Although excessive exposures to free silica were measured in only one instance, the action level (one-half the NIOSH recommended standard) was exceeded. Personal exposures to SO_2 approached the recommended standard of 1.3 mg/M^3. Exposures to NO and CO were will within their respective guidelines, and exposures to NO_2 were non-detectable (less than 0.0001 mg/M^3).

Soot Blowers

Two full shift personal samples collected for determination of free silica and fly ash exposures during soot blower maintenance showed non-detectable levels of free silica (less than 0.04 mg/M^3) and fly ash exposures below 0.3 mg/M^3.

Valve Repair

Two full shift breathing zone samples were obtained from maintenance workers at the Nixon plant while repairing valves on the upper levels. Free silica exposures were below the limit of detection, and fly ash exposures were reported below 2.5 mg/M^3. The same job performed at the Drake plant showed lower, yet similar results.

Inspections

Two breathing zone samples were collected during boiler and precipitator inspection for the duration of the task (approximately 2 hrs.). Excessive exposures to free silica were measured during both inspections.

Precipitators

Five breathing zone and three general area air samples were collected during precipitator cleanout for the duration of the task (approximately 4 hrs.). However, due to a duplication of numbers on the pre-numbered filter cassettes, only three of the TWA breathing zone results are reported. Worker exposures to free silica inside the precipitator were the highest of any measured during the survey; ranging from 0.57 to 6.31 mg/M^3 (as much as 125 X the recommended standard). Fly ash exposures ranged from 31.0 to 111.33 mg/M^3. Three area samples collected near the work site inside the precipitator averaged 0.76 mg/M^3 free silica and 37.62 mg/M^3 fly ash.

One of three free silica breathing zone samples collected during precipitator wash was reported above the detectable limit, at 0.13 mg/M^3. Fly ash exposures ranged from 0.68 to 3.67 mg/M^3; averaging 1.68. Observations of this job indicate that most of the airborne fly ash is liberated during the initial portion of wash, and once the internal areas of the precipitator become wet, dust levels decrease.

Bag House

Two respirable particulate breathing zone samples were collected during bag house inspection for the duration of the task (approximately 2 hrs.). Neither sample was above the analytical limit of detection for free silica, and fly ash exposures were reported as averaging approximately 3 mg/M^3. None of the breathing zone samples obtained for SO_2, NO, or NO_2 were above the analytical limit of detection. Carbon monoxide exposure was shown to be well within recommended guidelines. During the inspection, the odor of sulfur dioxide was intermittently detected. However, by the time the SO_2 meter could be set up, the odor had dissipated, and the instrument indicated no levels of exposure.

A summary of results for environmental samples collected during coal handling operations is contained in Table 4. Exposures to coal dust, and free silica contained in the coal dust are encountered by employees working directly with the unloading, movement, and deposition of the coal from the coal yard to the in-plant bunkers.

Coal Yard

Environmental air samples collected from employees working in the coal yard, including the supervisor, coal unloaders, linemen, locomotive operator, and tractor operator, plus a welder working in this area showed excessive exposures to coal dust on 2 of the 7 samples, occuring at the tractor operator and welder. Over-exposure was based on the calculated OSHA standard (the 3 samples above the analytical limit of detection for free silica averaged 6% of the respirable particulate weight). Four of the 7 samples for free silica were below the analytical limit of detection. The remaining 3, however, were above the NIOSH recommended standard. The three excessive exposures were measured from the welder, a rail-car lineman, and tractor operator (also engaged in running rail cars). Two breathing zone samples were collected for determination of total particulate exposures from workers at the coal unloading station and rail car manipulation. Total coal dust exposures ranged from 0.79 to 0.90 mg/M^3, with both respirable free silica concentrations reported at 0.06 mg/M^3. Based on the OSHA standard for total particulate exposure with a free silica content of greater than 5% (the content of free silica in these two samples was approximately 7%) excessive exposures were not indicated. An important factor to consider when evaluating these results is that the unloaded coal was wet from melted snow, which suppressed the dust levels. A number of workers commented during the survey that working conditions were not as "dusty" as normal.

Tripper Deck

No respirable free silica results were reported above the detectable limit at the tripper deck. The area sample for total particulate was reported at 0.14 mg/M^3 free silica. To determine the relative concentration of respirable vs. non-respirable particulates in the tripper deck area, side-by-side sampling was conducted on the tripper mechanism, measuring the two particulate fractions. Total particulates were reported at 4.71 mg/M^3 while respirable fraction was reported at 1.14; suggesting that the respirable fraction of coal dust exposures in this area are approximately one-fourth of the total dust exposure.

Crusher House

Two general area samples were collected in the crusher house, and were reported as averaging 0.20 mg/M^3 respirable coal dust. Neither filter was above the detectable limit for free silica.

However, the crusher mechanism operated for only a fraction of the shift, which makes the significance of environmental results of samples obtained in this area questionable.

Coal Handling; Nixon Plant

The coal handling areas at the Nixon facility were much less labor intensive due to automation. Coal dust and free silica samples were collected from the conveyormen and the tractor operator. While the data is suggestive that conveyormen are within the TLV for exposures to coal dust, the potential exists for excessive exposures to free silica, as demonstrated by the sampling results (Table 4). Of those samples reported above the detectable limit, free silica content ranged from 2 to 4 percent, suggesting that coal dust exposures would have to range above 1.5 to 2 mg/M^3 before the recommended standard would be exceeded.

Arsenic

Three of 14 samples collected for arsenic exposure determinations were reported as above the analytical limit of detection (Table 3) with results ranging from 4.9 to 9.8 ug/M^3; indicating exposures in excess of the NIOSH recommendation of 2.0 ug/M^3. Operations where the over exposures were measured included the bag house inspection, precipitator inspection, and during hopper maintenance (beating hoppers to settle the internal fly ash to the bottom levels). Although NIOSH recommends that arsenic samples be collected for 15 minute periods to reduce the possibility of measuring background airborne concentrations (in light of the extremely low recommended standard and documented occurences of ambient arsenic levels as high as 1.4 ug/M^3), samples were collected for the duration of a particular operation to quantify other possible trace metal exposures. However, the essential non-existance of ambient levels of arsenic was demonstrated through samples collected in other plant areas which showed levels below 0.4 ug/M^3. This suggests that measured quantities of airborne arsenic were a result of in-plant processes and not due to "natural" sources.

Trace Metals

Table 5 presents results of trace metal analysis. Area samples collected during precipitator clean-out showed extremely high air concentrations of aluminum (25.9 mg/M^3), calcium (16.8 mg/M^3), and iron (8.7 mg/M^3). Three consecutive samples were obtained from a single location, and as shown in the table, levels decreased dramatically as the job progressed. This is a result of the clean-out activity moving away from the area of sample collection. Metal exposures (other than arsenic) at other plant areas appeared to be within recommended or OSHA standards, for those metals with such standards.

Chlorine

An attempt was made at determining airborne concentrations of Cl_2 inside the chlorine addition building. However, equipment malfunction precluded the acquisition of environmental samples. Extremely cold weather conditons contributed to the splitting of feed water pipes which halted the process.

Asbestos

Maintenance tasks involving steam pipes, water pipes, meters, gauges, and seals require that the existing insulation material be temporarily removed to provide access. Bulk samples of insulation material obtained at nine locations revealed up to 60% asbestos content. Table 6 presents these analytical results.

Hydrazine

Short term, detector tube determinations for exposure to hydrazine were obtained while the substance was being added to the dilution vessels. Levels ranged from non-detectable to approximately 0.1 part per million (ppm). Short term detector tubes give only an indication of exposure concentrations, usually within plus or minus 25%. However, in light of the potentially carcinogenic nature of hydrazine, all exposures to this substance should be avoided.

Amines

General area samples were obtained from inside the chemical addition room of both plants for determinaton of airborne concentrations of dimethylamine and cyclohexylamine. Concentrations ranged from below the limit of detection (approximately 0.20 mg/M^3; air volume adjusted) to 0.58 mg/M^3 for dimithylamine, and from below the limit of detection (roughly 0.40 mg/M^3, air volume adjusted) to 1.36 for cyclohexylamine. Airborne concentrations of both were well within their respective exposure guidelines, and considering that the area is visited only periodically for routine inspection, these exposures are of little concern during normal production.

Mercury

General area samples were obtained from the maintenance technician's work area at the Drake and Nixon plants for airborne mercury. Mercury exposures were of concern due to the mercury content of the meters and gauges which the workers repair. Samples collected at the Drake plant were below the analytical limit of detection. The sample collected at the Nixon plant indicated airborne exposures of 0.001 mg/M^3, or 1/50th of the current NIOSH recommendation.

Heat Stress

Although a number of WBGT measurements were obtained during the survey, ambient weather conditions at the site make interpretations of results difficult. Outside temperatures were as low as -13^{o}F, with considerable wind. Table 7 presents results of WBGT measurments. All of the jobs conducted in these areas are periodic involving surveillance or equipment repair. No work practices were observed or monitored to give indications of how labor intensive these jobs normally are.

VII. CONCLUSIONS AND RECOMMENDATIONS

Of 34 breathing zone samples collected for fly ash, respirable exposures ranged from 0.0 to 111.33 mg/M^3, as compared to the OSHA standard of 5.0 mg/M^3. Of 24 breathing zone samples collected for coal dust, exposures ranged from 0.26 to 3.98 mg/M^3, as compared to the TLV of 2.0 mg/M^3 (with quartz content less than 5%). Of considerably more importance were free silica sampling results. Of the 55 respirable, breathing zone coal dust and fly ash samples analyzed for free silica, 17 were reported above the analytical limit of detection, indicating exposure concentrations ranging from 0.03 to 6.31 mg/M^3. Fourteen of the 17 detectable samples were above the NIOSH recommended standard of 0.05 mg/M^3. Of the 38 samples reported as non-detectable, only 4 were of insufficient collected air volume to have subsequent "less than" values in excess of the NIOSH standard. Therefore, roughly 30% of the respirable, breathing zone samples were found to be in excess of the NIOSH recommended standard. Of the 10 respirable samples obtained exclusively for fly ash and reported above the detectable limit for free silica, the content compromised a range of approximately 1.8 to 5.7%, averaging 3.3%. A similar analysis of the samples collected for coal dust shows silica content ranging from 2.0 to 8.4%, averaging 5.2% (N=8). Plant areas where over-exposures to free silica were measured included the upper levels during vacuum sweeping, during boiler and precipitator inspections, pulverizer and fan maintenance, precipitator clean-out and wash, walk-down of coal conveyors, coal unloading, the coal yard area, and on the tripper deck.

Three of 14 samples collected for determination of arsenic exposures showed values ranging from 4.9 to 9.8 ug/M^3; in excess of the NIOSH recommended standard of 2 ug/M^3.

Of 8 samples collected for determination of SO_2 exposures, 3 were found to match or exceed the NIOSH recommended standard. Excessive exposures were measured during pulverizer and fan maintenance.

Short-term detector tube measurements of hydrazine indicated levels of exposure matching the TLV during addition of the substance to dilution vessels.

Based on results of environmental monitoring and observations made during the NIOSH visit, the following recommendations are made.

1. In the absence of engineering controls, and the inability to feasibly substitute the currently used raw material (coal) for less toxic substances, establish and maintain a respiratory protection program in accordance with 29 CFR 1910.134.

   a. Development of the above program will require that at least one employee of the Utility be trained in proper respirator selection and use. Training is available through NIOSH "short-courses" or from commercial suppliers of respirators.

   b. Approved, single use, valveless type dust respirators appear to be adequate in most in-plant areas during routine operations for control of exposures to free silica and fly ash, and during coal handling operations for control of exposures to free silica and coal dust. These respirators should be worn in any areas where a potential for exposure exists.

   c. Levels of exposure to free silica and fly ash during precipitator cleanout warrant the use of approved full-face respirators equipped with high efficiency filters (at least 99.97% efficient against 0.3 um dioctyl phthalate). This type of respiratory protection should also be provided during internal boiler, precipitator, and bag house inspections due to the potential for extremely high, although short-term exposure conditions.

   d. Because no exposures to inorganic arsenic were observed during routine operations, only while conducting infrequent inspection/maintenance tasks, respirators as described in "c" above should provide sufficient protection in light of the physical form of arsenic present in the power plant environment (ie., arsenic adhered to fly ash particles; low volatility).

   e. Approved dust-gas respiratory protection should be provided to workers involved with maintenance tasks with potential exposure to flue gasses to protect against excessive exposures to SO_2.

2. Prohibit beards where respiratory protection is required. Respirators cannot provide sufficient protection if facial hair interferes with proper seal.

3. Provide medical examinations and an appraisal of the hazards of working with free silica and inorganic arsenic to workers with potential exposure to these substances.

4. Warning signs should be posted at areas where potential excessive exposure to fly ash or coal dust containing free silica exists.

5. While it is impractical to redesign the #'s 6 and 7 boilers to balanced draft systems, every effort should be made to locate and repair the leaks contributing to the in-plant fly ash.

6. Provide contract workers with all aspects of the medical and personal protection programs which are afforded regular employees.

7. An automatic method of hydrazine addition to the feed water should be devised and implemented. In the interim, personal protective equipment should be provided for this operation including respiratory protection (the use of the existing on-site escape SCBA respirators should suffice) and impervious gloves and aprons.

8. Discontinue the use of high-pressure air to remove fly ash deposits from clothing. Clothing should be vacuumed prior to removal.

9. Devise a source of local make-up air at the tripper deck. When the existing general ventilation was operating, coal dust appeared to be drawn from the conveyor chute.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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IX. DISTRIBUTION AND AVAILABILITY

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

Copies of this report have been sent to:

1. Director of Safety, City of Colorado Springs

2. Electrical Safety Representative, City of Colorado Springs

3. OSHA, Region VIII

4. NIOSH, Region VIII

For the purpose of informing the affected employees, a copy of this report shall be posted in a prominent place, accessible to the employees, for a period of thirty (30) calendar days.

TABLE 1
SAMPLING AND ANALYSIS METHODOLOGY
COLORADO SPRINGS PUBLIC UTILITIES
COLORADO SPRINGS, COLORADO
FEBRUARY 9 - 20, 1981

Substance	Collection Device	Flow Rate (lpm)	Duration(hrs.)	Analysis	Detection Limit(mg/sample)	Reference
Fly Ash (resp.)	M-5 Filter	1.7	6-8	electrobalance	0.01	# 29.02*
Fly Ash (total)	M-5 Filter	1.5	6-8	electrobalance	0.01	# 29.02
Coal Dust (resp.)	M-5 Filter	2.0	6-8	electrobalance	0.01	# 29.02
Coal Dust (total)	M-5 Filter	1.5	6-8	electrobalance	0.01	# 29.02
Mercury	iodine impregnated charcoal	0.2	6-8	AA spectrophotometer	0.0001	NIOSH Labs
Dimethylamine	Silica gel	0.2	6-8	Gas Chromatography	0.01	P&CAM #221
Cyclohexylamine	Silica gel	0.2	6-8	Gas Chromatography	0.02	P&CAM #221
Free Silica	M-5 Filter	1.7	6-8	x-ray diffraction	0.03	P&CAM #259
Nitrogen Oxide	Molecular Sieve (TEA)	0.05	6-8	Spectrophotometry	0.003	P&CAM #231
Nitrogen Dioxide	Molecular Sieve (TEA)	0.05	6-8	Spectrophotometry	0.003	P&CAM #231
Organic Vapors	Charcoal	0.20	6-8	Gas Chromatography	0.01	P&CAM #127
Chlorine	Drager Long-term	0.05	6-8	Visual	---	---
Sulfur Dioxide	Drager Long-term	0.05	6-8	Visual	---	---
NO & NO_2	Drager Long-term	0.05	6-8	Visual	---	---
Trace Metals	"AA" filters	1.5	6-8	ICP/Atomic Absorption	0.0005	NIOSH Labs
Carbon Monoxide	Drager Long-term	0.05	6-8	Visual	---	---
Arsenic	"AA" filters	1.5	6-8	Atomic Absorption	0.0003	P&CAM #S-309
Hydrazine	Drager Short-term	---	0.1	Visual	---	---

* From NIOSH Manual of Sampling Data Sheets

TABLE 2
EVALUATION CRITERIA
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Substance	Evaluation Criteria*(mg/M3)			Primary Health Effects
	NIOSH	OSHA	ACGIH	
Fly Ash	-----	5.0**	5.0**	Regulated as a nuisance particulate. Excessive concentrations of nuisance particulates may cause unpleasant deposits in the eyes, ears, and nasal passages, and may seriously reduce workroom visibility.
Free Silica (respirable)	0.05*	10 mg/M3/% SiO_2 + 2		Silicosis; a pneumoconiosis due to the inhalation of silicon dioxide-containing dust, which is a disabling, progressive, and sometimes fatal pulmonary fibrosis characterized by the presence of tyical nodulation in the lungs.
Free Silica (total)	-----	30 mg/M3/% SiO_2 + 2		
Coal Dust (less than 5% quartz)	-----	2.4	2.0	Coal workers' pneumoconiosis.
Coal Dust (greater than 5% quartz)	-----	Free Silica Formula		
Sulfur Dioxide	1.3	13.0	13.0	Severe irritant of the eyes, mucous membranes, and skin, caused by the rapidity with which it forms sulfurous acid on contact with moist substances.
Nitrogen Dioxide	1.8 ***	9.0	9.0	A respiratory irritant causing pulmonary edema and rarely, among survivors, bronchiolitis obliterans.
Nitric Oxide	30.0	30.0	30.0	While no effects in humans have been reported, cyanosis in animals has occured, apparently owing to the formation of methemoglobin.
Carbon Monoxide	38.5	55.0	55.0	Causes tissue hypoxia by preventing the blood form carrying sufficient oxygen.
Hydrazine	-----	1.3	0.13	A severe skin and mucous membrane irritant in humans; in animals, it is also a convulsant and carcinogen.
Chlorine	1.5***	3.0	3.0	A potent irritant of the eyes, mucous membranes, and skin; exposure causes pulmonary irritation.

TABLE 2 (CONTINUED)
EVALUATION CRITERIA
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Substance	Evaluation Criteria*(mg/M^3) NIOSH	OSHA	ACGIH	Primary Health Effects
Dimethylamine	-----	18.0	18.0	An irritant of the eyes and mucous membranes and a pulmonary irritant in animals; it is expected that severe exposure will cause the same effects in humans.
Cyclohexylamine	-----	-----	40.0	An irritant with potential carcinogenic, taratogenic, and mutagenic properties.
Mercury	0.05	0.1***	0.05	Acute exposure to mercury at high levels causes severe respiratory irritation, digestive disturbances, and marked renal damage, usually of delayed onset; chronic mercurialism, the form of intoxication most frequently caused by occupational exposure, is characterized by neurologic and psychic disturbances, anorexia, weight loss, and stomatitis. Skin absorption of organic mercury probably adds to the toxic effects of vapor inhalation.
Arsenic	0.002	0.010	0.200	Arsenic compounds are irritants of the skin, mucous membranes, and eyes; arsenical dermatoses and epidermal carcinoma are reported risks of exposure to arsenic compounds, as are other forms of cancer.

* Values represent time-weighted average exposure limits for up to a 10 hr. work-day unless otherwise specified.
** Treated and regulated as nuisance dust: 10 mg/M^3 of total dust (less than 1% quartz) or 5 mg/M^3 respirable dust.
*** Ceiling concentration. Exposures shall not exceed this concentration.

TABLE 3
SUMMARY OF EXPOSURES
MAINTENANCE OPERATIONS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Exposure Concentrations (mg/M^3)

JOB/LOCATION			Free Silica	Fly Ash	Coal Dust	SO_2	NO	NO_2	CO	As
Broom Sweeping	BZ*	Range	ND**	0.32-0.71						
		Mean	(0/2)***	0.43 (2/2)						
	Area	Range								
		Mean								
Vacuum Sweeping	BZ	Range	---	0.0-2.20						
		Mean	0.09 (1/5)	1.02 (5/5)						
	Area	Range								
		Mean								
P A Fans	BZ	Range	0.17-0.21	3.33-4.62		2.0-2.1		ND		
		Mean	0.19 (2/2)	3.98 (2/2)		2.1 (2/2)		(0/2)		
	Area	Range								
		Mean								
Pulverizers	BZ	Range	0.04-0.08		0.26-3.98	0.6-1.3			1.4-2.3	
		Mean	0.06 (3/7)		1.25 (7/7)	0.9 (3/4)			1.9 (2/2)	
	Area	Range					1.0-1.5	ND		ND
		Mean					1.3 (2/2)	(0/2)		(0/2)
Bag House	BZ	Range	ND	1.32-4.91		ND	ND	ND	---	---
		Mean	(0/2)	3.12 (2/2)		(0/2)	(0/2)	(0/2)	1.4 (1/2)	0.005 (1/2)
	Area	Range								
		Mean								
Soot Blowers	BZ	Range	ND	0.19-0.27						
		Mean	(0/2)	0.23 (2/2)						
	Area	Range								
		Mean								
Precip. Cleanout	BZ	Range	0.56-6.30	31.00-111.33						
		Mean	2.67 (3/3)	59.56 (3/3)						
	Area	Range	0.61-0.94	28.15-52.41						ND
		Mean	0.76 (3/3)	3.62 (3/3)						(0/3)
Precip. Wash	BZ	Range	---	0.68-3.67						ND
		Mean	0.13 (1/3)	1.68 (3/3)						(0/1)
	Area	Range								
		Mean								

TABLE 3 (CONTINUED)
SUMMARY OF EXPOSURES
MAINTENANCE OPERATIONS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Exposure Concentrations (mg/M^3)

JOB/LOCATION			Free Silica	Fly Ash	Coal Dust	SO_2	NO	NO_2	CO	As
Boiler Inspection	BZ	Range	---	3.24-13.58						ND
		Mean	0.31 (1/2)	8.41 (2/2)						(0/1)
	Area	Range								
		Mean								
Precip. Inspection	BZ	Range	---	---						---
		Mean	0.14 (1/1)	2.37 (1/1)						0.007 (1/1)
	Area	Range								
		Mean								
Hoppers	BZ	Range	ND	---						---
		Mean	(0/1)	0.37 (1/1)						0.010 (1/1)
	Area	Range								
		Mean								
Mezzanine	BZ	Range								
		Mean								
	Area	Range								ND
		Mean								(0/1)
Air Heater	BZ	Range	ND	---						
		Mean	(0/1)	0.37 (1/1)						
	Area	Range								
		Mean								
Upper Levels (Nixon)	BZ	Range	ND	0.53-2.53						
		Mean	(0/2)	1.43 (2/2)						
	Area	Range								
		Mean								
Upper Levels	BZ	Range	ND	---						
		Mean	(0/1)	0.09 (1/1)						
	Area	Range								
		Mean								

* BZ = Breathing Zone samples; Area = General area samples
** ND = None Detected
*** (Number of samples obtained / Number of samples reported above the analytical detection limit)

TABLE 4
SUMMARY OF EXPOSURES
COAL DUST & FREE SILICA
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Exposure Concentrations (mg/M^3)

JOB/LOCATION			Free Silica	Coal Dust
Unloading	BZ*	Range	ND**	---------
		Mean	(0/1)***	0.41 (1/1)
	Area	Range		
		Mean		
Rail Cars	BZ	Range	-----------	---------
		Mean	0.20 (1/1)	2.66 (1/1)
	Area	Range		
		Mean		
Tractor	BZ	Range	ND	---------
		Mean	(0/1	0.14 (1/1)
	Area	Range		
		Mean		
Locomotive	BZ	Range	ND	---------
		Mean	(0/1)	0.55 (1/1)
	Area	Range		
		Mean		
Crusher House	BZ	Range		
		Mean		
	Area	Range	ND	0.19-0.21
		Mean	(0/2)	0.20 (2/2)
Conveyors	BZ	Range	0.03-0.08	0.54-0.94
		Mean	0.06 (2/2)	0.74 (2/2)
	Area	Range		
		Mean		
Tripper Deck	BZ	Range	ND	---------
		Mean	(0/1)	3.89 (1/1)
	Area	Range	ND	0.92-1.14
		Mean	(0/2)	1.03 (2/2)

*BZ = Breathing Zone Sample
**ND = None Detected
*** (Number of samples obtained/number of samples reported above the analytical limit of detection)

TABLE 5
RESULTS OF TRACE METAL ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

CONCENTRATION (ug/M^3)

LOCATION/TYPE	As	Al	Ca	Cr	Cu	Fe	Li	Mg	Mn	Mo	Na	Ni	P	Pb	Te	Ti	Tl	V	Y	Zr
Plvzr. Maint./Area	ND	209	182	ND	ND	135	ND	41	ND	ND	49	ND	40	ND	1	21	ND	ND	ND	ND
Plvzr. Maint./Area	ND	68	ND	--	--	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Precip. Clnout/Area	ND	25910	16757	28	60	8663	47	2739	56	61	2460	11	2805	49	14	1099	8	63	18	64
Precip. Clnout/Area	ND	2540	1905	ND	ND	1000	--	302	--	--	--	--	--	ND	--	ND	--	--	--	--
Precip. Clnout/Area	ND	1081	541	ND	ND	469	--	117	--	--	--	--	--	ND	--	ND	--	--	--	--
Precip. Inspec./BZ	7	1715	1287	ND	4	663	--	261	--	--	--	--	--	ND	--	ND	--	--	--	--
Precip. Wash/BZ	ND	ND	77	ND	ND	72	--	21	--	--	--	--	--	ND	--	ND	--	--	--	--
Boiler Inspec./BZ	ND	1053	430	ND	ND	193	--	105	--	--	--	--	--	ND	--	ND	--	--	--	--
Hoppers/BZ	10	2584	2636	ND	5	930	--	351	--	--	--	--	--	ND	--	ND	--	--	--	--
Bag House/BZ	ND	1275	1001	ND	ND	471	ND	138	ND	3	159	ND	178	ND	ND	73	ND	3	ND	4
Bag House/BZ	5	938	474	--	--	326	--	109	--	--	--	--	--	--	--	--	--	--	--	--
Welding/BZ	--	--	--	--	ND	11	--	--	--	--	--	ND	--	--	--	--	--	--	--	--
Welding/BZ	ND	70	408	ND	4	939	ND	16	110	2	141	1	13	2	ND	16	ND	ND	ND	ND
Welding (NX)/BZ	--	--	--	--	ND	47	--	--	--	--	--	ND	--	--	--	--	--	--	--	--
Welding (NX)/BZ	--	--	--	--	ND	84	--	--	--	--	--	ND	--	--	--	--	--	--	--	--
O Discharge/Area	ND	ND	ND	--	--	ND	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mezzanine/Area	ND	54	ND	--	--	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 6
ASBESTOS CONTENT OF INSULATION MATERIAL
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Site of Collection	Determination
#7 unit main steam stop valve	ND
#5 feed water heater	ND
Boiler seal trough	10% Chrysotile
#7 bottom ash hopper; drain line north	ND
Soot blower warm-up drain line	1-2% Chrysotile; 30% Amosite
#7 steam drum; south end	ND
Gauges; top of #7 unit	40% Amosite
Air heater soot blower pressure control	10-20% Chrysotile
Cooling tower louvers	60% Chrysotile

TABLE 7
TEMPERATURE INDICES
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

Location	Wet bulb	Dry bulb	Globe	WBGT
Top of #7 Boiler	60	93	97	71
Side of #7 unit, seventh floor	60	93	99	72
Bearing Check Point, #7 unit	74	126	147	97
NIXON Plant				
Inside Fly Ash Silo	55	59	42	48
Burner Deck, 5' from furnace	103	108	67	79
Burner Deck, 5' from furnace	105	111	72	83
Burner Deck, near feed pipe	117	114	66	80
BAG HOUSE				
Near inner wall west end	124	75	141	95
Near inner wall, east end	122	76	139	92
Lower Level	89	63	109	77

APPENDIX A
RESULTS OF PARTICULATE ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

FLY ASH AND FREE SILICA

SAMPLE #	DATE	LOCATION	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3) (Quartz)	(Fly Ash)	COMMENTS
VACUUM SWEEPING								
3674/3663	2-19-81	#7 Unit	BZ, T*	07:22-14:04	0.603	0.35 - 0.40	16.02	Vacuum Sweeping
3682	2-19-81	#7 Unit	BZ, R***	06:48-14:06	0.744	ND**	0.94	Vacuum Sweeping
3041	2-17-81	#7 Unit	BZ, R	10:16-14:25	0.423	ND	0.80	Vacuum Sweeping
1209	2-17-81	#7 Unit	BZ, R	10:18-14:25	0.420	ND	0.00	Vacuum Sweeping
3053	2-18-81	#7 Unit	BZ, R	07:44-11:55	0.427	0.10	2.20	Vacuum Sweeping
3047	2-18 81	#7 Unit	BZ, R	07:46-14:44	0.711	ND	1.15	Vacuum Sweeping
BROOM SWEEPING								
3698	2-10-81	Basement	BZ, R	07:55-14:35	0.680	ND	0.32	Janitor; sweeping Fly ash (broom)
3704	2-10-81	Basement	BZ, R	07:53-14:35	0.479	ND	0.71	Janitor; sweeping Fly ash (broom)
PRECIPITATORS								
3675/3673	2-19-81	#7 Precipitator	BZ, R	06:55-11:46	0.495	6.31	111.33	Precipitator Clean-out
3681/3672/ 3666	2-19-81	#7 Precipitator	BZ, R	06:58-11:45	0.488	1.13	36.34	Precipitator Clean-out
3680/3678	2-19-81	#7 Precipitator	BZ, R	06:59-10:38	0.372	0.56	31.00	Precipitator Clean-out
3668/3669	2-19-81	#7 Precipitator	Area, R	09:20-11:45	0.247	0.61	28.15	3/4 toward end of precip
3676/3671	2-19-81	#7 Precipitator	Area, R	09:20-11:45	0.247	0.73	32.29	1/2 toward end of precip
3684/3670	2-19-81	#7 Precipitator	Area, R	09:20-11:45	0.245	0.94	52.41	@ end of precip.
3847	2-20-81	#7 Precipitator	BZ, R	07:47-10:00	0.226	0.13	3.67	Precipitator Wash.
3845	2-20-81	#7 Precipetator	BZ, R	07:52-10:37	0.281	ND	0.68	Precipitator Wash
3852	2-20-81	#7 Precipitator	BZ, R	07:48-09:37	0.185	ND	0.70	Precipitator Wash
1212	2-18-81	#7 Precipitator	BZ, R	11:16-14:10	0.296	0.14	2.37	Precip. Inspection
OPERATIONS								
3699	2-10-81	Operations	BZ, R	07:22-14:30	0.728	ND	0.23	Conducted walk-down of entire plant
3697	2-10-81	Operations	BZ, R	07:25-14:43	0.745	ND	0.08	Walk-downs of entire plant
3701	2-10-81	Operations	BZ, R	07:50-14:40	0.697	ND	0.36	walk-downs of entire plant
3819	2-12-81	Operations	BZ, R	07:03-14:55	0.802	ND	0.14	Walk-downs of facility
3687	2-12-81	Operations	BZ, R	07:44-15:03	0.746	ND	0.19	Walk-downs of facility
3822	2-12-81	Operations	BZ, R	07:45-15:30	0.791	ND	0.34	In Control room entire shift
3814	2-12-81	Operations	BZ, R	15:08-22:46	0.779	ND	0.19	Walk-downs of facility
3817	2-12-81	Operations	BZ, R	15:05-22:35	0.765	ND	0.08	Walk-down of facility

APPENDIX A (CONTINUED)
RESULTS OF PARTICULATE ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

FLY ASH AND FREE SILICA

SAMPLE #	DATE	LOCATION	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3) (Quartz)	(Fly Ash)	COMMENTS
MEZZANINE AREA								
3707	2-10-81	Mezanine	Area, R	09:07-15:04	0.607	ND	0.41	Near #6 unit.
SILO: NIXON								
3694	2-12-81	Silo-Top Floor	Area, R	16:18-22:42	0.653	ND	1.63	
BOILER INSPECTION								
3686	2-13-81	Boiler	BZ, R	09:05-10:39	0.160	0.31	13.58	Boiler Inspection
3051	2-13-81	Boiler	BZ, R	06:58-10:26	0.219	ND	3.24	Boiler Inspection(off for 79 min.)
BAG HOUSE								
3816	2-17-81	Bag House	BZ, R	10:50-13:15	0.247	ND	4.91	Simulated Bag House Inspection
3059	2-17-81	Bag House	BZ, R	11:05-13:20	0.223	ND	1.35	Simulated Bag House Inspecgtion
SOOT BLOWER MAINTENANCE								
3702	2-10-81	#7 Soot Blower	BZ, R	06:59-14:37	0.779	ND	0.27	Maintenance operations.
3703	2-11-81	Soot Blowers	BZ, R	06:55-14:50	0.808	ND	0.19	#'s 5,6,& 7 Soot Blower Maintenance
AIR HEATER MAINTENANCE								
3706	2-11-81	#6 Air Heater	BZ, R	06:46-14:43	0.811	ND	0.37	Air Heater Maintenance
GENERAL UPPER LEVELS								
3815 (NX)	2-12-81	Upper Levels	BZ, R	07:40-15:25	0.791	ND	2.33	Maintenance of upper levels
3812	2-12-81	Upper Levels	BZ, R	07:42-15:52	0.833	ND	0.53	Maintenance of upper levels
3689	2-11-81	Entire in-plant	BZ, R	06:54-14:46	0.802	ND	0.09	Equipment Checks
HOPPERS								
3825	2-12-81	Hoppers	BZ, R	12:33-14:40	0.216	ND	0.37	Beating Hoppers

* BZ, T = Breathing zone sample, total particulate exposure
** ND = None Detected
*** BZ, R = Breathing zone sample, respirable particulate exposure
(NX) = Nixon Plant

APPENDIX A (CONTINUED)
RESULTS OF PARTICULATE ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

COAL DUST AND FREE SILICA

SAMPLE #	DATE	LOCATION	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3) (Quartz)	(Coal Dust)	COMMENTS
COAL HANDLERS								
3709	2-10-81	Tripper Deck	BZ, R	06:50-14:45	0.808	ND	3.89	Part of shift in shop area
3048	2-11-81	Locomotive	BZ, R	06:38-15:16	1.036	ND	0.46	
3050	2-11-81	Coal Handling	BZ, R	06:40-15:22	1.044	0.20	2.66	Tractor operator & rail cars
3061	2-11-81	Coal Handling	BZ, R	06:40-15:17	1.034	0.06	1.24	Rail car
3056	2-11-81	Near Crusher House	BZ, R	08:12-14:27	0.750	ND	0.43	
3052	2-11-81	Tripper Deck	Area, R	07:40-15:07	0.894	ND	0.92	
3040	2-11-81	Crusher House	Area, R	08:04-15:32	0.896	ND	0.21	Second Floor
3691/3055	2-11-81	Crusher House	Area, R	08:07-15:30	0.882	ND	0.19	Third Floor
3811 (NX)	2-12-81	Conveyor	BZ, R	08:04-15:28	0.888	0.03	0.54	Walk-down of coal conveyors
3813 (NX)	2-12-81	Conveyor	BZ, R	08:05-15:28	0.886	0.08	0.94	Walk-down of coal conveyors
3827 (NX)	2-12-81	Coal Handling	BZ, R	08:07-15:27	0.880	ND	0.14	Tractor Operator
1203	2-18-81	Coal Handling	BZ, R	11:15-14:23	0.376	0.13	3.01	Welding in Coal Area
1202	2-18-81	Coal Handling	BZ, R	11:25-16:32	0.614	ND	0.41	Unloading Rail Cars
1211	2-18-81	Tripper Deck	BZ, R	11:26-14:44	0.396	ND	1.04	Operating Tripper
3045	2-18-81	Coal Handling	BZ, T	11:21-16:50	0.658	0.06	0.79	Unloading Rail Cars
3820	2-18-81	Coal Handling	BZ, T	11:28-14:10	0.624	0.06	0.90	Running Rail Cars
3829	2-18-81	Coal Handling	Area, T	11:40-16:36	0.592	0.14	4.71	Positioned on Tripper
1205	2-18-81	Coal Handling	Area, R	11:46-16:36	0.580	ND	1.14	Side-by-side w/#3829
PULVERIZER MAINTENANCE								
3690	2-10-81	Pulverizers	Area, R	08:43-15:00	0.754	ND	0.96	Between 7-B&C pulverizers
3039	2-11-81	Pulverizer	BZ, R	06:43-15:00	0.994	ND	0.26	Pulverizer Maintenance
3046	2-11-81	Pulverizer	BZ, R	06:44-12:40	0.712	ND	0.58	Pulverizer Maintenance
3059	2-11-81	Pulverizer	BZ, R	06:50-14:53	0.966	ND	0.32	Pulverizer Maintenance
3696	2-13-81	Pulverizers	BZ, R	07:40-14:57	0.874	ND	0.95	Pulverizer maintenance
3823	2-13-81	Pulverizers	BZ, R	07:42-14:57	0.870	0.05	1.09	Pulverizer maintenance
3828	2-13-81	Pulverizers	BZ, R	07:43-14:57	0.868	ND	0.63	Pulverizer maintenance
1197	2-17-81	Pulverizers	BZ, R	07:08-14:41	0.906	0.04	1.23	Pulverizer Maintenance
3058	2-17-81	Pulverizers	BZ, R	07:11-14:35	0.888	0.08	3.98	Pulverizer Maintenance

APPENDIX A (CONTINUED)
RESULTS OF PARTICULATE ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

CEMENT DUST AND FREE SILICA

SAMPLE #	DATE	LOCATION	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3) (Cristobalite)	(Dust)	COMMENTS
REFRACTORY AREA								
3853	2-20-81	Refractory Area	Area, R	09:23-12:19	0.299	0.13	5.15	Cement Dust: Mid Refractory Area
3662	2-20-81	Refractory Area	Area, R	09:23-12:19	0.299	ND	3.94	Cement Dust: Mid Refractory Area

FLY ASH, COAL DUST, AND FREE SILICA

SAMPLE #	DATE	LOCATION	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3) (Quartz)	(Fly ash & Coal Dust)	COMMENTS
FAN MAINTENANCE								
3705/3692	2-10-81	#7 PA Fan	BZ, R	06:44-14:23	0.780	0.17	3.33	Fan Maintenance (@ 1.7 lpm)
3708/3693	2-10-81	#7 PA Fan	BZ, R	06:46-14:23	0.777	0.21	4.62	Fan Maintenance (@ 1.7 lpm)
3810	2-12-81	#7 PA Fan	BZ, R	07:35-15:25	0.940	ND	0.53	Fan Maintenance
3809	2-12-81	#7 PA Fan	BZ, R	07:39-15:27	0.936	ND	1.24	Fan Maintenance

included these as Resp dust with Gunter

APPENDIX B
RESULTS OF GAS AND FUME ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

SAMPLE #	DATE	LOCATION	SUBSTANCE	TYPE	DURATION	VOLUME(M^3)	CONCENTRATION(mg/M^3)	COMMENTS
SO_2-1	2-10-81	7-c PA Fan	SO_2	BZ	07:23 - 14:23	0.008	1.95	Maintenance
SO_2-2	2-10-81	7-c PA Fan	SO_2	BZ	07:15 - 14:20	0.009	2.08	Maintenance
NO_2-1	2-10-81	7-c PA Fan	NO_2	BZ	07:23 - 14:23	0.002	ND	Maintenance
NO_2-2	2-10-81	7-c PA Fan	NO_2	BZ	07:15 - 14:20	0.009	ND	Maintenance
MV-1	2-10-81	Inst. shop	Mercury	Area	08:48 - 15:02	0.058	ND	Near work bench
O-1	2-11-81	Inst. Shop	Organics	Area	07:31 - 15:13	0.096	8.3	Total organics
N-1 (NX)	2-12-81	Inst. Shop	Mercury	Area	08:55 - 15:45	0.070	0.001	On bench
N-1	2-10-81	#7 Plvzr	NO	Area	11:15 - 14:58	0.004	0.964	50' from open PA duct
N-1	2-10-81	#7 Plvzr	NO_2	Area	11:15 - 14:58	0.004	ND	50' from open PA duct
N-2	2-10-81	#7 Plvzr	NO	Area	11:17 - 14:55	0.002	1.693	8' from open PA duct
N-2	2-10-81	#7 Plvzr	NO_2	Area	11:17 - 14:55	0.002	ND	8' from open PA duct
AA-3	2-10-81	#7 Plvzr	Trace Metals	Area	08:45 - 11:30	0.248	SEE TABLE 5	8' from open PA duct
AA-4	2-10-81	#7 Plvzr	Trace Metals	Area	11:30 - 14:56	0.309	SEE TABLE 5	8' from open PA duct
C-1	2-11-81	#7 Plvzr	C O	BZ	06:45 - 15:00	0.096	2.3	Maintenance
S-1&5	2-11-81	#7 Plvzr	SO_2	BZ	06:45 - 15:00	0.109	1.0	Maintenance;
C-2	2-11-81	#7 Plvzr	C O	BZ	06:47 - 12:40	0.079	1.4	Maintenance
S-2&4	2-11-81	#7 Plvzr	SO_2	BZ	06:47 - 12:40	0.012	1.3	Maintenance
S-3&6	2-11-81	#7 Plvzr	SO_2	BZ	06:52 - 14:53	0.088	0.5	Maintenance
SO_2-A	2-17-81	#7 Plvzr	SO_2	BZ	07:10 - 14:41	0.009	ND	#7c Pulverizer Maintenance
Amine 1	2-10-81	Chem Add Rm	Cyclohexyl	Area	08:33 - 14:50	0.051	1.362	Near #7 Boiler feed
Amine 1	2-10-81	Chem Add Rm	Dimethyl	Area	08:33 - 14:50	0.051	ND	Near #7 Boiler feed
Amine 2	2-10-81	Chem Add Rm	Cyclohexyl	Area	08:35 - 14:50	0.051	ND	Near #5 NL 100 feed line
Amine 2	2-10-81	Chem Add Rm	Dimethyl	Area	08:35 - 14:50	0.051	ND	Near #5 NL 100 feed line
NA-15(NX)	2-12-81	Chem Add Rm	Cyclohexyl	Area	16:05 - 20:21	0.069	ND	On walkway
NA-15(NX)	2-12-81	Chem Add Rm	Dimethyl	Area	16:05 - 20:21	0.069	0.435	On walkway
NA-11(NX)	2-12-81	Chem Add Rm	Cyclohexyl	Area	09:00 - 15:57	0.079	ND	On walkway
NA-11 NX	2-12-81	Chem Add Rm	Dimethyl	Area	09:00 - 15:57	0.079	0.635	On walkway
NA-10 NX	2-12-81	Chem Add Rm	Cyclohexyl	Area	08:58 - 15:57	0.086	0.467	On walkway
NA-10 NX	2-12-81	Chem Add Rm	Dimethyl	Area	08:58 - 15:57	0.086	0.584	On walkway
NA-10 NX	2-12-81	Chem Add Rm	Dimethyl	Area	08:58 - 15:57	0.086	0.584	On walkway
A-100	2-13-81	Chem Add Rm	Cyclohexyl	Area	07:56 - 15:04	0.082	ND	Center of Room
A-100	2-13-81	Chem Add Rm	Dimethyl	Area	07:56 - 15:04	0.082	ND	Center of Room
A-101	2-13-81	Chem Add Rm	Cyclohexy	Area	07:53 - 15:04	0.082	ND	Center of Room
A-101	2-13-81	Chem Add Rm	Dimethyl	Area	07:53 - 15:04	0.082	ND	Center of Room

APPENDIX B (CONTINUED)
RESULTS OF GAS AND FUME ANALYSIS
COLORADO SPRINGS PUBLIC UTILITIES
FEBRUARY 9-20, 1981

SAMPLE #	DATE	LOCATION	SUBSTANCE	TYPE	DURATION	VOLUME (M^3)	CONCENTRATION (mg/M^3)	COMMENTS
C-3	2-11-81	#6 Air Heater	C O	BZ	07:03 - 14:43	0.041	2.6	Maintenance
N-10	2-11-81	#6 Air Heater	NO	BZ	07:00 - 14:43	0.089	ND	Maintenance
N-10	2-11-81	#6 Air Heater	NO_2	BZ	07:00 - 14:43	0.089	ND	Maintenance
$BHSO_2$-1	2-17-81	Bag House	SO_2	BZ	10:50 - 13:15	0.003	ND	Simulated Bag House inspection
$BHSO_2$-2	2-17-81	Bag House	SO_2	BZ	11:05 - 13:20	0.003	ND	Simulated Bag House inspection
BHNOx-1	2-17-81	Bag House	NO	BZ	10:50 - 13:15	0.003	ND	Simulated Bag House inspection
BHNOx-1	2-17-81	Bag House	NO_2	BZ	10:50 - 13:15	0.003	ND	Simulated Bag House inspection
BHNOx-2	2-17-81	Bag House	NO	BZ	11:05 - 13:20	0.003	ND	Simulated Bag House inspection
BHNOx-2	2-17-81	Bag House	NO_2	BZ	11:05 - 13:20	0.003	ND	Simulated Bag House inspection
BHCO-1	2-17-81	Bag House	CO	BZ	10:50 - 13:15	0.003	4.4	Simulated Bag House inspection
BHCO-2	2-17-81	Bag House	CO	BZ	11:05 - 13:20	0.003	ND	Simulated Bag House inspection
AA-200	2-17-81	Bag House	Trace Metals	BZ	10:50 - 12:30	0.150	SEE TABLE 5	Simulated Bag House inspection
AA-201	2-17-81	Bag House	Trace Metals	BZ	11:05 - 13:20	0.202	SEE TABLE 5	Simulated Bag House inspection
AA-2	2-10-81	Mezzanine	Trace Metals	Area	09:08 - 15:04	0.531	SEE TABLE 5	Mezzanine level, south of #7 unit
AA-1	2-10-81	"0" Discharge	Trace Metals	Area	09:15 - 15:15	0.540	SEE TABLE 5	Near slurry conveyors
AA-10	2-11-81	2^{nd} Floor	Trace Metals	BZ	07:35 - 14:45	0.645	SEE TABLE 5	Welding I-Beams
AA-11	2-11-81	2^{nd} Floor	Trace Metals	BZ	07:35 - 14:45	0.645	SEE TABLE 5	Welding I-Beams
30	2-12-81	Ash Hoppers	Arsenic	BZ	12:31 - 14:40	0.194	0.010	"Beating" fly ash hoppers
Cl_2-1	2-18-81	Cl_2 Bldng.	Chlorine	Area	06:46 - 15:24	0.011	0.09	Chlorinator; H_2O treatment
AA18-1	2-18-81	#7 Precip.	Trace Metals	BZ	11:19 - 14:10	0.257	SEE TABLE 5	Precipitator inspection
AA19-1	2-19-81	#7 Precip.	Trace Metals	Area	08:10 - 09:24	0.111	SEE TABLE 5	20' inside precipitator hatch
AA-46	2-19-81	#7 Precip.	Trace Metals	Area	09:50 - 10:32	0.063	SEE TABLE 5	20' inside precipitator hatch
AA19-2	2-19-81	#7 Precip.	Trace Metals	Area	10:32 - 11:46	0.111	SEE TABLE 5	20' inside precipitator hatch
AA20-1	2-20-81	#7 Precip.	Trace Metals	BZ	07:50 - 10:00	0.195	SEE TABLE 5	Precipitator wash
MN-2 (NX)	2-12-81	Air Compressor	Trace Metals	BZ	07:37 - 15:23	0.699	SEE TABLE 5	Welding; Nixon
MN-1 (NX)	2-12-81	Air Compressor	Trace Metals	BZ	07:38 - 15:25	0.700	SEE TABLE 5	Welding; Nixon
AA-100	2-13-81	#7 Boiler	Trace Metals	BZ	09:28 - 10:25	0.114	SEE TABLE 5	Boiler inspection
CO-10	2-13-81	#7 Boiler	C O	BZ	09:28 - 10:26	0.001	9.9	Boiler inspection

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