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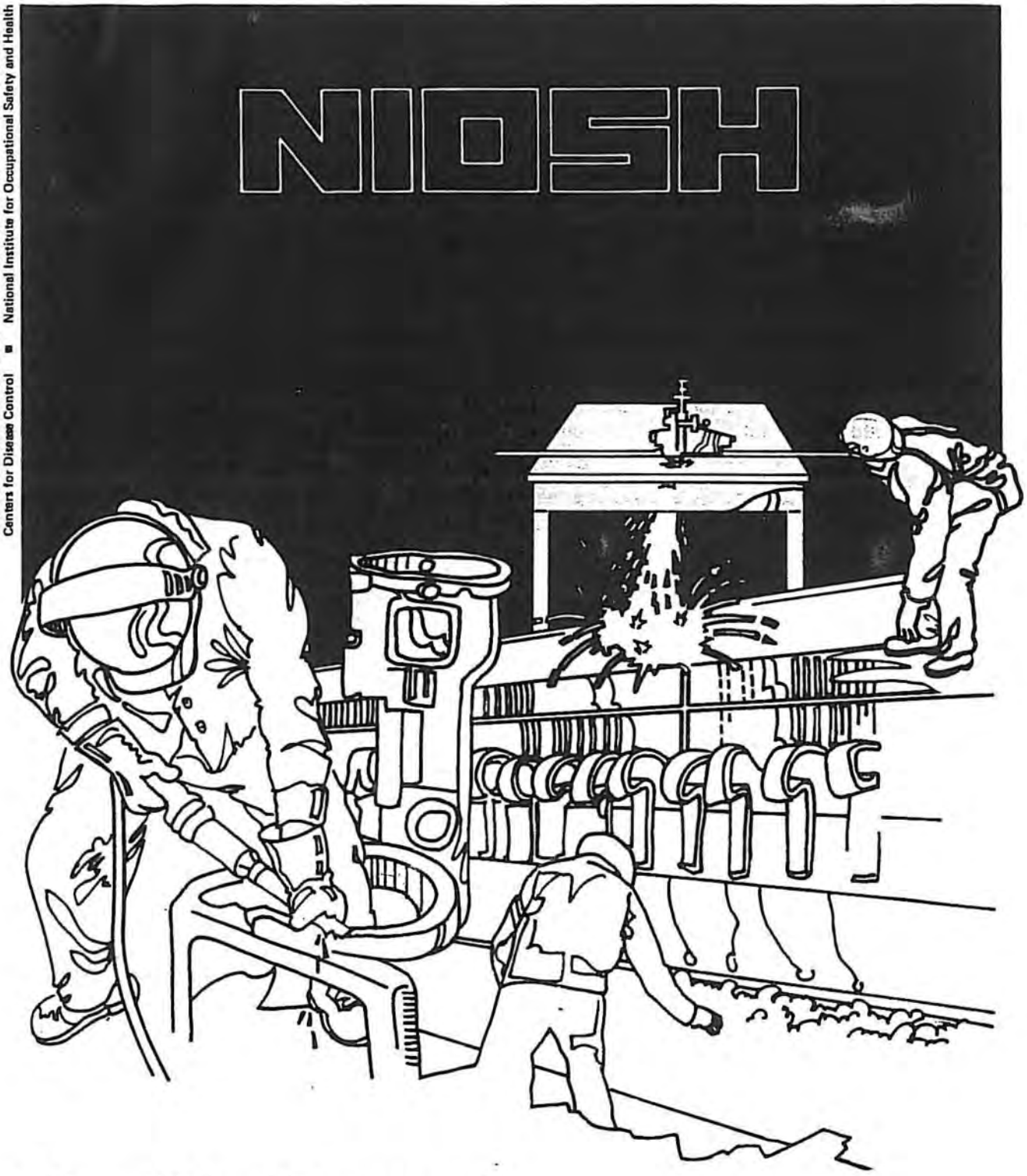

# Health Hazard Evaluation Report

HETA 83-191-1423
NATIONAL ZOOLOGICAL PARK
CONSERVATION CENTER
FRONT ROYAL, VIRGINIA

## 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 83-191-1423
FEBRUARY 1984
NATIONAL ZOOLOGICAL PARK
CONSERVATION CENTER
FRONT ROYAL, VIRGINIA

NIOSH INVESTIGATOR:
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## I. SUMMARY

In March of 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from the facilities manager of the National Zoological Park Conservation Center in Front Royal, Virginia, to evaluate formaldehyde exposures in the newly constructed Small Mammal Building. Formaldehyde was off-gassing from wooden truss rafters inadvertently treated with an exterior, rather than interior, chemical process to make them fire retardant. The building was closed for more than two weeks prior to sampling to measure "worst case" conditions. Samples collected on April 20, 1983, found airborne formaldehyde levels ranging from 0.11 to 0.43 parts per million (ppm) and averaging 0.26 ppm.

Based on air samples collected under extreme "worst case" conditions, NIOSH concluded that under normal operating conditions exposure levels within the Small Mammal Building would be in accordance with current NIOSH guidelines which call for the control of formaldehyde exposures to the lowest feasible level.

KEYWORDS: SIC: 8421, ammonia, fire-retardants, formaldehyde, wood-treating.

## II. INTRODUCTION & BACKGROUND

In March 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request from the facilities manager of the National Zoological Park Conservation Center to evaluate formaldehyde exposures in the newly-constructed Small Mammal Building located at the Exotic Animal Breeding Farm in Front Royal, Virginia.

The Conservation Center is part of the Smithsonian Institute and serves as a breeding farm for the National Zoo. The Conservation Center itself, however, is not open to the public and is not designed for visitors. It was established to accommodate endangered species and species that do not breed well in urban zoos. Thus, it is located in a secluded mountain region adjoining the Shenandoah National Park in order to assure privacy and provide as natural a setting as possible.

The Small Mammal Building, when completed, will consist of a central office and kitchen area and two wings, one for mammals and one for birds. Construction on the bird wing is scheduled to begin within a year. The remainder of the building is essentially completed and is expected to receive its new occupants in the very near future. The mammal wing is 180 feet long with an interior width of 50 feet. (See diagram.) It is a very open structure with solar panels that provide natural lighting and thermal assistance during the heating season. Thus, the rafters are necessarily exposed. These truss rafters were inadvertently treated with an exterior, rather than interior, chemical process to make them fire-retardant. Zoo personnel were not aware of this until construction had proceeded to the point that formaldehyde off-gassing from the rafters was no longer dispersed to the outside. Once the roof was completed, the problem was obvious. (Formaldehyde is highly irritant to the eyes, nose, and upper respiratory tract.) Repeated treatment with ammonia gas reduced exposure levels considerably. (Formaldehyde reacts with ammonia to produce hexamethylenetetramine and a number of unstable addition products.)[1] However, the facilities manager sought NIOSH's advice before assigning personnel to work in the building. Once in-operation, the building will employ one to three workers. One worker will be needed for eight hours a day to handle daily chores. Up to three workers will be necessary from time to time to change habitats within individual cages. In addition, approximately once a month, researchers will conduct a 24-hour observation.

## III. METHODS

The last ammonia treatment took place on March 28, 1983. The building was vented from March 29 to April 2. On April 3, the building was closed and remained so until April 21. Samples were collected on April 20 to measure formaldehyde levels. Thus, the levels measured exceeded even worst case operating conditions since under no circumstances would the building be expected to remain closed for 18 days with no fresh air. To simulate operating temperature and humidity, the building was heated to 80°F and the relative humidity was maintained at 50% prior to sampling. Chemical detector tubes, an infrared spectrophotometer, and NIOSH analytical method # P&CAM (Physical and Chemical Analytical Method) 125 were used to determine formaldehyde levels.[2] An infrared spectrophotometer was also used in conjunction with another study to ascertain the effective range of the instrument. This direct reading instrument provided the capability of detecting any possible areas of unusually high concentrations. Sampling parameters were adjusted to maximize analytical sensitivity at low concentrations, which were expected on the basis of previous monitoring results provided by the builder. Samples were collected at the same locations which had been used for the earlier monitoring conducted by the builder. These locations were well distributed throughout the building and were situated at various heights to detect any stratification that might have occurred.

## IV. EVALUATION CRITERIA

The Occupational Safety and Health Administration (OSHA) permissible exposure limit for formaldehyde is 3 ppm Time-Weighted Average (TWA) with the condition that the exposure may not exceed 5 ppm for any 30 minute period. At no time may exposures exceed 10 ppm. (29 CFR 1910.1000, Table Z-2 as of July 1, 1982.) (1.2 $mg/m^3$) based on complaints of irritation, disturbing odor, and disturbed sleep after exposures to formaldehyde at 1 to 2 ppm. This ceiling concentration was to be determined on the basis of a 30 minute sampling period.[3]

Acute exposure to formaldehyde can cause a variety of symptoms. From 0.1 to 5 ppm formaldehyde causes a burning sensation in the eyes, tearing, and general irritation of the upper respiratory passages. Exposures on the order of 10 to 20 ppm are associated with coughing, tightness in the chest, a feeling of pressure in the head, and palpitation of the heart. At 100 ppm and above, formaldehyde becomes immediately dangerous to life or health (IDLH) and is capable of causing pulmonary edema, pneumonitis or death.

Currently, NIOSH recommends that, "formaldehyde be handled as a potential occupational carcinogen" based on studies in which laboratory rats exposed to formaldehyde vapor developed nasal cancer. Based on these studies and demonstrated mutagenic

capabilities, NIOSH recommends the reduction of occupational exposures to "the lowest feasible limit."[4]

Several studies link formaldehyde exposure to nasal cancer in rats. Particularly interesting are results of a study conducted by the Chemical Industry Institute of Toxicology (CIIT) in which three groups of rats were exposed to different concentrations of formaldehyde vapors.[5] Of 240 rats exposed to 15 ppm, 103 (43%) developed nasal cancer at 24 months of exposure. Of 240 rats exposed to 6 ppm, two (less than 1%) developed nasal cancer. Of 240 exposed to 2 ppm, none developed nasal cancer.[5] Nasal cancer in rats is rare. The NIOSH Current Intelligence Bulletin states that "at the National Cancer Institute, only two cases of nasal squamous cell carcinoma have been observed in 5,884 unexposed Fischer 344 rats".

## V. RESULTS

Two brands of chemical detector tubes used at the outset failed to detect the presence of formaldehyde. The limit of detection for both brands was 0.5 ppm. Accordingly, sampling parameters were adjusted to optimize analytical sensitivity at low concentrations.

NIOSH analytical method # P&CAM 125 is sensitive to formaldehyde concentrations ranging from 0.1 to 2.0 ppm. This method yielded the results tabulated in Table 1. Levels ranged from 0.11 to 0.43 ppm and averaged .26 ppm. No perceptible trends were noted concerning such sampling variables as height above the floor, location by cage number, or morning vs afternoon.

A direct reading infrared spectrophotometer was also used in conjunction with an independent study to determine the effective range of the instrument. The results obtained with this instrument were consistent with the above results.

## VI. DISCUSSION

To understand the implications of the results obtained, the following considerations are important. The building was closed for 17 days prior to sampling, a situation which will never occur once the building is in operation. With the passage of time the amount of formaldehyde released from the trusses will decrease steadily. Thus, the formaldehyde levels encountered during the survey are orders of magnitude higher than what would be expected during normal use of the building. Finally, very low levels of formaldehyde were measured. Had the building not been closed for so long to allow formaldehyde vapors to accumulate prior to sampling, it is very unlikely that the level of formaldehyde would have been detectable using even the most sensitive analytical method available to NIOSH. Thus, under normal operating conditions the formaldehyde exposures in the Small Mammal Building should present very little hazard.

A recent publication by CIIT contains a risk assessment of the carcinogenic potential of formaldehyde for rats.[6] The tabulated values most closely approximating the values obtained in the Small Mammal Building correspond to an increased risk of developing nasal carcinomas equal to one chance in 100 million. If the increased risk was one chance in 100,000,000 under "worst case" conditions, then under normal operating conditions the increase in risk must truly be negligible. Similar risk assessments are not available for other species.

## VII. CONCLUSIONS

Under normal usage, exposure levels within the Small Mammal Building would be in compliance with current NIOSH guidelines that exposures be maintained at the lowest feasible limit.

## VIII. RECOMMENDATIONS

No additional corrective actions are necessary at this time.

## IX. REFERENCES

1. Kirk-Othmer Encyclopedia of Chemical Technology, second edition, John Wiley & Sons, New York, 1980, pages 643-644.

2. NIOSH Manual of Analytical Methods, second edition, Vol. 1, 1977. DHEW (NIOSH) Publication No. 77-157-A.

3. Criteria for a Recommended Standard: Occupational Exposure to Formaledhyde. DHEW (NIOSH) Publication No. 77-126.

4. Current Intelligence Bulletin 34, Formaldehyde: Evidence of Carcinogenicity, April 15, 1981.

5. Halperin, W.E., et al, "Nasal cancer in a worker exposed to formaldehyde", Journal of the American Medical Association, 1983, 49: 510-512.

6. Gibson, J.E., editor, Formaldehyde Toxicity, Chemical Industry Institute of Toxicology Series, Hemisphere Publishing Corp., Washington, 1983, Chapter 26, Risk Assessment Using a Combination of Testing and Research Results by James E. Gibson.

7. Gibson, op.cit., Chapter 10, A 26-Week Inhalation Toxicity Study with Formaldehyde in the Monkey, Rat, and Hamster by George M. Rusch, Henry F. Bolte, and William E. Rinehart.

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## XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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. National Zoological Park Conservation Center
2. NIOSH Regional Office III

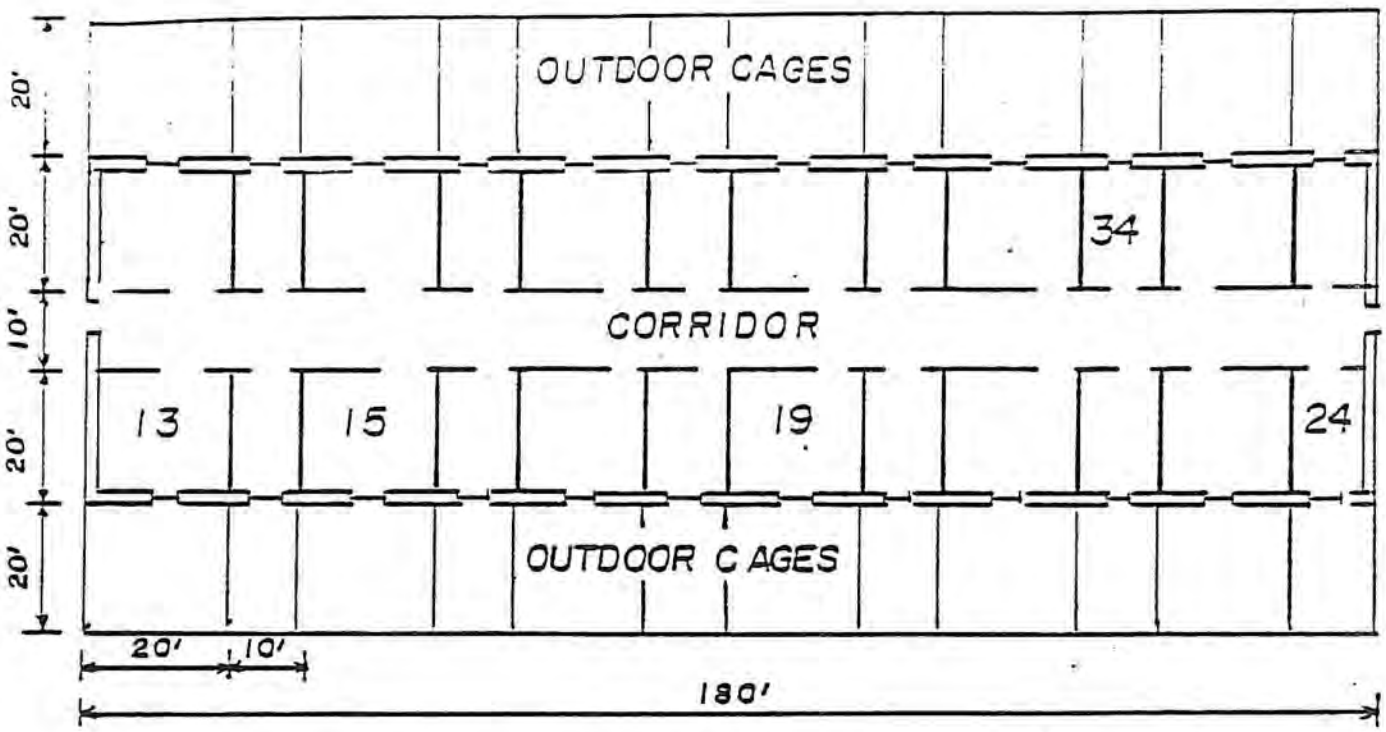
For the purpose of informing affected employees, it is requested that copies of this report be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1

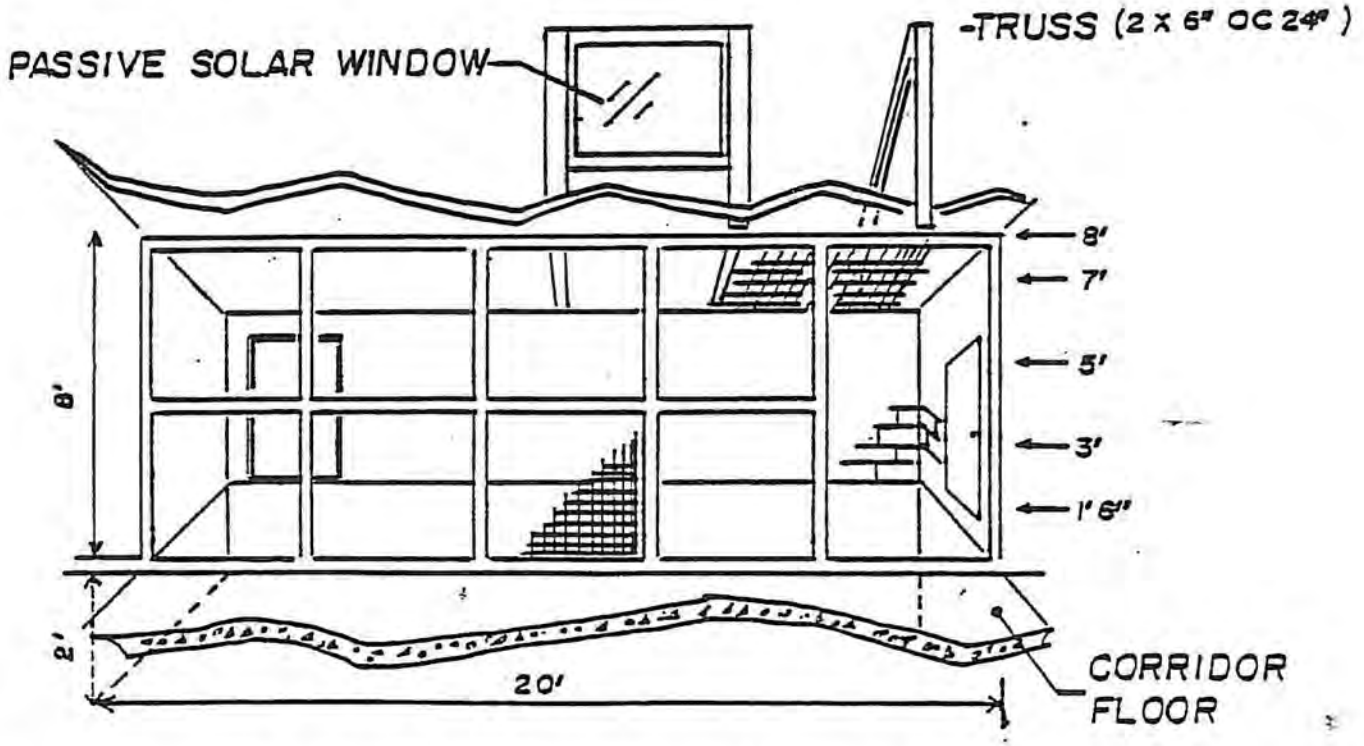
Formaldehyde Levels in the Small Mammal Building
April 20, 1983

| Cage # | Height Above Floor In Feet | Morning (11:43-12:52) In ppm | Afternoon (2:41-3:50) In ppm | Average per Cage In ppm |
|---|---|---|---|---|
| 13 | ceiling | 0.26 | 0.33 | 0.30 |
| 15 | 5' | 0.21 | 0.43 | 0.32 |
| 19 | 3' | 0.20 | 0.24 | 0.22 |
| 34 | 7' | 0.30 | 0.11 | 0.21 |
| 24 | 1 1/2' | 0.26 | 0.19 | 0.23 |
| | Morning Average | 0.25 | Afternoon Average 0.26 | Overall Average 0.26 |

DIAGRAM




FLOOR PLAN OF SMALL ANIMAL FACILITY. NUMBERS INDICATE CAGES WHERE $CH_2O$ WAS MEASURED.




CUT-AWAY VIEW OF REPRESENTATIVE CAGE SHOWING HEIGHT ABOVE CORRIDOR FLOOR WHERE $CH_2O$ WAS MEASURED