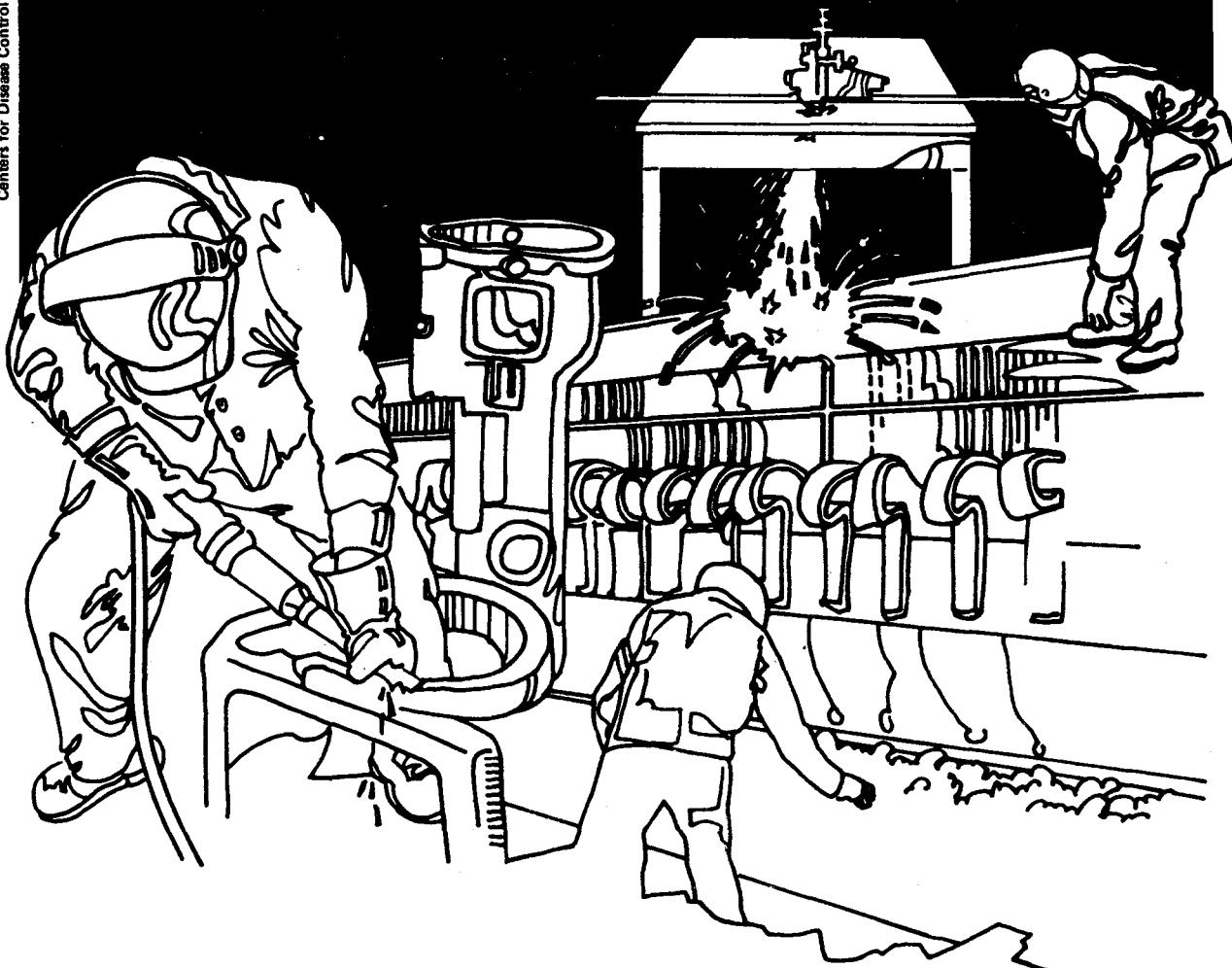


NIOSH



# Health Hazard Evaluation Report

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HETA 80-101-1157  
CINCINNATI ZOO  
CINCINNATI, OHIO

## 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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TA 80-101-1157  
AUGUST 1982  
CINCINNATI ZOO  
CINCINNATI, OHIO

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I. SUMMARY

During August - October 1980, the National Institute for Occupational Safety and Health (NIOSH), at the request of the Cincinnati Department of Health, investigated exposures to silica among employees who clean bird cages at the Cincinnati Zoo. The investigation also included an epidemiological analysis of an apparently high rate of positive tuberculin (TB) skin tests among zoo employees.

To determine if there was significant exposure to either respirable dust or silica during the cleaning of the sand-covered floor of the bird cages, NIOSH collected personal and area air samples. Respirable dust and free silica concentrations ranged from 1.7 to 2.1 mg/m<sup>3</sup> and 0.32 to 0.60 mg/m<sup>3</sup>, respectively. Since exposure periods were relatively short (70-90 minutes), 8-hour time-weighted-average (TWA) levels were calculated assuming no exposure the rest of the day. Using this procedure, 1 of the 4 samples (0.36 mg/m<sup>3</sup>) for respirable dust exceeded the Occupational Safety and Health Association (OSHA) standard (0.29 mg/m<sup>3</sup>) and 3 of the 4 free silica samples (ranging up to 0.1 mg/m<sup>3</sup>) exceeded the NIOSH recommended standard of 0.05 mg/m<sup>3</sup>.

NIOSH also administered questionnaires to zoo employees and reviewed both zoo and county TB skin test records. Seven (16%) of the 45 current non-office employees had converted from a negative to a positive skin test since 1975; three others had a positive initial skin test. There was no evidence of TB among animals in recent years, but two former employees had active tuberculosis while working at the zoo. The epidemiologic information suggested that person-to-person transmission of infection may have occurred during noon-time socializing at an old maintenance building.

Exposure to silica-containing dust during the cleaning of bird cages is infrequent and of short duration. However, due to the potentially high air concentrations of respirable free silica, measures should be instituted to reduce exposures. On the basis of the questionnaires and TB skin test records, NIOSH determined that although there was a cluster of TB infections among zoo employees, and that although person-to-person transmission apparently occurred at the zoo, this was not an occupational health problem per se. Recommendations for avoiding excessive exposure to crystalline silica and for improving the TB surveillance program (intended primarily for the protection of susceptible animals) are included in Section VIII of this report.

KEYWORDS: SIC 8421 (Arboreta, Botanical, and Zoological Gardens), crystalline silica, tuberculosis, TB skin test

**II. INTRODUCTION**

On August 1, 1980, NIOSH received a request from the City of Cincinnati, Department of Health, Division of Professional Services, to evaluate possible exposures to silica dust and bird droppings among employees who clean bird cages at the Cincinnati Zoo. On August 12 and September 2, 1980, NIOSH conducted walk-through inspections of the bird cage areas, interviewed zoo personnel, and reviewed pertinent health records. Follow-up visits were made on September 17, and October 3, 1980 and January 15, 1981 to collect environmental data and additional medical information. Interim reports summarizing the initial environmental and medical findings, were forwarded to management and labor representatives in December 1980 and March 1981.

**III. BACKGROUND**

The Cincinnati Zoo occupies approximately 65 acres of land and has 5,000 animals on year-round display. It is divided into approximately 12 areas on the basis of type of animal or habitat. Each area has one head keeper and 2-5 keepers. There is also a number of support service areas including: (1) a commissary, where all animal food is prepared; (2) a nursery, housing infant animals; and (3) an exhibit area, where artificial rocks and other materials are made. At the time of the NIOSH survey there were 50 bookkeeping and maintenance employees and 22 administrative and educational personnel employed at the zoo. The aviary area, where approximately six workers are assigned, was the area of initial concern in this evaluation.

During the initial site visit, employees in the aviary area expressed concern about potential dust problems while cleaning the bird cages. The sand-covered floors of the bird cages were swept by broom to remove bird droppings and debris. The materials from the sweepings were scooped into a 14" by 14" screened-bottom shaker box and shaken to separate the sand and debris, the remaining contents were dumped into a waste container for removal and the treated or cleaned sand was then distributed throughout the cage in an effort to create a natural habitat for the birds. While the cages were being swept, visible clouds of dust were noted on several occasions. Only one worker was seen wearing respiratory protection during cleaning procedures.

Zoo employees also expressed concern about positive tuberculin (TB) skin tests among workers. On the basis of discussions with the zoo curator, zoo veterinarian, and county Tuberculosis control officials, NIOSH learned that the zoo and the Hamilton County Tuberculosis Control Office conduct an annual TB screening program among zoo workers for the protection of susceptible animal populations,. Sporadic screening began in 1974. A systematic annual screening program was initiated in 1976. Subsequently, the county has conducted routine pre-employment and annual TB screening tests during April of each year.

Nurses administer a 0.1 cc intradermal dose of intermediate strength purified protein derivative (PPD) to all employees at the zoo. In 72 hours, the nurses return to read the tests and to administer tests to workers who were absent during the initial testing. Tests showing 10 mm or more induration are read as positive, reported to zoo officials and individual workers, and recorded in the county's TB files. Indurations of less than 4 mm are read as negative. Indurations of 5-9 mm are read as doubtful and repeated in six weeks. Follow-up medical evaluation of positive individuals is conducted by the county or by the individual's personal physician at his/her option. The county's evaluation includes a chest X-ray to detect primary active disease. There is apparently no epidemiologic follow-up.

IV. METHODS

A. Environmental

During September, October, and November 1980 and January 1981 personal and area air samples were collected to determine if significant respirable dust or silica exposure existed as a result of cleaning the bird cages. Airborne samples were collected on 37-mm poly vinyl chloride (PVC) membrane filters held in plastic field monitoring cassettes. Sampling pumps calibrated at 1.7 and 9.1 liters per minute (Lpm) were used to draw air through the cyclone filtered cassettes. The monitoring cassettes used for personal sampling were attached to the worker's uniform (in his breathing zone) and connected via tygon tubing to a 1.7 Lpm vacuum pump. Additionally, samples were placed at various locations throughout the bird cages. These samples were collected in a manner similar to the personal sampling methods, except that, the pumps were operated at 9.1 Lpm. Analyses of all silica samples were conducted by NIOSH Method P & CAM 259.1. Total and respirable dust exposures were determined gravimetrically.

B. Medical

On September 17, NIOSH administered a questionnaire to all available zoo employees. The questionnaire included questions concerning respiratory symptoms, occupational exposures, PPD test results, recent chest X-rays, and medications for tuberculosis. NIOSH subsequently reviewed and abstracted the zoo and county TB records for PPD test and chest X-ray results on all present and former zoo employees. On October 3, NIOSH administered a second questionnaire to workers identified from the first questionnaire or record review as having a positive PPD. The questionnaire was also administered to a control group that we attempted to match for comparable duration of employment. Questions covered job history at the zoo, social activities at work, social relationships with other employees, and family history of TB and positive PPDs. The hypothesis of this case-control study, based on information

obtained during the course of the investigation, was that presence at noon-time social gatherings in an old maintenance building was a risk factor for developing a positive TB skin test.

**V. EVALUATION CRITERIA**

**A. Crystalline Silica**

Silicosis<sup>2</sup> is a lung disorder caused by the repeated inhalation of crystalline silica particles. Occupational activities in which silicosis has historically occurred include mining, quarrying, tunnelling, sandblasting, foundry work, pottery making, and refractory products manufacturing. The characteristic lesions of silicosis are fibrotic nodules in the lungs. Unless exposure is extremely intense, several years of exposure usually precede any evidence of the disease. In its early stages, silicosis is manifested by the appearance on the chest X-ray of small rounded opacities, usually appearing first in the upper lung zones. It is not until the advance stages that substantially diminished lung capacity and shortness of breath occur, although a slight decrease in lung capacity has been demonstrated epidemiologically to occur earlier, even prior to X-ray changes.<sup>3,4</sup> Silicosis increases the risk of pulmonary tuberculosis in the event of exposure to the infectious organism.<sup>2,5</sup> NIOSH recommends that exposure to respirable crystalline silica not exceed a full-shift time-weighted average of 50 ug/m<sup>3</sup>.<sup>6</sup> The OSHA standard for respirable silica dust is calculated using the following equation:

$$\text{Respirable dust standard} = 10 \text{ mg/m}^3$$

$$\frac{\% \text{SiO}_2 + 2}{}$$

Where % SiO<sub>2</sub> is the percent free silica in the respirable dust

**B. Tuberculosis<sup>5</sup>**

Tuberculosis is a disease caused by the micro-organism Mycobacterium tuberculosis (or, rarely in the United States, M. bovis). Active disease develops in a minority of people infected. The lungs are the most common site of active disease. A positive skin test indicates infection, but not necessarily active disease. Treatment with antituberculosis drugs is appropriate for persons with active disease and for some persons whose only evidence of current infection is a positive skin test. The decision to use medication in the latter case is based on age (which affects risk), whether the infection is known or suspected to be recent, whether there was previous untreated or inadequately treated active disease, and whether there are other medical conditions that either increase susceptibility to tuberculosis or increase the risk of an adverse reaction to the drug.

VI. RESULTS

A. Environmental

The results of the personal samples for respirable dust and silica are presented in Tables 1 and 2. Respirable dust concentrations were found to range from 1.7-2.1 mg/m<sup>3</sup>, and free silica concentrations ranged from 0.32-0.60 mg/m<sup>3</sup>. Exposure periods during this study were relatively short (70-90 minutes). Because the evaluation criteria are based on full-shift TWA concentrations, the TWA levels were calculated for comparison purposes assuming no other dust exposures occurred during the work shift other than those which were measured. The resulting 8-hr. TWA free silica concentrations ranged from non-detectable to 0.1 mg/m<sup>3</sup> with 3 of the 4 samples exceeding the NIOSH recommended standard of 0.05 mg/m<sup>3</sup> (Table I). One of the four samples for respirable dust (October 3) exceeded the OSHA silica standard (Table II). Therefore, even though exposure periods were limited, exposure levels were high and exceeded recommended concentrations for an 8-hr. time period.

Total dust concentrations measured over the sampling periods were 332 mg/m<sup>3</sup> and 341 mg/m<sup>3</sup> (Table 3). On an 8 hr. TWA basis, assuming no other dust exposure, these would represent exposures of 62 mg/m<sup>3</sup> and 64 mg/m<sup>3</sup>. Although the primary concern is respirable silica exposure rather than total dust, the airborne dust concentrations are very high and also exceed nuisance dust exposure criteria which is 15.0 mg/m<sup>3</sup> (OSHA).

Area sample results for September 17 and October 3, 1980 are presented in Table 4.

Little or no ventilation was noted in the small aviary cages. This was evident from observations of dust clouds which, when generated by cleaning (sweeping, screening sand), hung in the air adjacent to the worker's breathing area.

B. Medical

1. Questionnaire Results

The questionnaire was administered to 48 (68%) of the 71 zoo employees. Their mean age was 34 years, and their mean job duration was seven years. The respondents included 24 zoo keepers, who had a mean age of 32 years and a mean job duration of nine years; 14 administrative personnel, who had a mean age of 33 years with a mean job duration of 4 years. The ten garden and maintenance personnel had a mean age of 34 years and a mean job duration of 6.5 years.

Seven (10%) of the 71 workers reported current respiratory symptoms that were not attributable to an obvious cause, i.e., cold, flu, exertion. There was, however, no apparent consistent pattern of symptoms among them. Five (71%) of the seven were smokers, and five reported "hayfever" (seasonal allergies). Only two workers reported fever (one associated with drug therapy; one associated with arm trauma). Seven (10%) workers reported having a positive TB test (mean age 53 years, mean job duration 14 years). Two of these had positive tests prior to working at the zoo. Of the five who reported a positive test after starting work at the zoo, two worked in the bird cage area, two worked in the carnivore house, and one worked in maintenance.

Two of the bird cage workers reported respiratory symptoms (i.e., dyspnea, shortness of breath, productive cough), one reported allergies, and the other reported a positive PPD.

## 2. Analysis of TB Skin Test Data

Review of the TB skin test records maintained by the zoo and by the county health department revealed a high rate of PPD conversion among zoo employees. Seven (16%) of the 45 current, non-office employees had converted from a known negative to a known positive PPD since the start of screening in 1975. Three others with unknown prior PPD status also were positive. Thus, the overall prevalence of skin test positivity was 10/45, or 22%, twice as high as the self-reported prevalence. In addition, five former employees who had worked at the zoo since 1975 also had a positive PPD. All ten PPD-positive current employees had chest X-ray readings of inactive primary TB, and nine received prophylactic drug therapy.

There was a strong association between PPD positivity and age. Employees with a positive PPD tended to be older (mean age 51 years) than those with a negative test (mean age 31 years).

Animal TB was considered as a possible source of TB since caged zoo populations are susceptible to TB. However, review of the zoo's necropsy and other data revealed no cases of TB, no unexplained epidemics, or evidence of TB at necropsy.

From county TB records two former employees with active TB were identified. One was noted to have had an abnormal chest X-ray in 1975 but did not have a positive sputum culture nor receive drug therapy until June, 1976. The other was known by Kentucky TB officials to have TB-positive sputum; this employee was a part-time employee and was not identified by the zoo's TB screening program. Figure 1 shows the period of possible infectivity of these two employees in relation to the detection

of positive PPDs by the screening program. There is an overlap of the cluster of positive skin tests with respect to the duration of exposure to the two cases with active disease, although a majority of skin test conversions occurred before one of the employees began work at the zoo. This suggests that the cluster might have been attributable to person-to-person transmission.

Neither of the employees with active TB were animal handlers, which might explain the absence of TB in the animal population. Both worked in an office in the old maintenance building shared by business and maintenance personnel. This building, directly adjacent to the carnivore house, served as a noontime social center until it was torn down in 1979. Since several "cases" of positive TB skin test occurred in employees working in areas near the old maintenance building, we suspected that the noon-time socializing may have provided a site for person-to-person exposure to TB. While the data from the second questionnaire survey seemed to support this hypothesis (odds ratio for noon-time presence at the old maintenance building: 3.5), the control group was not comparable with respect to either age (38 years vs. 51 for the cases) or seniority (10 years vs. 15.5 for the cases).

The boosting phenomenon<sup>7</sup> may also be a factor in the high rate of PPD positivity in this population. This phenomenon, a change from a negative to a positive skin test unrelated to recent infection with *M. tuberculosis* or *M. bovis*, is due to the effect of repeated skin testing of persons who have had a previous tuberculous infection or infection by one or more of the nontuberculous mycobacteria.

#### VII. SUMMARY AND CONCLUSIONS

Employees who clean bird cages may sometimes be exposed to levels of crystalline silica that exceed both the NIOSH recommended standard and the OSHA standard. These exposures, however, are for periods of 45 minutes to an hour, once or twice a month, and for not more than a few years. At the levels measured, it is unlikely that exposure to crystalline silica under these circumstances constitutes a substantial health hazard, but the possibility should be kept in mind so that any alterations of work patterns or procedures do not inadvertently increase exposure.

NIOSH found no unusual occurrence of respiratory disease at the Cincinnati Zoo. The rate of tuberculin reactivity among zoo keepers at the Cincinnati Zoo, however, was higher than expected. Two former employees with active TB, apparently acquired outside the zoo, may have been a source of person-to-person transmission. Transmission may have occurred in the old maintenance building during noontime socializing.

During the time of the NIOSH study, there was no evidence of either active TB disease in current employees or of current or past active TB in the animal population.

## **VIII. RECOMMENDATIONS**

### **A. Environmental**

1. The most certain and direct method of reducing the potential for overexposure to crystalline silica is to substitute another, less toxic material, such as garnet, ground nut shells, cereal husks, or sawdust.
2. A source of ventilation is greatly needed in the individual bird cages. As noted during the survey, each cage had overhead sky-lights. These sky-lights should be opened to help exhaust and/or disperse the dust. The opening of the sky-lights should also reduce the extreme summer heat generated by the thermal effect of the glass.
3. Until such time when a less toxic material is substituted for the silica sand, disposable dust respirators should be provided as a means of control during routine cleaning operations.
4. Written procedures governing the use of respiratory protection should be established. Such procedures should provide the user with instruction and training as to proper utilization of the respirator and its limitation.

### **B. Medical**

1. Bearing in mind that the primary purpose of the TB screening program is the protection of the animals, the program should be broadened to include all students, volunteers, and part-time workers as well as full-time employees.
2. New employees with a negative PPD test should be re-tested a week later.<sup>7</sup> A change to a positive test identifies a boosting effect and would thus not be misinterpreted, when a positive test occurs a year later, as a conversion caused by a recent tuberculous infection.
3. Employees with negative PPD tests should be re-tested at annual intervals to monitor for conversions. Converters, and persons with initially positive tests (including those manifesting the booster effect), should be medically evaluated for active tuberculosis and treated, therapeutically or prophylactically, as appropriate.<sup>5</sup>

4. PPD test results should be recorded in millimeters of induration to assist in evaluating the influence of boosting and in evaluating questionable positives and conversions.
5. The collective results of all PPD tests in the zoo employees should be filed in a way that facilitates easy retrieval and review for epidemiological purposes.

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Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. 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. Cincinnati Zoo
2. City of Cincinnati, Department of Health
3. NIOSH, Region V
4. OSHA, Region V

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

TABLE 1

Cage Cleaner's Respirable Silica Exposure Levels  
As Compared to the NIOSH Recommended Level\*Cincinnati Zoo  
Cincinnati, Ohio  
TA 80-101

<u>Date</u>	<u>Sampling Period</u> <u>(Minutes)</u>	<u>Respirable Free Silica Concentration</u> <u>mg/m<sup>3</sup></u>	<u>Calculated 8-Hr. TWA Respirable Free Silica Concentration</u> <u>mg/m<sup>3</sup></u>
9/17/80	70	ND	----
10/3/80	82	0.60	0.10
1/15/81	90	0.32	0.06
	90	0.32	0.06

\* NIOSH Recommended 8-Hr TWA is 0.05 mg/m<sup>3</sup>

TABLE 2

Cage Cleaner's Respirable Dust Exposure Levels  
As Compared to the OSHA StandardCincinnati Zoo  
Cincinnati, Ohio  
TA 80-101

<u>Date</u>	<u>Sampling Period (Minutes)</u>	<u>Respirable Dust Concentration (mg/m<sup>3</sup>)</u>	<u>Calculated 8-Hr TWA Respirable Dust Concentration (mg/m<sup>3</sup>)</u>	<u>% Free Silica</u>	<u>Calculated OSHA 8-Hr TWA Respirable Silica Standard (mg/m<sup>3</sup>)</u>
9/17/80	70	N.D.	----	----	----
10/3/80	82	1.8	0.36	33	0.29
1/15/81	90	2.1	0.39	16	0.56
	90	1.7	0.32	19	0.48

\* OSHA Standard Calculated from formula: 
$$\frac{10 \text{ mg/m}^3}{\% \text{ Free Silica} + 2}$$

TABLE 3  
Cage Cleaner's Total Dust Exposure Levels

Cincinnati Zoo  
Cincinnati, Ohio  
TA 80-101

<u>Date</u>	<u>Sampling Period</u> (Minutes)	<u>Total Dust</u> <u>Concentrations</u> (mg/m <sup>3</sup> )	<u>Calculated</u> <u>8-Hr TWA Total Dust</u> <u>Concentration</u> (mg/m <sup>3</sup> )
11/26/80	90	332	62
	90	341	64

OSHA Standard is: 15 mg/m<sup>3</sup>

TABLE 4  
Area Samples Results for Total Dust, Respirable Dust and Silica

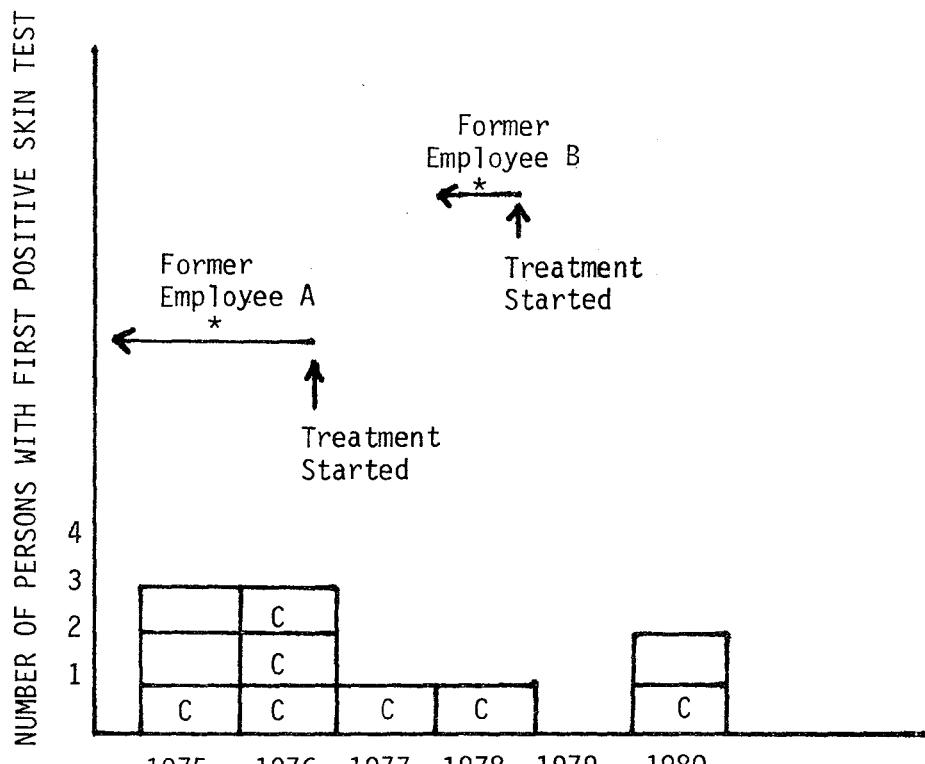
Cincinnati Zoo  
Cincinnati, Ohio  
TA 80-101

<u>SAMPLING DATE</u>	<u>LOCATION</u>	<u>SAMPLING TIME</u> (minutes)	<u>TOTAL DUST</u> (mg/M <sup>3</sup> )	<u>RESPIRABLE DUST</u> (mg/M <sup>3</sup> )	<u>% FREE SILICA</u>	<u>FREE SILICA CONCENTRATION</u> (mg/M <sup>3</sup> )
9/17/80	Various bird cages	88	1.0	---	26	0.26
9/17/80	" " "	70	---	0.08	---	N.D.
9/17/80	" " "	88	---	1.7	38	0.67
10/3/80	Roadrunner cage	16	---	9.4	21	2.0
		16	11.5	---	---	---
10/3/80	Blue-napped mouse cage	38	---	0.82	27	0.22
	" " " "	73	---	1.6	49	0.76
	" " " "	73	4.3	---	---	---
10/3/80	Burrowing owl cage	8	---	2.4	100	2.4
	" " "	8	6.3	---	---	---

FIGURE 1

TIME OF OCCURRENCE OF FIRST POSITIVE TB SKIN  
TEST AMONG CURRENT ZOO EMPLOYEES IN RELATION  
TO POTENTIAL PERIOD OF INFECTIVITY OF TWO FORMER EMPLOYEES

Cincinnati Zoo  
Cincinnati, Ohio  
TA 80-101



CALENDAR YEAR

C Converter = Previous Skin Test Negative

Previous Skin Test Status Unknown

\* These lines represent the period of potential infectivity of active tuberculosis cases (former employees)

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