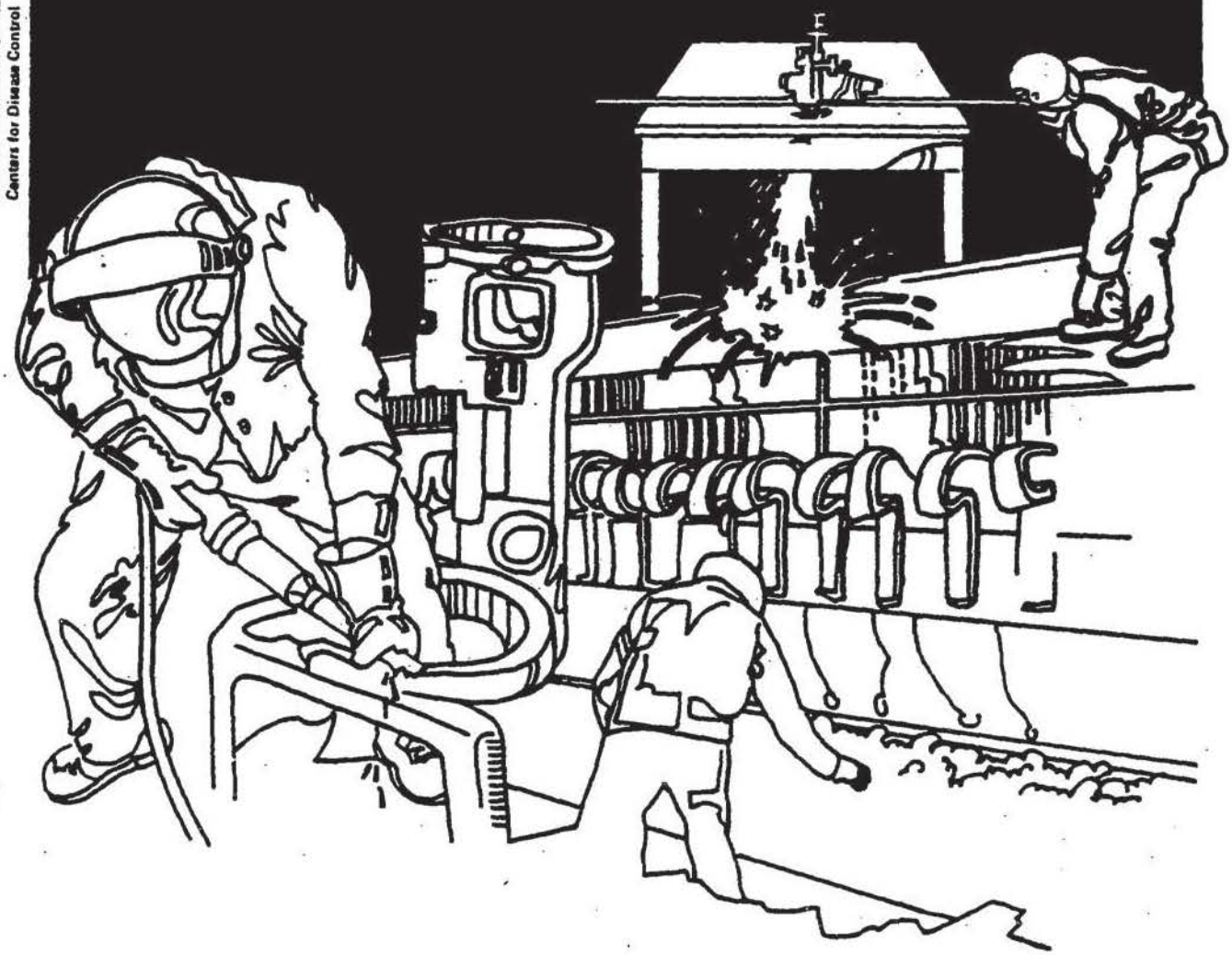
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 84-384-1580
CRYSTAL ZOO
BOULDER, 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.

HETA 84-384-1580
APRIL 1985
CRYSTAL ZOO
BOULDER, COLORADO

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I. SUMMARY

In August 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from plant management at the Crystal Zoo, Boulder, Colorado to evaluate exposures to lead and other substances among workers grinding, polishing, and gluing leaded glass crystal art objects.

On August 21 and 22, 1984, an environmental and medical evaluation was conducted by NIOSH investigators. The environmental evaluation consisted of breathing zone measurements for 1-1-1-trichloroethane, toluene, petroleum distillate, lead, quartz, cristobalite, and total particulate. Eight-hour time weighted noise measurements were also performed.

All environmental measurements were well below the evaluation criteria except lead. Five out of six lead samples exceeded the NIOSH evaluation criteria of 0.05 mg/M^3. The average of all six lead samples was 0.06 mg/M^3. Lead values range from 0.03 to 0.08 mg/M^3. Time weighted eight hour noise level measurements did not show any overexposures in the grinding department.

Medical monitoring and evaluation consisted of blood lead and free erythrocyte protoporphyrin (FEP) determinations on eight of nine workers in the leaded crystal grinding room. Medical questionnaires were completed on all eight workers. There were no excessive blood leads (over 40 ug/dl) and no evidence of lead toxicity was found in the medical histories. The mean blood lead value in the grinding department was 29.1 ug/dl--range 22-36 mg/dl.

On the basis of the environmental data, NIOSH determined that a health hazard existed from over-exposures to lead in the grinding department. Recommendations that can help eliminate this hazard are included in this report.

KEYWORDS: SIC 3229 (Pressed and blown glass and glassware), lead, silica (quartz, cristobalite), 1-1-1-trichloroethane, toluene, petroleum distillate

II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request in August, 1984 from the management of the Crystal Zoo, Boulder, Colorado to evaluate lead exposures among workers sanding and polishing leaded crystal. The request was prompted by concern for workers' health rather than the presence of illness. Other potential exposures, such as silica, 1-1-1-trichloroethane, toluene, and petroleum distillates also existed and were added to the evaluation. These substances are used in polishing, gluing, and assembly of the lead crystal art objects.

Results of all medical and environmental monitoring were discussed with management and workers in October, 1984.

III. BACKGROUND

This facility receives leaded crystal from a European firm; this crystal contains about 40 percent lead by weight. The crystal is cut, ground, and polished into various art objects. Pieces of the leaded crystal are glued together and are then shipped to various distribution centers. All phases of the process were evaluated.

IV. EVALUATION DESIGN & METHODS

A. Environmental

Free crystalline silica samples were collected on pre-weighted FWSB filters and analyzed using NIOSH method 7500. 1-1-1-trichloroethane, toluene, and petroleum, distillates were collected on organic vapor charcoal sampling tubes and analyzed using NIOSH method 127.

Lead samples were collected on 37mm AA filters and analyzed using NIOSH method 7082. Noise measurements were made with a direct reading instrument.

B. Medical

All workers and supervisors in the grinding room and cleaning room (propane torches) were interviewed for work history and medical problems. Most consented to have blood drawn for blood lead and free erythrocyte protoporphyrin (FEP) determination. Three additional workers were recruited from the gluing areas to have histories and blood work done for no lead exposure comparisons.

Blood lead determinations were done using anodic stripping voltammetry.

VI. EVALUATION CRITERIA & TOXICOLOGY

A. Environmental

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assesment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards by contrast are based solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

	Environmental Exposure Limits 8-Hour Time-Weighted Average (TWA)	
	mg/M3	
Lead	0.05	(NIOSH/OSHA)
1-1-1-Tricholoroethane	1900	(ACGIH) (NIOSH/OSHA)
Toluene	375	(ACGIH) (NIOSH/OSHA)
Petroleum distillate	*	
(Quartz) free crystalline silica	.1	(ACGIH)
(Cristobalite) free crystalline silica	.05	(ACGIH)
Total particulate (respirable)	5.0	(ACGIH) (OSHA)
Noise 8 hr. (TWA)	85	(ACGIH/NIOSH)

mg/M^3 = milligrams of substance per cubic meter of air.
*No evaluation criteria available

B. Medical

Blood lead levels below 40 ug/dl 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/dl. Lead levels between 40-60 ug/dl in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/dl represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/dl are considered dangerous and often require hospitalization and medical treatment.

The Occupational Safety and Health Administration (OSHA) standard[1] for lead in air is 50 ug/M^3 calculated as an 8-hour time-weighted average for daily exposure. The standard also dictates that workers with blood lead levels greater than 60 ug/100g whole blood (1 ug/deciliter is roughly equivalent to 1 ug/100g whole blood) must be immediately removed from further lead exposure if confirmed by a follow-up test, and workers with average lead levels of 50 ug/100g or greater must also be removed. Removal is also possible on medical grounds. Removed workers have protection for wage, benefits, and seniority for up to 18 months until they can return to lead exposure areas.

Free erythrocyte protoporphyrin (FEP) levels of 16-50 ug/dl are considered within the normal range. Elevations can be due to interference with hemoglobin production caused by excessive lead exposure, anemia, and to a few other less likely diseases. Lead in increased levels leads to increased levels of FEP in the red cells. Because this occurs at the time the red cell is being formed, and once formed the red cell lasts about 120 days, the FEP gives an indication of average lead exposure over the past 3-4 months. This relationship is not particularly evident until elevated FEP levels are found.

C. Toxicological

Lead[3,4] - Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

1-1-1-Trichloroethane is a colorless liquid with a mild odor similar to chloroform. Trichloroethane may enter the body by inhalation of the vapors, ingestion, and absorption through the skin. Exposure to 1-1-1-trichloroethane may cause central nervous system depression, liver, and heart effects. Human subjects exposed to 900-1000 ppm for 20 minutes have experienced lightheadedness, uncoordination, impaired equilibrium and transient eye irritation. A few scattered reports have indicated mild kidney and liver injury from severe exposure. Skin irritation has occurred from occupational contact. A number of human fatalities related to industrial exposure in closed spaces have been reported. 20,000 ppm for 60 minutes is expected to produce coma and possible death.[5]

NIOSH is currently recommending an action level of 200 ppm for classifying "inhalation exposure" to 1-1-1-trichloroethane. When in excess of this level, personnel should be warned of possible congenital abnormalities.[6] In current Intelligence Bulletin #27, NIOSH has suggested that 1-1-1-trichloroethane be treated in the workplace with caution because of its chemical similarity to four other chloroethanes shown to be carcinogenic in laboratory animals.

Toluene presents a health hazard by inhalation, absorption, and ingestion. It causes irritation of eyes, nose, and skin. It also produces fatique, weakness, confusion, headache, dizziness, and drowsiness. Very high levels can cause death. Chronic exposures may cause liver and kidney damage. Maintaining levels below 375 mg/M^3 should protect a worker from any harmful effects.[7]

Petroleum distillates - This is usually an aliphatic hydrocarbon with relatively low toxicity. It can cause defattying dermatitis. It does not normally cause liver or kidney damage. It is very similar to Stoddard solvent which has a standard of 1800 mg/M^3.

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 non-periodic, 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 hour working day, 40 hour work week. 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 on-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.

Respirable Particulate - Exposures to respirable particulate may cause unpleasant deposits in the eyes and nasal passages. Some respirable problems due to deposition in the lungs may also occur.

Noise,[8] commonly defined as unwanted sound, covers the range of sound which is implicated in harmful effects. Noise can be classified into many different types, including wide-band noise, narrowband noise, and impulse noise. To describe the spectrum of a noise, the audible frequency range is usually divided into eight frequencybands, each one-octave wide, and sound pressure level (SPL) measurements are made in each band using a special sound level meter. A wide-band noise is one where the acoustical energy is distributed over a large range of frequencies. Examples of wide-band noise can be found in the weaving room of a textile mill and in jet aircraft operations.

Narrow-band noises, with most of their energy confined to a narrow range of frequencies, normally produce a definite pitch sensation. For a true narrow-band noise, only a single octave band will

contain a significant SPL. The noise caused by a circular saw, planer, or other power cutting tools is occasionally of the narrow-band type, but usually there is some spreading of the acoustic energy to several of the octave bands. The impulse type of noise consists of transient pulses occurring in repetitive or non-repetitive fashion. The operation of a rivet gun or a pneumatic hammer usually produces repetitive impulse noise. The firing of a gun is an example of non-repetitive impulse noise.

Exposure to intense noise causes hearing losses which may be temporary, permanent, or a combination of the two. These impairments are reflected by elevated thresholds of audibility for discrete frequency sounds, with the increase in dB required to hear such sounds being used as a measure of the loss. Temporary hearing losses, also called auditory fatique, represent threshold losses which are recoverable after a period of time away from the noise. Such losses may occur after only a few minutes of exposure to intense noise. With prolonged and repeated exposures (months or years) to the same noise level, there may be only partial recovery of the threshold losses, the residual loss being indicative of a developing permanent hearing impairment.

VII. RESULTS AND DISCUSSION

A. Environmental

On August 21 and 22, 1984, NIOSH performed an environmental and medical evaluation. The environmental investigation consisted of time-weighted average (TWA) measurements of lead, 1-1-1-trichloroethane, toluene, petroleum distillate, free crystalline silica, total respirable particulate, and noise. Results are presented in Tables I, II, and III. Five of six lead samples exceeded the evaluation criteria. The average lead level was 0.05 mg/M^3. Only trace quantities of 1-1-1-trichloroethane, toluene, and petroleum distillate were observed. Free crystalline silica was not present in any of the breathing zone or bulk samples. The total respirable nuisance dust exposure was very low--a high of 2.5 mg/M^3 and a low of 0.1 mg/M^3. The average for the seven samples was 0.56 mg/M^3. Noise measurements were all less than 85 dBA for the 8 hour TWA.

B. Medical

Nine (9) workers were included from the grinding room. Of these, blood was obtained on eight. One worker had only been in the grinding room for two days. His laboratory results, which were in a range similar to unexposed workers, are excluded from the analysis, leaving seven (7) lead exposed workers with laboratory work.

Four (4) workers working with the propane torches were included in the study. Of these, two had laboratory work. Interviewing revealed that the flaming of glass to produce small parts involved

pyrex glass rather than high lead crystal. Blood leads on the flame workers were in the same range as the unexposed workers who glued. Therefore, the flame workers were included in the unexposed group to give a total of five (5) unexposed workers who had laboratory work.

The comparison of the lead exposed grinders and the unexposed workers is shown in Table IV. The grinders did show a statistically significant increase in blood lead level over that found in the unexposed workers (mean blood lead of 29.1 ug/dl vs. 7.2 ug/dl). Considering that most of the grinders had over 2 years of exposure and their predicted leads were close to the actual levels found (mean difference 0.7 + 4.7 ug/dl), it appears unlikely that any workers will suffer from lead toxicity from current exposure levels. However, the difference in blood lead level between grinders and unexposed workers shows that the grinders are getting some lead exposure. Further, the average blood lead level among grinders is at the upper limit of levels acceptable for pregnant women whose fetus needs protection. Thus, reducing lead exposure is desirable so both men and women can have equal opportunity to work in the area without concern for effects on possible pregnancies.

Review of the medical questionnaires did not suggest problems from lead exposure. The only complaint in the grinding room concerned noise. Two flame workers complained of nasal irritation, drying, and sneezing. Another complained of eye irritation. The gluers had problems with their faces breaking out, but observed that use of the face shields (as opposed to safety goggles) helped considerably.

VIII. CONCLUSIONS

Based on environmental levels of lead, a health hazard existed at the time of this survey. The work force in the grinding room appears stable, allowing one to infer that the lack of excessive blood lead and FEP levels indicates that environmental lead levels are usually not excessive. However, lead exposure is sufficient to be of concern, particularly if any pregnant women were to be working in the area. No evidence of lead toxicity was found in the medical histories.

IX. RECOMMENDATIONS

1. Because there is some lead exposure in the grinding room, it is important that work practices to reduce likely lead exposure be followed faithfully, particularly keeping food and smoking material out of the work area and anywhere else which might be contaminated with lead containing dust. This will be particularly important if any women of child bearing age should be assigned to the grinding room.

2. No dry grinding or polishing of the leaded glass should be permitted.

3. Down draft ventillation should be installed on all the grinding stations.

X. REFERENCES

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5. NIOSH Current Intelligence Bulletin #27, Chloroethanes: Review of Toxicity, DHEW No. 78-181, August 1978.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 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 NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Crystal Zoo, Boulder, Colorado
2. U.S. Department of Labor/OSHA, Region VIII
3. NIOSH, Region VIII
4. Colorado Department of Health

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

TABLE I

Breathing Zone and General Room Air Concentrations of Lead
at the Crystal Zoo, Boulder, Colorado

August 21-22, 1984

Sample #	Job	Sampling Time	mg/M^3 Lead
21	grinder	6:50 - 2:15	0.06
20	grinder	6:48 - 2:12	0.06
22	general room	7:12 - 2:12	0.07
23	general room	6:58 - 2:15	0.08
1	grinder	7:00 - 2:07	0.03
2	grinder	7:00 - 2:08	0.06
Evaluation criteria			0.05

Laboratory limit of detection mg/filter .003

TABLE II

Breathing Zone Air Concentrations of 1-1-1-Trichloroethane, Toluene, and Petroleum Distillate at the Crystal Zoo, Boulder, Colorado

August 21, 1984

Sample #	Job	Sampling Time	mg/M^3 1-1-1-trichloroethane	Toluene	Petroleum Distillate
01	gluer	7:15 - 10:00	8.5	*	*
02	gluer	7:15 - 10:00	8.5	*	*
03	gluer	7:21 - 10:00	10.7	*	*
04	gluer	7:22 - 10:00	9.7	*	*
05	inspector	7:25 - 10:00	9.7	*	*
06	assembler	7:28 - 8:30	3.2	25.8	*
07	assembler	8:30 - 10:30	13	*	*
08	gluer	10:15 - 1:50	4.2	*	*
09	gluer	10:15 - 2:00	4	*	*
11	gluer	10:15 - 1:57	11.3	*	*
12	gluer	10:15 - 1:52	4.6	*	*
13	gluer	10:15 - 1:00	7.8	*	*
50	gluer	7:03 - 7:35	*	181	114
51	gluer	7:07 - 9:45	2	*	*
52	gluer	7:10 - 9:45	2	*	*
53	gluer	7:10 - 9:45	4.4	*	*
56	gluer	9:45 - 12:30	5.3	*	*
57	gluer	9:45 - 12:30	2	*	*
58	gluer	9:45 - 12:20	2	*	*
Evaluation criteria			1900	375	*
Laboratory limits of detection mg/tube			0.01	0.01	0.1

*No available standard

TABLE III

Breathing Zone and General Room Air Concentrations of
Crystalline Silica (Quartz, Cristobalite) and Total Particulate
at the Crystal Zoo, Boulder, Colorado

August 21, 1984

Sample #	Job	Sampling Time	mg/M^3 Quartz	mg/M^3 Cristobalite	mg/M^3 Total Particulate
FB-984	grinder	7:05 - 2:05	*	*	0.5
FB-2092	gen. room	6:54 - 2:12	*	*	0.2
FB-1030	grinder	6:56 - 1:40	*	*	2.5
FB-982	grinder	6:57 - 2:12	*	*	0.2
FB-2094	grinder	6:52 - 2:02	*	*	0.1
FB-2090	grinder	7:05 - 9:48	*	*	0.1
FB-1033	grinder	6:52 - 2:15	* (1)0.1	* (1)1.05	0.3 / 5
Laboratory limit of detection mg/sample			0.015	0.015	0.01

(1)Notice of intended changes 1984-85 - ACGIH, TLV

TABLE IV

Age, Months Grinding, Blood Lead and Free Erythrocyte Protoporphyrin (FEP) by Grinding Exposure of over 1 Week

The Crystal Zoo
Boulder, Colorado

August 22, 1984

		Grinding * Department	Non-Exposed Workers	Total
Number		7	5	12
Men		7	2	9
Women		0	3	3
Age	Mean	24.9	22.4	23.8
	Standard Deviation	+ 2.9	+ 2.9	+ 3.0
	Range	21 - 30	18 - 25	18 - 30
Months Grinding				
	Mean	28.9	0	---
	Standard Deviation	+ 7.6		
	Range	20 - 42		
Blood Lead (ug/dl whole blood)				
	Mean	29.1	7.2	20.0
	Standard Deviation	+ 5.2	+ 4.3	+ 12.2
	Range	22 - 36	2 - 13	2 - 36
	Normal			less than 40
Statistical Significance:				
Student t, 2-tailed (10 degrees of freedom)				7.687
Probability of Chance Occurance				less than 0.001
FEP (ug/dl whole blood)				
	Mean	31.4	21.6	27.3
	Standard Deviation	+ 14.0	+ 4.2	+ 11.8
	Range	17 - 53	18 - 28	17 - 53
	Normal			16 - 50

* One grinder with only two days' exposure is omitted.

ug/dl whole blood = micrograms/deciliter whole blood = ug/cubic centimeter (cc)