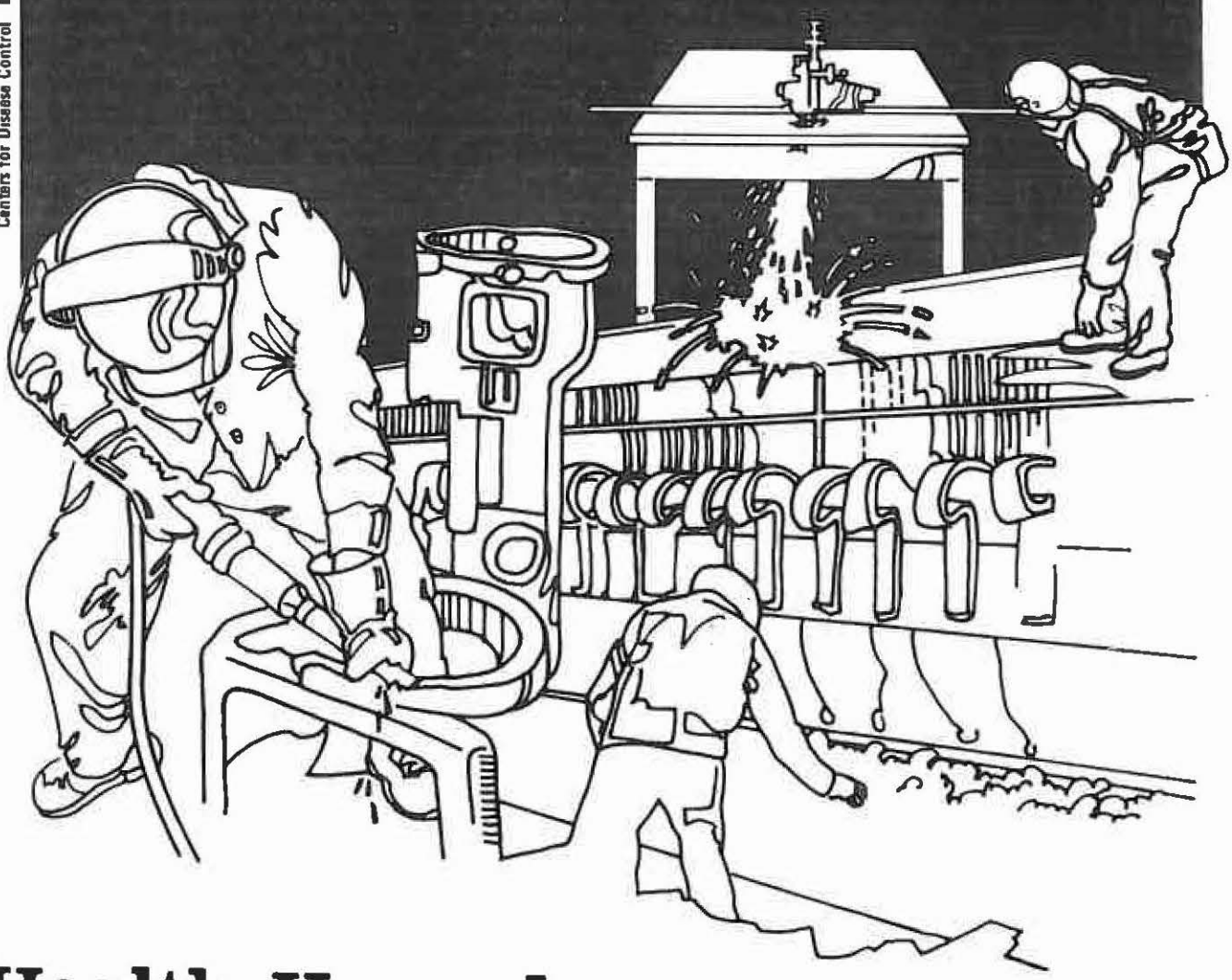
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HHE 80-032-814
MAGMA COPPER COMPANY
SAN MAMUEL, ARIZONA

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. 699(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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HE 80-032-814
February 1981
Magma Copper Company
San Manuel, Arizona

NIOSH INVESTIGATORS
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I. SUMMARY

In December 1979, the National Institute for Occupational Safety and Health (NIOSH) received a request from the authorized representative of the United Steel Workers Local 937 to determine if a potential health hazard existed to arsenic, cadmium, copper, lead and sulfur dioxide in the reverbatory furnace and converter departments of the Magna Copper Company smelter, San Manuel, Arizona.

An initial survey was conducted on March 6, 1980, and an environmental and medical survey was conducted on April 22 and 23, 1980. Personal breathing zone samples were collected for airborne arsenic, cadmium, copper, lead and sulfur dioxide. The medical evaluation consisted of reviewing the company medical records, employee interviews, blood lead analysis, and urine arsenic analysis.

Analysis of environmental data indicated no overexposure to arsenic, cadmium, copper or lead as the concentrations were well below the OSHA standards and/or the NIOSH recommended standards. Thirty-eight of 75 (51%) TWA personal samples for sulfur dioxide exceeded the 1974, NIOSH recommended standard of 2 ppm and 14 (19%) exceeded the OSHA standard of 5 ppm. Thirteen of the 14 samples that exceeded 5 ppm occurred on the April 23, swing shift. Respirators were not worn continually, but were usually worn by the workers when high concentrations of sulfur dioxide were present.

Blood lead levels were all below 40 ug Pb/100 ml. Four workers had urine arsenic levels greater than 100 ug As/1. Many workers complained of upper respiratory and skin irritation, occasional shortness of breath, increased phlegm production and prolonged respiratory infections since beginning work in the smelter.

On the basis of this data, NIOSH determined that a hazard from overexposure to sulfur dioxide existed in the reverbatory furnace and converter departments of the Magna Company smelter. The potential hazard to the individual worker is reduced by periodic use of respirators when they are in high concentrations of sulfur dioxide, but repeated short term exposures may be resulting in impaired respiratory function, and excess respiratory tract illness among the workers. Engineering controls should be used to reduce the airborne sulfur dioxide concentrations. Recommendations to reduce the sulfur dioxide exposure are included in section VIII of this report.

KEYWORDS: SIC 3331 (Primary copper smelters) arsenic, cadmium, copper, lead, sulfur dioxide, respiratory symptoms.

II. INTRODUCTION

In December, 1979, NIOSH received a request from the authorized representative of the United Steel Workers Local 937 to determine if a potential health hazard existed to arsenic, cadmium, copper, lead and sulfur dioxide in the reverbatory furnace and converter departments of the Magma Copper Company smelter, San Manuel, Arizona. An initial survey was conducted in March 1980, and an environmental/ medical survey was conducted on April 22 and 23, 1980. A written report, including environmental results and recommendations, was submitted to the company and union on August 13, 1980. Individual letters were sent to workers in July, 1980, informing them of their test results. It was recommended that the four workers with elevated urine arsenic levels be retested as soon as possible.

III. BACKGROUND

Magma Copper Company is a primary copper smelter. This evaluation involves only the reverbatory furnace and converter departments. Concentrated copper ore is fed into the top of the reverbatory furnace where it is heated to the molten stage. Periodically the slag and matte are tapped with the slag being carried out in railroad slag pots and the matte being transferred to the converter in ladles. Copper matte is poured into the converter where the sulfur is oxidized and the matte is converted to metallic copper.

There are approximately thirty workers per shift in the reverbatory area and twenty per shift in the converter area. These departments operate three shifts per day, seven days per week. There are exhaust hoods over the matte tap holes, however, fumes and gases still can be seen escaping the hoods. There are no exhaust hoods over the slag troughs or the opening through which the slag pots are filled. There are exhaust hoods over the converter openings, however, they do not appear to be totally adequate. The employees are issued NIOSH approved respirators for protection against sulfur dioxide and metal fumes and they wear them when performing certain jobs and/or when they are intermittently exposed to sulfur dioxide. There was no respirator fit testing program in effect at the time of the survey. The company provides a change room and showers, however, these are not utilized by all of the employees.

Medical services provided by the company are:

1) pre-employment examinations: general physical examinations, including spirometry beginning in 1980 and audiograms beginning in 1977.

2) annual examinations: audiograms for those with excessive noise exposures, spirometry for those using respirators.

The only medical problems which had been reported to the company as potentially work-related were a number of dermatitis cases, cause undefined. All of the employees currently employed in the reverbatory and converter areas were tested for blood lead levels and arsenic urine levels in the past two years. One worker has been found to have an environmental lead exposure level over the OSHA standard, but did not have any elevated blood lead level. Three workers were found to have elevated urine arsenic levels, and following a change in work practices were re-tested and reportedly had levels within the normal range. At present there is no periodic testing for blood and arsenic levels because the environmental monitoring does not demonstrate an exposure which would require such monitoring under OSHA standards.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Breathing zone and area samples were collected for arsenic or cadmium, copper and lead on celluose ester membrane filters which preceded potassium hydroxide treated filters used to collect sulfur dioxide. All samples were collected at a flow rate of 1.0 liter per minute due to the increased pressure drop resulting from the use of 2 filters in each cassette. Additional information regarding collection and analysis is shown below.

SUBSTANCE	COLLECTION MEDIUM	ANALYTICAL METHOD	LIMITS OF DETECTION
Arsenic	Celluose ester membrane filter	Hydride generation	25 ng/filter
Cadmium	" "	NIOSH P&CAM 173	2 ug/filter
Copper	" "	" "	2 ug/filter
Lead	" "	" "	3 ug/filter
Sulfur Dioxide	Potassium Hydroxide treated filter	NIOSH P&CAM 268	10 ug/filter

B. Medical

During the initial survey, interviews with seven workers indicated a high rate of eye, nose throat and skin irritation and some complaints of chronic bronchitis, symptoms of chronic obstructive pulmonary disease, and respiratory reactions to fumes and gases in the reverbatory and converter areas.

On the return visit NIOSH medical staff, with the assistance of members of the Rocky Mountain Center for Occupational and Environmental Health staff, obtained blood and urine specimens from 92 workers on all three shifts, Venous blood samples were drawn and analyzed for lead content, utilizing the Delves-Cup Atomic Absorption Procedure (limit of detection = 6 ug Pb per 100 mr dl). Urine samples were analyzed for arsenic content utilizing the procedure of Pierce, et al., Applied Spectroscopy, Vol. 30: 38-42; 1976 (limit of detection = 3 ug As/l).

Aproximately twenty workers were interviewed in depth utilizing an adaptation of the British Medical Council Respiratory Symptom questionnaire for respiratory symptoms which might be related to sulfur dioxide exposure. These interviews have been analyzed as case report information which would contribute to a determination of the need for further assessment of the effects of sulfur dioxide exposure in this workplace.

V. EVALUATION CRITERIA

A. Environmental

SUBSTANCE	NIOSH RECOMMENDED STANDARDS*	CURRENT OSHA STANDARDS**
Arsenic	2 ug/cu m***	10 ug/cu m
Cadmium	40 ug/cu m	100 ug/cu m (fume)
Copper	-	200 ug/cu m (dust)
Copper	-	0.2 mg/cu m (fume)
		1.0 mg/cu m (dust)
Lead	50 ug/cu m	50 ug/cu m
Sulfur Dioxide	2 ppm	5ppm

* NIOSH time weighted averages based on up to 10 hours of exposure.
** OSHA time weighted averages based on up to 8 hours of exposure
*** As determined by a 15-minute sampling period.

Occupational health standards are established at levels designed to protect individuals occupationally exposed to toxic substances on an eight hour per day, forty hour per week basis over a normal working lifetime.

B. Medical

Blood lead levels below 40 ug Pb/100ml were considered within normal limits (7). Urine arsenic levels in community populations are usually less than 50 ug/l (16). Levels greater than 100 ug/l are regarded as abnormal, possibly representative of excessive occupational exposure and requiring repeat testing for confirmation (4,7,)

C. Toxicology

Arsenic

Inorganic arsenic poisoning can be acute or chronic. The general public is exposed to arsenic in some food, primarily seafood. Occupational exposure is by inhalation (breathing), direct skin and mucous membrane contact, and ingestion (contamination of hands, food, and smoking material). Manifestations of chronic inorganic arsenic poisoning inlcude dermatitis, warts, hyperkeratoses ("calluses") of the palms and soles, conjunctivitis, respiratory tract irritation, ulceration and perforation of the nasal septum, headache, drowsiness, confusion, convulsions, anemia, and muscle weakness. Arsenic is a cause of skin cancer, lung cancer and of a rare liver cancer, angiosarcoma. Smelter workers as a group have increased (non smoking habit related) lung cancer death rates.

Normal urine arsenic levels vary greatly, primarily depending on arsenic levels in the diet. Urine arsenic levels in community populations are usually less than 50 ug/l (16). Levels greater than 100 ug/l are regarded as abnormal, possibly representative of occupational exposure. Because of the variability of arsenic levels, anyone found to have a level greater than 100 ug/l should be re-tested to confirm the finding. (1,2,3,4,5)

Copper Mist, Dust and Fume

Inhalation of dusts and mists of copper and copper salts result in irritation of the upper respiratory tract and, occasionally, ulceration and perforation of the nasal septum. Metal fume fever, a 24-48 hour illness characterized by chills, fever, aching muscles, dryness in the mouth and throat and headache may occur due to exposure to metal oxide fume rather than copper dust. Copper particles embedded in the eye result in a pronounced foreign body reaction, with characteristic discoloration of eye tissue.

Allergic contact dermatitis due to copper, although rare, has been reported.

Lead

Lead accumulates in the body and is excreted slowly. The general public is exposed to small amounts of lead in food, water, and air. Occupational lead exposure is primarily by inhalation, and to a lesser degree by ingestion (contamination of hands, food, and smoking material). Lead poisoning is a chronic process, although symptoms may develop suddenly after sufficient chronic exposure. Manifestations of lead poisoning in adults include decreased appetite, abdominal pain, nausea, constipation (or diarrhea),

fatigue, irritability, insomnia, headache, anemia, muscle pain, sore joints, tremor, weakness of the extensor muscles of the wrists and ankles and impaired kidney function. There is some evidence that occupational lead toxicity can impair fertility.

Blood lead levels below 40 ug/100 ml whole blood are considered to be normal levels which may result from daily environmental exposure. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/100 ml. Lead levels between 40-60 ug/100 ml in lead exposed workers indicated excessive absorption of lead and may result in some adverse health effects. Levels of 60/100 ml represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/100 ml are considered dangerous and often require hospitalization and medical treatment. (7,8,9,10)

Sulfur Dioxide

a. Acute (short-term) Effects

Sulfur dioxide is a chemical gas which combines with water on moist surfaces to form sulfurous acid. This acid, like all acids, causes reddening and stinging irritation to skin surfaces and mucous surfaces (for example, nose, throat, eyes and lung). Thus, persons exposed to sulfur dioxide gas at concentrations of 20 parts of gas in every million parts of air (20 ppm) experience choking and sneezing. Exposure to 50 ppm usually causes nosebleeds, runny nose, watering, stinging eyes, cough, difficulty breathing, and wheezing due to airway narrowing in the lungs. Very high levels of sulfur dioxide can cause pneumonia and/or permanent scarring of lungs (bronchiolitis obliterans). (11)

b. Chronic (long-term) effects:

Studies of long-term, low level (less than 10 ppm) sulfur dioxide exposure have given conflicting results (12, 13, 14, 15). Careful standardization of spirometry procedures and a clear separation between exposed and control groups are necessary to provide meaningful results in such studies. When these precautions are respected, studies indicate significant reduction in lung capacity (FVC) and expiratory flow rate (FEV-1)for workers exposed to sulfur dioxide levels (0.5 - 3 ppm) within the current standard (5). An increae in chronic bronchitis and "days off" due to respiratory illness was reported in the same group of workers. These findings were not explained by respondents' smoking habits. Altogether, the data suggest that chronic low level sulfur dioxide exposure can cause or accelerate the development of chronic bronchitis and emphysema (and obstructive lung disease).

VI. RESULTS AND DISCUSSION

A. Environmental

All 23 arsenic and 46 cadmium, copper and lead air sampling results (except 1 copper and 1 lead) were well below the OSHA standards and/or the NIOSH recommended levels. The subcharge operator had a four hour exposure to copper of 1.02 mg/cu m and to lead of 30 ug/cu m. He spends 4 hours per day at this job. The other portion of his day is spent as charge operator in the bin area, where the airborne copper and lead levels were very low. His eight hour time weighted average exposure is about 40 to 50% of the permissible exposure levels for these substances.

The OSHA standard for sulfur dioxide is 5 ppm while the NIOSH recommended exposure level is 2 ppm. Seventy-five personal air samples were collected for sulfur dioxide on two consecutive days on the first and second shifts. Thirty-eight of the 75 samples (51%) exceeded 2 ppm and 14 of the 75 (19%) exceeded 5 ppm. Thirteen of the 14 samples that exceeded 5 ppm occurred on the April 23 swing shift.

The plant was operating at reduced capacity during the day shift on April 22 due to air pollution requirements. There were 20 reverbatory furnace taps on the April 22 day shift and 27 taps on the April 23 swing shift. A summary of the results is listed below.

DATE	LOCATION	NUMBER SAMPLES	AVE. CONC. PPM	NUMBER GREATER THAN 2 PPM	NUMBER GREATER THAN 5 PPM
4/22 day shift	Reverbatory area	16	2.19	8 (50%)	1 (6%)
4/22 day shift	Reverbatory area	15	1.06	2 (13%)	0 (0%)
4/22 day shift	Total	31	1.64	10 (32%)	1 (3%)
4/23 swing shift	Reverbatory	19 area	3.70	15(79%)	5(26%)
4/23 swing shift	Converter	15 area	5.57	13(87%)	8(53%)
4/23 swing shift	Total	34	4.52	28(82%)	13(38%)

As shown in the above table, 32% of the sulfur dioxide samples on April 22 and 82% on April 23 exceeded the NIOSH recommended level of 2 ppm, and 3% on April 22 and 38% on April 23 exceeded the OSHA standard of 5 ppm. The individual sample results (tables 1 and 2.) show that the subcharge operators, feedermen, punchers and cranemen are the jobs that most frequently have high sulfur dioxide exposures.

Respirators were not worn continually, but were usually worn by the workers when high concentrations of sulfur dioxide were present. Several workers wore beards which prevent a proper leak-free respirator fit. Many of the workers did not wash their hands prior to eating lunch or smoking. This practice increases the potential of ingesting the materials clinging to the hands by transferring them to the food.

Conditioned air is fed into the crane cabs, however, the systems are not doing an effective job of removing the sulfur dioxide as shown by the measurements (7.8, 7.9 and 8.0 ppm) taken inside the cabs.

Local exhaust ventilation is installed over the matte tap holes. These are not totally effective as gases and fumes were seen escaping from the hoods.

B. Medical

All workers had blood lead levels below 40 ug lead per 100 ml of blood (Table 3) and in fact there were no samples with lead levels above 25 ug lead per 100 ml. Four urine arsenic levels were above 100 ug As/l, (Table 4) 160 in a skimmer, 330 in a tapper, 710 in a puncher and 710 in a slagmotorman. Because of the low urine arsenic levels found in the work force as a whole (only 8 of 92 values were greater than 50 ug As/l), as well as within the four work groups named, we conclude that the four elevated levels do not represent a widespread problem of excessive arsenic exposure in this workplace.

Analysis of the 20 questionnaires completed during the second visit, as well as informal interviews with workers during both visits, suggests strongly that sulfur dioxide exposure in the smelter may have produced a range of respiratory system problems including severe upper respiratory irritation, chronic obstructive pulmonary disease and occupational asthma, in addition to complaints of skin irritation.

VI. CONCLUSION

On the basis of the data in this investigation, NIOSH determined that a potential hazard from overexposure to sulfur dioxide existed in the reverbatory furnace and converter departments. This respiratory hazard to the individual worker is reduced by the periodic use of respirators when they are in high concentrations of sulfur dioxide Engineering controls should be used to reduce the airborne sulfur dioxide concentrations.

VIII. RECOMMENDATIONS

1. The local exhaust ventilation systems over the reverbatory furnace matte and slag tap holes are not fully effective. These need to be redesigned and exhaust volumes adjusted to capture the fumes and gases.

2. Local exhaust ventilation should be considered as a control over the slag trough and over the hole leading to the slag pots.

3. Supply air is blowing directly on the open hood face of #1 North matte tap. This air disturbs the air entering the hood and reduces capture efficiency. This supply should be moved or blocked off.

4. Several hoods do not fit closely enough to the reverbatory furnace. Close-fitting hoods will prevent gases and fumes from escaping through these openings.

5. Several hoods were not centered properly under the connecting ducts, thereby reducing the exhaust air volumes through the hoods. They should be properly adjusted.

6. Local exhaust ventilation should be considered for the converter slag return spout.

7. The sources of the escaping gases and fumes from the converter and reverbatory furnace should be identified and the emissions controlled through the use of engineering controls.

8. The filters in the crane cabs need improved maintenance as indicated by the high sulfur dioxide levels in the cabs.

9. Employees should not wear beards or moustaches that prevent a seal of the respirator against the face.

10. Employees should wash their hands before eating or smoking.

11. There should be a full written respirator program, including training of the workers, fit testing of the respirators, and maintenance, etc., as required by the OSHA regulations (CFR 1910.134).

12. The company should provide a worker education program regarding the potential hazards of sulfur dioxide, arsenic, and lead.

13. Workers in the converter and reverbatory furnance areas should be re-tested for urine arsenic levels at least twice more, at 6 month intervals, to confirm the finding reported here that elevated urine arsenic levels are not a work-related hazard.

IX. REFERENCES

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2. NIOSH Recommended Standard for Occupational Exposure to Inorganic Arsenic, U.S. Government Printing Office: 1974 657-061/2015.

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16. P.J. Landrigan: Arsenic; State of the Art. Environmental Health Perspectives (in press)

X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this complete Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (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 NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Magma Copper Company

2. United Steel Workers, Local 937

3. U.S. Department of Labor, Occuptional Safety and Health Administration, Region IX, San Francisco, California;

4. National Institute for Occupational Safety and Health, Region IX, San Francisco, California.

For the purpose of informing the 200 affected employees, the employer shall promptly post this Determination Report in a prominent place(s) near the work area of the affected employees for a period of thirty (30) calendar days.

XI. ACKNOWLEDGEMENTS

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TABLE I

REVERBATORY FURNACE DEPARTMENT
ARSENIC, CADMIUM, COPPER, LEAD AND SULFUR DIOXIDE
AIR CONCENTRATIONS

Magma Copper Company
San Manuel Arizona
HHE 80-32

JOB	SHIFT	DATE	SAMPLE #	SAMPLE TIME (minutes)	SAMPLE VOLUME (liters)	TIME WEIGHTED AVERAGES				
						Arsenic ug/m^3	Cadmium ug/m^3	Copper mg/m^3	Lead ug/m^3	Sulfur Dioxide PPM
Motorman	1	4/22/80	1	420	470	-	<4	0.04	6	1.1
Motorman	1	4/22/80	4	465	465	0.06	-	-	-	2.7
Motorman	2	4/23/80	52	419	419	0.8	-	-	-	0.8
Motorman	2	4/23/80	55	418	418	-	<5	0.10	10	1.3
Motorman	2	4/23/80	58	403	403	-	<5	0.07	14	3.0
Motorman	2	4/23/80	50	422	422	-	<5	0.04	7	3.2
Motorman	2	4/23/80	43	420	420	0.8	-	-	-	2.6
Charge and sub-charge operator (1/2 day at bin area, 1/2 at #24 belt)	1	4/22/80	2	455	455	-	<4	0.02	<7	2.0
" " "	1	4/22/80	3	435	435	0.2	-	-	-	2.7
Charge operator (bin area)	2	4/23/80	56	198	198	-	<10	0.01	<15	0.01
Subcharge operator (#24 belt)	2	4/23/80	60	186	186	-	<11	1.02	38	10.8
Charge operator (bin area)	2	4/23/80	61	186	186	0.03	-	-	-	0.1
Subcharge operator (#24 belt)	2	4/23/80	48	241	241	2.9	-	-	-	9.5
Feederman	1	4/22/80	5	455	455	-	<4	0.09	<7	5.1
Feederman	1	4/22/80	7	450	450	0.3	-	-	-	3.1
Feederman	1	4/22/80	10	440	440	-	<4	0.09	<7	5.7
Feedermen	2	4/23/80	59	404	404	-	<5	0.07	<7	2.9

TABLE I (cont.)

JOB	SHIFT	DATE	SAMPLE #	SAMPLE TIME (minutes)	SAMPLE VOLUME (liters)	TIME WEIGHTED AVERAGES				
						Arsenic ug/m^3	Cadmium ug/m^3	Copper mg/m^3	Lead ug/m^3	Sulfur Dioxide PPM
Feederman	2	4/23/80	44	453	453	0.3	-	-	-	5.2
Feederman	2	4/23/80	46	435	435	-	<5	0.01	<7	5.6
Tapper	1	4/22/80	6	455	455	0.1	-	-	-	1.1
Tapper	1	4/22/80	9	455	455	-	<4	0.01	<7	1.3
Tapper	2	4/23/80	51	420	420	-	<5	0.05	<7	2.3
Tapper	1	4/22/80	12	430	430	-	<5	0.11	<7	2.6
Tapper	1	4/22/80	13	430	430	-	<5	0.18	<7	1.6
Tapper	2	4/23/80	45	435	435	0.3	-	-	-	5.4
Tapper	2	4/23/80	49	430	430	-	<5	0.28	<7	3.9
Tapper	2	4/23/80	47	422	422	-	<5	0.04	<7	3.4
Spoutman	1	4/22/80	8	450	450	-	<4	0.03	<7	0.9
Spoutman	2	4/23/80	41	430	430	2.5	-	-	-	3.7
Spoutman	2	4/23/80	42	429	429	-	<5	0.01	9	3.1
Reverbman	1	4/22/80	14	415	415	0.2	-	-	-	1.0
Reverbman	1	4/22/80	15	410	410	-	<5	0.05	<7	1.3
Reverbman	2	4/23/80	57	214	214	-	<9	0.25	<14	3.7
Arch-Blower	1	4/22/80	11	440	440	-	<5	0.07	<7	3.2
Arch-Blower	1	4/22/80	17	420	442	0.4	-	-	-	1.6
Lunch Room Area Sample	1	4/22/80	24	435	435	0.06	-	-	-	0.04
Lunch Room Area Sample	1	4/22/80	25	435	435	-	<5	0.02	<7	0.04
Lunch Room Area Sample	2	4/23/80	53	438	438	0.17	-	-	-	0.04
Lunch Room Area Sample	2	4/23/80	54	438	438	-	<5	0.01	<7	0.3

TABLE 2

CONVERTER DEPARTMENT
ARSENIC, CADMIUM, COPPER, LEAD AND SULFUR DIOXIDE
AIR CONCENTRATIONS

Magma Copper Company
San Manuel Arizona
HHE 80-32

JOB	SHIFT	DATE	SAMPLE #	SAMPLE TIME (minutes)	SAMPLE VOLUME (liters)	TIME WEIGHTED AVERAGES				
						Arsenic ug/m^3	Cadmium ug/m^3	Copper mg/m^3	Lead ug/m^3	Sulfur Dioxide PPM
Craneman	1	4/22/80	96	417	417	-	< 5	0.01	< 7	1.8
Craneman	1	4/22/80	05	423	423	-	< 5	0.01	< 7	0.5
Craneman	2	4/23/80	100	462	462	-	< 4	0.01	9	8.0
Craneman	2	4/23/80	119	441	441	-	< 4	< 0.01	< 7	0.7
Inside crane	1	4/22/80	81	130	130	0.19	-	-	-	-
Inside crane	2	4/23/80	109	427	427	0.06	-	-	-	7.9
Inside Crane	2	4/23/80	90	428	428	0.22	-	-	-	7.8
Heavy Equipment Operator	1	4/22/80	104	458	458	-	< 4	< 0.01	< 7	0.1
Heavy Equipment Operator	2	4/23/80	92	443	443	-	< 4	0.36	11	3.6
Skimmer Converter #6	1	4/22/80	113	425	425	-	< 5	0.12	21	2.4
Skimmer Converter #4	1	4/22/80	88	439	439	0.22	-	-	-	1.3
Skimmer Converter #3	1	4/22/80	87	442	442	-	< 4	0.05	11	1.1
Skimmer Converted #1	1	4/22/80	86	461	461	-	< 4	0.06	< 6	0.8
Skimmer Converter #1	2	4/23/80	83	460	460	0.14	-	-	-	3.1
Skimmer Converter #4	2	4/23/80	107	457	457	-	< 4	< 0.01	9	0.53
Skimmer Converter #3	2	4/23/80	99	466	466	-	< 4	0.26	30	4.2
Skimmer Converter #6	2	4/23/80	112	453	453	-	< 4	0.17	9	14.4

TABLE 2 (cont.)

JOB	SHIFT	DATE	SAMPLE #	SAMPLE TIME (minutes)	SAMPLE VOLUME (liters)	TIME WEIGHTED AVERAGES				
						Arsenic ug/m^3	Cadmium ug/m^3	Copper mg/m^3	Lead ug/m^3	Sulfur Dioxide PPM
Puncher Converter #6	1	4/22/80	85	437	437	0.07	-	-	-	3.2
Puncher Converted #3	1	4/22/80	94	423	423	-	< 5	0.33	< 7	0.6
Puncher Converter #4	1	4/22/80	84	418	418	-	< 5	0.03	< 7	0.8
Puncher Converter #1	1	4/22/80	102	413	413	1.26	-	-	-	0.7
Puncher Converter #1	2	4/23/80	82	460	460	-	< 4	0.02	< 6	5.0
Puncher Converter #3	2	4/23/00	108	453	453	-	< 4	0.06	9	4.2
Puncher Converter #6	2	4/23/80	117	442	442	-	< 4	0.07	9	5.1
Puncher Converter #4	2	4/23/80	118	453	453	0.31	-	-	-	10.8
Laborer	1	4/22/80	93	435	435	-	< 5	0.3	< 7	1.5
Laborer	2	4/23/80	114	403	403	-	< 5	0.35	32	2.4
Maintenance Foreman	1	4/22/80	103	423	423	-	< 5	0.03	9	0.6
Department Head Foreman	1	4/22/80	98	399	399	-	< 5	0.02	< 7	0.5
Foreman	2	4/23/80	101	440	440	-	< 4	0.09	9	5.8

TABLE 3
REVERBATORY AND CONVERTER DEPARTMENT WORKERS
BLOOD LEAD CONCENTRATIONS

MAGMA COPPER COMPANY
San Manuel, Arizona
HHE 80-32

(The following numbers are milligrams of lead per 100 parts of blood)

Reverbmen Reverb.)	Slagmotormen (Reverb.)	Tappers (Reverb.)	Charge Ops. (Reverb.)	Sub Charge Ops. (Reverb.)	Feedermen (Reverb.)	Cranemen (Convert.)	Skimmers Convert.)	Punchers (Convert)	Dept. Laborer (Convert.)	Equip. Ops. (Convert.) (
15	16	14	17	16	14	13	12	19	18	22
20	22	12	9	10	16	19	20	25	15	11
13	14	15	15	13	13	12	24	16	13	12
13	21	15			17	19	18	18	16	15
12	12	11			15		15	16	19	
16	16	13			14		13	14	13	
	18	19			16		17	17		
	15	17			10		19	12		
	9	9			8					
	14	13			11					
	16	11								
	13	14								
	14	22								
	8									

TABLE 4

REVERBATORY AND CONVERTER DEPARTMENT WORKERS
URINE ARSENIC CONCENTRATIONS
UG ARSENIC/LITER URINE
MAGMA COPPER COMPANY
San Manuel, Arizona
HHE 80-32

Reverbmen (reverb.)	Sub Charge Optr.(reverb.)	Charge Optr (reverb)	Feederman (reverb)	Tappers (reverb)	Slagmotormen (reverb.)
29	3	35	65	24	49
31	48	31	29	13	33
20	29	27	21	31	36
20			32	5	61
20			12	26	38
17			31	36	19
			25	47	18
			12	32	24
			26	12	710
			11	26	13
			22	330	43
				55	28
				35	26
					15

Converter Operator	Cranemen Converter	Equip. Optr. (converter)	Punchers (converter)	Skimmers (converter)
23	14	35	22	37
11	22	24	7	15
29	75	6	23	22
29	13	7	35	28
27			11	13
26			45	16
			16	12
			17	12
			20	13
			710	23
			12	19
				25

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