HEALTH HAZARD EVALUATION REPORT 72-123-78
HAZARD EVALUATION SERVICES BRANCH
DIVISION OF TECHNICAL SERVICES

Establishment: Central Maine Power Co.
Wyman Station
Yarmouth, Maine

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October 1973

U.S. Department of Health, Education, and Welfare
National Institute for Occupational Safety and Health
Cincinnati, Ohio 45202

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
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CENTRAL MAINE POWER CO.
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I. SUMMARY DETERMINATION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding exposure of workers to sulfur dioxide and to dust containing vanadium pentoxide at W.F. Wyman Station, Central Maine Power Co., Yarmouth, Maine. An evaluation of workers' potential exposures to dust possibly containing silica was also made.

The Occupational Health Standards promulgated by the U.S. Department of Labor (Title 29, Code of Federal Regulations, Chapter XVII, Subpart G, Section 1910.93, Table G-1 and Table G-3) applying to substances of this evaluation are:

Substance	Eight-Hour Time-Weighted Average Concentration	
Sulfur Dioxide	5 ppm*	13 mg/m^3**
Crystalline Silica (respirable dust)	--	$\frac{10}{\%SiO_2+2}$ mg/m^3**
C**** Vanadium pentoxide dust	--	500 ug/m^3***

*ppm - parts of vapor or gas per million parts of contaminated air by volume.
**mg/m^3 - milligrams of compound per cubic meter of air at 25°C and 760 mm Hg.
***ug/m^3 - micrograms of compound per cubic meter of air at 25°C and 760 mm Hg pressure.
****Ceiling value - an employee's exposure should at no time exceed the value given for vanadium pentoxide dust.

Occupational health standards are established at levels designed to protect workers occupationally exposed to a substance on an 8-hour per day, 40-hour per week basis over a normal working lifetime.

The 8-hour time-weighted average (TWA) exposures to sulfur dioxide were very low for all workers. For the watch engineer and equipment tenders (operators) the exposure varied from 0.05 to 1.3 mg/m^3 (0.02 to 0.49 ppm) while for those performing maintenance work the exposure range was from 0.04 to 0.29 mg/m^3 (0.02 to 0.11 ppm). The exposure of workers to vanadium pentoxide was also found to be very low. Operators were exposed to air dust levels of <1.6 to <2.0 ug/m^3 vanadium pentoxide while workers performing maintenance were exposed to a range of <1.6 to 6.7 ug/m^3 vanadium pentoxide. Although exposures were measured under work conditions which are normal most of the time, no samples were obtained during maintenance work inside the boilers. Four area samples were obtained for silica analysis, but silica was not detected on any of the filters.

Thirty workers in the electric power plant were interviewed regarding exposure to sulfur dioxide (SO_2) and vanadium dust. Classic histories indicative of excessive exposure to vanadium were obtained from 20 of 23 workers. The most symptomatic workers were those who were present or past smokers and/or who had various allergic conditions. Histories of symptomatology compatible with over-exposure to SO_2 were obtained from a majority of workers, but the symptoms were usually mild and short lived.

Urine vanadium levels did not reveal excessive excretion of vanadium. Although a few fingernail cystine values were abnormal, they were not considered to be of serious health consequence.

The worker population on the whole appeared to be healthy at the time of the evaluation. Medical histories collected during the evaluation showed workers to be suffering mostly and significantly from acute respiratory illness which is believed to be due to vanadium over-exposure following maintenance work inside boilers. The group did not appear to be troubled by chronic respiratory conditions.

It is determined by the investigators that sulfur dioxide, dust containing vanadium, and respirable dust containing silica at the concentrations found in this work environment at the time of the environmental-medical evaluation were not toxic. This determination is based upon (1) physical examinations, (2) biological assay results and (3) environmental sampling results. However, on the basis of medical histories obtained during the investigation it is apparent that under certain conditions such as working inside boilers without respiratory protection, exposures to vanadium sufficient to cause ill effects may occur. These medical histories also showed that under certain conditions such as working near boiler leaks without respiratory protection, exposures to sulfur dioxide sufficient to cause ill effects may also occur. Recommendations for the prevention of such occurrences have been made in the full report.

Copies of this Summary Determination are available from the Hazard Evaluation Services Branch, NIOSH, U.S. Post Office Building, Room 508, 5th and Walnut Streets, Cincinnati, Ohio 45202. Copies have been sent to:

a) Central Maine Power Co., Yarmouth, Maine
b) Chairman, Local 839 IBEW
c) U.S. Department of Labor - Region I
d) Regional Program Director, NIOSH, Region I

For purposes of informing the approximately 30 affected employees of the results of this investigation, the employer shall post a copy of this Summary Determination, for a period of 30 calendar days at or near the work places of affected employees.

II. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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 National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of employees regarding alleged exposure of workers to sulfur dioxide and to dust containing vanadium at the Wyman Station, Central Maine Power Co. located at Yarmouth, Maine.

The plant is a steam electric generating station with three boilers burning #6 residual fuel oil. The request alleged the number 3 boiler as being the primary source of gaseous and particulate emissions in the work area. There are approximately 30 employees at the plant who could normally be exposed to dust or gas during some part of their work shift.

III. BACKGROUND HAZARD INFORMATION

A. Standards

The Occupational Health Standards as promulgated by the U.S. Department of Labor (Title 29 Code of Federal Regulations, Chapter XVII, Subpart G, Section 1910.93, Table G-1 and Table G-3) applicable to substance of this evaluation are:

Substance	Eight-Hour Time-Weighted Average Concentration	
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****Ceiling value - an employee's exposure should at no time exceed the value given for vanadium pentoxide dust.

B. Toxic Effects

Sulfur dioxide (SO_2) is one of the most widely encountered contaminants in the work place. It is primarily an irritant gas and its effects are due to the formation of sulfurous acid on contact with moist mucosa.

In industry over-exposure to SO_2 is usually of a more chronic nature. Symptoms usually consist of sensations of burning, dryness and pain in the nose and throat and may be accompanied by a dry or productive cough. The initial upper and lower respiratory tract symptoms normally regress with suitable treatment and removal from the atmosphere.

There has been some evidence that with SO_2 air levels at the TLV of 5 ppm there is increased airway resistance.[1] Investigators have reported various symptoms such as throat irritation, upper respiratory irritation, and some nosebleeds at a concentration of 10 ppm. It is thought that the TLV of 5 ppm will prevent respiratory tract irritation in most workers[2] and result in only minimal effects in workers sensitive to irritant gases.[2]

Vanadium is a trace metal ubiquitous in nature and may be an essential metal for the human body since it has many biologic actions. However, the major hazard from vanadium over-exposure is that of mucous membrane irritation, especially of the respiratory tract. Excessive levels of vanadium can cause severe irritation of the lungs leading to the classic symptoms of delayed-onset chest tightness, congestion, cough and wheezing. In some cases, symptoms may develop into more serious conditions such as broncho-pneumonia and pulmonary edema. There is no good evidence that individual episodes of lung irritation lead to chronic lung disease or permanent debilitating lung conditions. The green-black tongue reported by some investigators is not believed to be a sign of poisoning but merely as an indication of vanadium presence in a part of the respiratory tract.

As an aid in approximating exposure to vanadium, Mountain, Stockell and Stockinger[3] have analyzed fingernails for cystine, and amino acid whose levels in fingernails are depressed in association with abnormal urinary excretion of vanadium. Many investigators have suggested normal levels of urinary vanadium.[4-9]

Silica (Silicon dioxide-SiO_2) which is finely divided and in the free state can cause the pneumoconiosis called silicosis. Several factors appear to be important in the development of silicosis: exposure to high concentrations of finely divided free crystalline silica dust, duration of exposure, the synergistic action of other ions, differences in individual susceptibility, and the presence of infections especially tuberculosis. Chronic pulmonary silicosis is the type most often seen in industry and usually occurs only after long exposure (sometimes 15-30 years) to silica dust. Prevention is extremely important since treatment is not effective for the pulmonary lesions. Insuring that levels of free silica are below the Federal Standard is the best preventative measure.

IV. HEALTH HAZARD EVALUATION

A. Initial Visit-Observational Survey

Mr. Paul Alvarado, RPD, Region I and Mr. Robert Rosensteel, Industrial Hygiene Engineer conducted an initial visit at the W.F. Wyman Steam Station, Central Maine Power Co., Yarmouth, Maine on January 30-31, 1973.

There was an initial conference at which time the authority for Health Hazard Evaluations was outlined, the official notice of intent to conduct a Health Hazard Evaluation, copy of the Occupational Safety and Health Act of 1970, and the Regulations governing Health Hazard Evaluations were given to a company representative. Questions about the above were then briefly discussed.

A walk-through inspection of the plant was conducted by the NIOSH investigators accompanied by representatives of the employer and employees. The upper levels of #3 boiler had been pointed out as the area where workers had most often noticed leaks from #3 boiler. At the 134 ft. level, dust was observed to have settled on pipes and other surfaces. At the 92 ft. level the employee's representative pointed out that sulfur dioxide leaks had been quite bad in the past. The area near the automatic ash handling system at the 67 ft. level was observed to be quite dusty although workers are not usually in this area for more than short periods unless operating problems require maintenance workers to remain here for longer periods of time.

During the visit a total of fourteen workers were interviewed concerning possible health effects which workers might feel were associated with exposure to substances during work hours. An exit interview was conducted with representatives of the company and union. The necessity for a future study to determine the levels of sulfur dioxide and vanadium in the workplace was pointed out.

B. Environmental Evaluation

The follow-up environmental-medical evaluation was conducted on April 12-13, 1973.

The environmental evaluation was directed at determining the exposure of workers to three substances: vanadium pentoxide, sulfur dioxide, and free silica. The levels of vanadium pentoxide and sulfur dioxide were measured using one sampling train which was attached to the workers being monitored. The cellulose filter of the sampling train was attached in the worker's breathing zone with a clip to his lapel. The filter was sampled open face with the exposed face of the filter pointed downward to prevent dust falling from the workers' clothes onto the exposed filter surface.

The sampling train was composed of a three-piece filter cassette containing a 0.45 u pore size cellulose membrane filter, plastic tubing connecting the filter to the inlet of an all glass midget impinger containing 15 ml of 0.3 N hydrogen peroxide absorbing solution, plastic tubing from the outlet of the midget impinger was then connected to a standard MSA Model G personal sampling pump. The pump was used to aspirate a flow of two liters per minute through the sampling train. Each pump had been calibrated, and the calibration chart in conjunction with the pump's rotameter was used to adjust the pump to a two liter per minute flow. Each pump was checked periodically by one of the NIOSH investigators and if necessary the flow was corrected to two liters per minute.

The filter was dissolved in nitric acid and hydrolyzed with hydrochloric acid. Vanadium content was then determined by atomic absorption spectroscopy. The minimum detectable limit of vanadium was 0.9 ug per filter. The hydrogen peroxide absorbing solution was analyzed for sulfur dioxide content by titration with standard 0.002 N sodium hydroxide solution. The minimum detectable limit of this method is approximately 10 micrograms per impinger. The minimum measurable concentrations of sulfur dioxide and vanadium pentoxide for this evaluation were 0.012 mg/m^3 and 0.9 ug/m^3 respectively.

Some symptoms of workers suggested the possibility of exposure to sulfuric acid mist. However, the production of sulfuric acid mist occurs at an approximate ratio of 80 parts by weight of sulfur dioxide to one part of sulfuric acid.[10] On this basis there would have to be a very high concentration of sulfur dioxide, about six times the Federal Standard of 13 mg/m^3, before the sulfuric acid concentration approached the Federal Standard of 1.0 mg/m^3 for sulfuric acid. For this reason the sulfur dioxide measurements were considered to be sufficient for evaluation.

Since there are reports of significant silica levels appearing in residual fuel oil ash,[11] it was decided to monitor the work environment for possible exposure to silica containing dust. Dust samples for silica analysis were obtained using a nine liter per minute steel cyclone with the respirable fraction from the cyclone collected on a PVC membrane filter contained in a three piece cassette. Flow rate was controlled by maintaining a 15" mercury vacuum on the downstream side of a calibrated critical orifice. The dust collected on the filter was analyzed using a colorimetric analytical method. The minimum measurable concentration of silica dust for this evaluation was 0.0017 mg/m^3. Locations for obtaining the silica samples were selected as representing the dustiest areas of the plant based upon observations made during the initial and follow-up visits.

For each worker who had a sampling train attached to him the start and end times were accurately recorded, and the total sample volume was then calculated from the flow rate and total elapsed time of the sample. The concentration of the substance was then expressed as milligrams per cubic meter of contaminated air. Sulfur dioxide concentrations were expressed as parts of sulfur dioxide per million parts of contaminated air. All substances were measured in workers' breathing zones with the exception of silica which was obtained utilizing area sample locations.

The results obtained for sulfur dioxide concentrations are contained in Table I. Operating personnel (watch engineer and equipment tenders) were monitored continuously throughout the shift while maintenance workers were sampled for a shorter period. The maintenance work was of a nature requiring frequent entrance and exit through small manholes at the #2 Boiler Condenser which made sampling with an impinger very difficult. For this reason the impinger sampling times were shortened to times less than a shift and fewer samples were obtained for maintenance workers.

Sulfur dioxide levels were quite low with a range of 0.05 to 1.27 mg/m^3 (0.02 to 49 ppm) being measured in the breathing zones of operating personnel while workers performing maintenance work had sulfur dioxide measurements which ranged from 0.04 to 0.28 mg/m^3 (.02 to .11 ppm). Operating personnel could be expected to have greater potential for exposure to sulfur dioxide under conditions of the survey since they normally work in all three boiler areas during the shift and especially would be exposed in #3 Boiler area. Mechanical maintenance workers were working on the condenser of #2 Boiler while it was down so exposure would be expected to be minimal. All the sulfur dioxide levels measured are far below levels reported to cause adverse health effects in workers, as well as the Federal Standard of 13 mg/m^3 (5 ppm). Seven detector tubes were used to measure SO_2 levels in the #3 Boiler area without SO_2 being detected on any tube (<1 ppm). These sulfur dioxide results could be expected since no leaks in the #3 Boiler system were observed during the evaluation.

The results obtained for vanadium dust air levels which were measured in the breathing zones of workers are contained in Table II. All workers were monitored for the entire shift. The potential for exposure to dust containing vanadium did not seem very high since very few workers were in areas where dust had collected and could become suspended in the air due to work activities in the area. Three workers, the outside maintenance crew, were observed to have the greatest potential for exposure to dust possibly containing vanadium. All results were very low in comparison to levels of vanadium exposure which have been reported to cause adverse effects in workers[2] and the Federal Standard for exposure to vanadium pentoxide dust of 500 ug/m^3. Results are reported to be less than the actual entries appearing in Table II for the majority of the data since the amount of

vanadium detected on the filters was below the lowest measurable limit of the analytical method. Only three filters were found to have a vanadium content above the minimal value, two of the outside maintenance workers and one mechanical maintenance worker.

The results of the samples obtained for silica analysis are contained in Table III. Silica was not detected on any of these samples.

C. Medical Investigation Procedures

Thirty employees in all job classifications were interviewed regarding general health and history of symptoms consistent with over-exposure to vanadium dust and SO_2. A physical examination which included examination of the eyes, nose, mouth and chest was also performed on all participants. Twenty-four hour urine collections were taken for vanadium analysis.[12] Urine samples were collected during the work shift (8 hr. sample) and for the remaining 16 hours (16 hr. sample) to observe possible differences in exposure vs. post exposure excretion of vanadium.[3] Fingernail clippings were obtained on 11 workers for cystine analysis.

Medical Investigation Results

Employee interviews: Of the thirty (30) employees interviewed, 23 have past exposure to dust during routine filter changes or boiler overhaul. Twenty of 23 reported symptoms consistent with vanadium over-exposure. Symptoms were usually delayed from 3 to 12 hours after beginning exposure and start with chest tightness or heaviness. Workers describe it "like a cold coming on". With many workers, the chest heaviness develops further into a productive cough and, at times, wheezing. Only three workers reported actual shortness of breath. It was very unusual for a worker to lose time from work and few saw their private physicians for these symptoms. The full symptom complex of chest heaviness, productive cough and wheezing noted in 9 of the 23 exposed workers occurred almost solely (8 of the 9) in smokers or past smokers and in workers with an allergic history (childhood asthma, eczema, dust or pollen allergy). No history of green black tongue could be elicited from any worker.

Periodic leaks in boiler #3 involving SO_2 resulted in a variety of symptoms ranging from mild nausea to nasal stuffiness (20 of 25) and rarely acute shortness of breath (1 of 25). Boiler leaks did not result in a symptom complex such as experienced by boiler dust exposure.

No workers were symptomatic on the day of questioning since no major work was being performed inside boilers nor were any leaks present in boiler #3. The last major boiler cleaning involving potential heavy dust exposure occurred four days prior to our visit.

Physical exam: No workers were found to have any significant physical findings. However, three workers who had been doing minor boiler overhaul had black dust particles in their nose, which is evidence of some dust exposure.

Urinary Vanadium: 8-hour collection (exposure period): 30 samples were obtained. The results ranged from <14 ug/liter to 31 ug/liter. One sample had 31 ug/liter; 1 had 19 ug/liter; 1 had 16 ug/liter; 2 had 15 ug/liter; and 25 had <14 ug/liter. The lower limit of sensitivity of the method was 14 ug/liter.

16-hour collection (non-exposure period): 28 samples were collected. The results ranged from <14 ug/liter to 23 ug/liter. One sample had 23 ug/liter; another had 21 ug/liter, another had 19 ug/liter; and another had 17 ug/liter. Two samples had 15 ug/liter and the remaining 22 had <14 ug/liter.

There was no difference in excretion of vanadium when comparing urine collections, exposure vs. non-exposure period.

Normal values for unexposed groups have ranged up to 20-25 ug/liter,[4,5,7,9] Exposed populations may be as high as 30 ug/liter[4] and even 100 ug/liter[8] without exceeding the present air standard or becoming symptomatic. The one worker with a urine vanadium value of 31 ug/liter had not had any heavy exposure to vanadium for many days and was not symptomatic.

Fingernail cystine: Eleven workers' fingernails were analyzed for cystine and values ranged from 10.8 to 8.1 per cent. According to Stockinger,[13] 8.6 per cent was considered the lower limit of normal. Four values fell below this limit. Unfortunately no controls from the local area were available for comparative purposes.

Discussion

Over-exposure to vanadium dust and SO_2 gas is episodic because of the unpredictability of leaks in boiler #3 and of difficulties in changing filters and boiler staging. The fact that the workmen are not required to wear respirators nor is there any uniform respirator used, leads often to no respirator protection and consequently to frequent significant symptoms of vanadium over-exposure. Less often the lack of respirator protection will result in somewhat milder symptoms of SO_2 over-exposure.

Although no workers were symptomatic on the day of interview nor were there significant physical findings (both due probably to the fact that there was little exposure to dust or SO_2 that day), many workers reported a history of symptoms compatible with vanadium and SO_2 over-exposure.

Interestingly, the most significantly affected workers who were exposed to vanadium were those who had smoking histories or allergic histories suggesting that they may be more susceptable to this irritant and that this group above all ought to wear respiratory protection continuously when working in dusty areas.

Urine values for vanadium usually reflect recent exposure to vanadium since 61% of a dose is excreted within 24 hours.[14] The individual urine vanadium values were considered to be normal except for one value which was slightly out of the normal range for an unexposed population but not considered to be abnormal for an exposed but healthy population. The attempt to determine whether there was any difference in urinary excretion during and after exposure for a 24 hour period was not revealing. There were no obvious differences between the two groups of data.

With regard to the fingernail cystine levels, without the benefit of local controls, which were unavailable, one must conclude that some cystine values were abnormal and that this implies past exposure (approximately 3 months ago) to vanadium which lead to statistically abnormally high urinary vanadium levels. However, cystine levels are known to return to normal upon lower exposure[3] and have not been shown to be of any health consequence other than indicating interference with cystine incorporation into growing nails.

Thirty workers in the electric power plant were interviewed regarding exposure to sulfur dioxide (SO_2) and vanadium dust. Classic histories indicative of excessive exposure to vanadium were obtained from 20 to 23 workers with exposure to vanadium in dusty operations. The most symptomatic workers were those who were present or past smokers and/or had various allergic conditions. Histories of symptomatology compatible with over-exposure to SO_2 were obtained from a majority of workers, but the symptoms were usually mild and short-lived.

Urine vanadium levels did not reveal excessive excretion of vanadium. Although a few fingernail cystine values were abnormal, they were not considered to be of serious health consequence.

The worker population on the whole appeared to be healthy at the time of the evaluation. Medical histories collected during the evaluation showed workers to be suffering mostly and significantly from acute respiratory illness which is believed to be due to vanadium over-exposure following maintenance work inside boilers. The group did not appear to be troubled by chronic respiratory conditions.

D. Conclusions

It is determined by the investigators that sulfur dioxide, dust containing vanadium, and respirable dust containing silica at the concentrations found in this work environment at the time of the environmental-medical evaluation were not toxic. This determination is based upon (1) physical examinations, (2) biological assay results and (3) environmental sampling results. However, on the basis of medical histories obtained during the investigation it is apparent that under certain conditions such as working inside boilers without respiratory protection, exposures to vanadium sufficient to cause ill effects may occur. These medical histories also showed that under certain conditions such as working near boiler leaks without respiratory protection, exposures to sulfur dioxide sufficient to cause ill effects may also occur.

V. RECOMMENDATIONS

Environmental

1. Whenever workers are exposed to dust which may contain vanadium as occurs when changing filters, working on the ash handling system, or working inside boilers, appropriate respiratory protection should be made mandatory. The requirements for respiratory protection as promulgated by the U.S. Department of Labor are contained in Title 29, Code of Federal Regulations, Chapter XVII, Subpart I, Section 1910.134. Selection of proper respirators should be guided by American National Standard Practices for Respiratory Protection Z 88.2-1969.

2. Personnel working in the area of a boiler leak should use respirators to prevent the irritant effects of exposure to sulfur dioxide until the leak has been repaired. Selection of respiratory protection should be guided by the references given above.

Medical

3. Appropriate medical monitoring for workers exposed to dust containing vanadium should include pre-employment and annual screening for significant respiratory problems and when indicated, chest x-rays.

VI. REFERENCES

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VII. TABLES

TABLE I

EMPLOYEE EIGHT-HOUR TIME WEIGHTED AVERAGE
EXPOSURE TO SULFUR DIOXIDE ON 4/12-13/73

DATE	JOB TITLE	TIME OF SAMPLE (MIN)	8-HOUR TIME WEIGHTED AVERAGE EXPOSURE CONCENTRATION	
			mg/m^3	ppm
4/12	Watch Engineer	449	0.16	0.06
4/12	Equipment Tender-Fire Deck Level	432	0.31	0.12
4/12	Equip. Tender-Turbine Level	437	1.3	0.49
4/12	Equip. Tender-Pump Room Level	447	0.09	0.03
4/13	Equip. Tender-Fire Deck Level	422	0.06	0.02
4/13	Equip. Tender Turbine Level	435	0.05	0.02
4/13	Equip. Tender-Pump Room Level	398	0.05	0.02
4/13	Mech. Maintenance Worker 1	225	0.09	0.03
4/13	Mech. Maintenance Worker 2	234	0.09	0.03
4/13	Mech. Maintenance Worker 3	89	0.28	0.11
4/13	Mech. Maintenance Worker 4	220	0.04	0.02
4/13	Plant Analyst	234	0.09	0.03

TABLE II

EMPLOYEE EIGHT-HOUR TIME WEIGHTED AVERAGE
EXPOSURE TO VANADIUM PENTOXIDE ON 4/12-13/73

DATE	JOB TITLE	TIME OF SAMPLE (MIN)	8-HOUR TIME WEIGHTED EXPOSURE CONCENTRATION ug/m^3
4/12	Watch Engineer	449	<1.8
4/12	Equip. Tender-Fire Deck Level	492	<1.6
4/12	Equip. Tender-Turbine Level	497	<1.6
4/12	Equip. Tender-Pump Room Level	447	<1.8
4/13	Equip. Tender-Fire Deck Level	422	<1.9
4/13	Equip. Tender-Turbine Level	445	<1.8
4/13	Equip. Tender-Pump Room Level	398	<2.0
4/13	Mech Maintenance Worker 1	371	<2.2
4/13	Mech Maintenance Worker 2	485	<1.7
4/13	Mech Maintenance Worker 3	463	<1.7
4/13	Mech Maintenance Worker 4	427	<1.9
4/13	Mech Maintenance Worker 5	364	<2.2
4/13	Mech Maintenance Worker 6	361	4.0
4/13	Elect. Maintenance Worker 1	500	<1.6
4/13	Elect. Maintenance Worker 2	471	<1.7
4/13	Elect. Maintenance Worker 3	471	<1.7
4/13	Outside Maintenance Worker 1	449	5.6
4/13	Outside Maintenance Worker 2	426	6.7
4/13	Outside Maintenance Worker 3	405	<2.0
4/13	Steam Plant Analyst 1	440	<1.8
4/13	Steam Plant Analyst 2	500	<1.6

TABLE III

AREA SAMPLES FOR EXPOSURE TO SILICA CONTAINING DUST

DATE	SAMPLE LOCATION	TIME OF SAMPLE (MIN)	SILICA CONCENTRATION mg/m^3
4/12/73	#3 Boiler-134' Level	645	<.0017
4/12/73	#3 Boiler-120'8" Level	641	<.0017
4/13/73	#3 Boiler-at 1K B Soot blower	477	<.0023
4/13/73	#3 Boiler-92' Level	382	<.0029