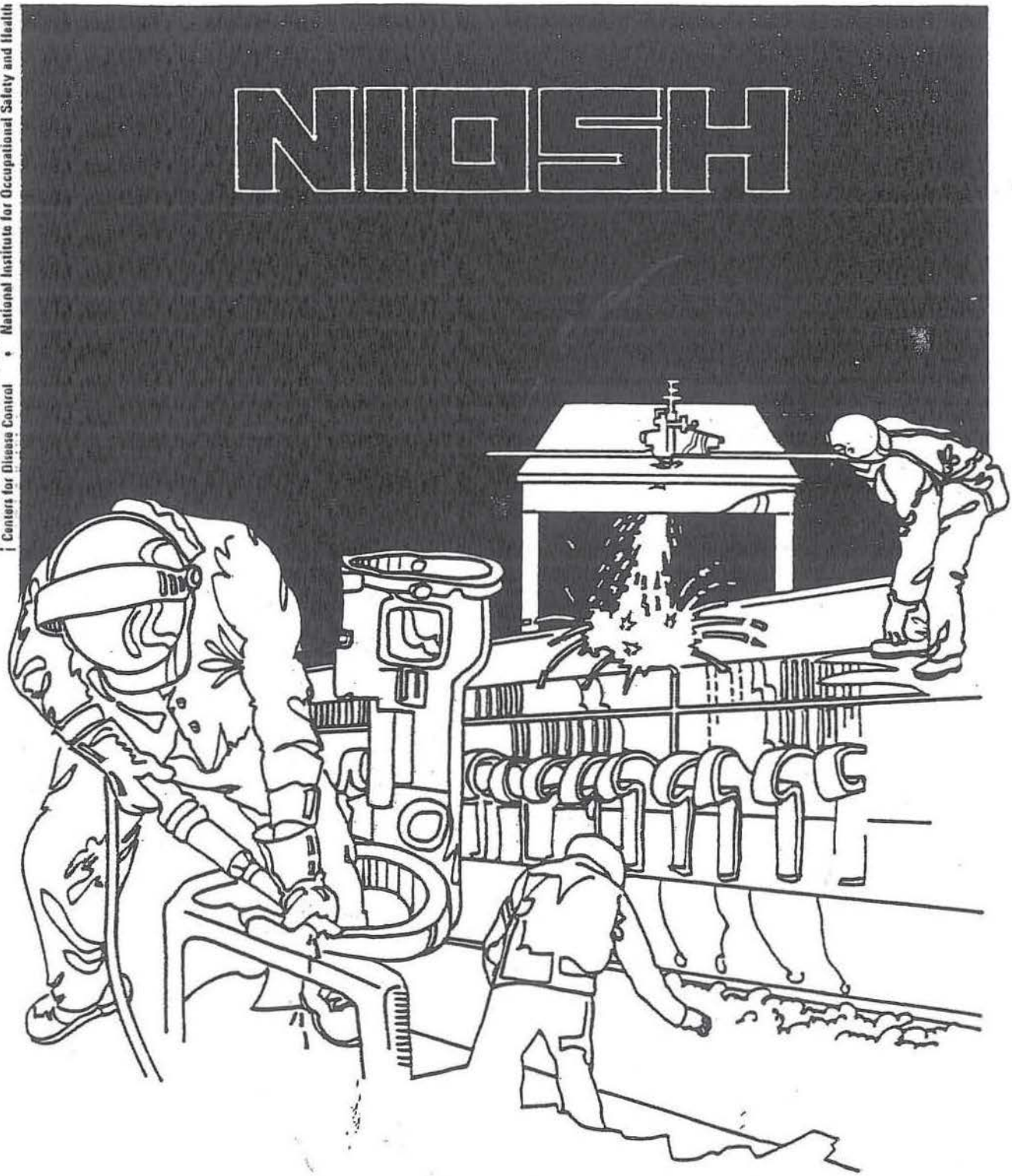
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES • Public Health Service
Centers for Disease Control • National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

80-105-763

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 80-105-763
NOVEMBER 1980
SCHOOL OF VETERINARY MEDICINE
AUBURN UNIVERSITY
AUBURN, ALABAMA

NIOSH INVESTIGATOR:
Richard Patnode

I. SUMMARY

In March, 1980, NIOSH received a request from the Campus Safety Engineer of Auburn University, Auburn, Alabama, to conduct a Health Hazard Evaluation of the Large and Small Animal Surgery areas within the School of Veterinary Medicine to determine exposure levels of the waste anesthetic gases: nitrous oxide, halothane, and methoxyflurane. These gases are used under a variety of conditions - with and without scavenging - to anesthetize animals for surgery and research. Up to ten students and employees may be exposed during routine procedures in the Large Animal Surgery areas, while over 60 students and employees may be exposed during routine procedures in the Small Animal Surgery areas. Area and personal environmental samples were taken using air bags and infrared spectrophotometry to determine nitrous oxide levels and using charcoal adsorption tubes and gas chromotography to determine halothane and methoxyflurane levels. Results of sampling conducted June 24-26 are expressed in ppm (parts per million) and summarized as follows:

Location	Gas	Exposure Mean Range	Recommended Standard
Large Animal Surgery	Halothane*	2.4, 1.0-4.8 ppm	2.0 ppm
Student Surgery Lab	Methoxyflurane*	2.0, 1.3-3.3 ppm	2.0 ppm
Client Surgery	Nitrous Oxide		
	with scavenging	15, 10-25 ppm	25 ppm
	without "	56, 7-85 ppm	25 ppm

* Without scavenging

The survey concluded that when scavenging equipment is used, exposure levels are within acceptable limits. In the absence of scavenging, exposure levels exceed acceptable limits. Recommendations made at the time of the survey and in subsequent correspondence are presently being implemented by the University.

KEYWORDS: SIC 8221 (Colleges, Universities, and Professional Schools), halothane, methoxyflurane, nitrous oxide, and anesthetic gases.

II. INTRODUCTION

In accordance with the Occupational Safety and Health Act of 1970, the Campus Safety Engineer requested a survey to determine exposure levels of waste anesthetic gases in surgical areas within the Veterinary School. NIOSH had conducted such a survey within the Small Animal Surgery Department (HHE 80-4-706) in December of 1979. The present survey was requested to evaluate the effectiveness of corrective measures taken subsequent to the earlier survey and to evaluate the Large Animal Surgery Department which had not participated in the earlier survey. The survey was conducted June 23-27, 1980. On July 10, 1980, letters were sent to the Campus Safety Engineer and to the Chief of Small Animal Surgery stating the results of sampling for nitrous oxide, and on October 3, 1980, letters were sent stating the results of sampling for halothane and methoxyflurane.

III. BACKGROUND

The School of Veterinary Medicine contains a Department of Large Animal Surgery and a Department of Small Animal Surgery.

Large Animal Surgery is performed in two operating rooms. One or two instructors and five to ten students are present during a typical operation. Halothane is used to achieve anesthesia. Instead of scavenging, a recirculating system is used in which exhaled air is treated to remove carbon dioxide and to restore oxygen. This treated air is then inhaled again. In this way, anesthetic gas exhaled by the animal is rebreathed. If there are no leaks in the system, then theoretically this system should minimize the exposure to operating room personnel.

Small Animal Surgery is performed in two areas. The first area is the Student Surgery Laboratory which is a large open room where as many as 20 operations are performed simultaneously by three-member student surgical teams on essentially healthy animals. Approximately 60 students, two instructors, and one technician are present during these laboratory sessions. Methoxyflurane is used to achieve anesthesia and scavenging equipment is not usually used in this area. The second surgical area within Small Animal Surgery is the Client Surgery Area. Here advanced students perform necessary surgery on ailing animals from surrounding communities. Nitrous oxide is the most widely used gas in Client Surgery, but halogenated anesthetic agents are also used as needed. Scavenging equipment is available within this area, but is not always utilized.

IV. EVALUATION DESIGN AND METHODS

Nitrous oxide sampling was accomplished by using battery powered sampling pumps to fill 22-liter inert plastic bags with air drawn from the subject's breathing zone. The samples were then brought to a central location, the contents analyzed, the bags purged twice with clean air and reused. All air from within the bags was exhausted outside the building to prevent recirculation of contaminated air. Air used to purge the bags was exhausted through the analyzer to purge the analyzer of any contamination and to ascertain that no nitrous oxide remained in either the bags or the analyzing chamber. Nitrous oxide concentrations were determined on-site using a MIRAN 1A Portable Ambient Air Analyzer, an infrared spectrophotometer, pre and post-calibrated daily with known concentrations of nitrous oxide.

To sample for halothane and methoxyflurane air was drawn from the subject's breathing zone through charcoal adsorption tubes via low-flow sampling pumps. These tubes were later analyzed by gas chromatography.

V. EVALUATION CRITERIA

NIOSH recommends environmental limits of 25 ppm nitrous oxide and 0.5 ppm halogenated anesthetic agent when both are administered concurrently or 25 ppm nitrous oxide and 2.0 ppm halogenated agent when either gas is used separately. Evidence indicates that either gas is potentially toxic with chronic, low level exposure.

The primary health effect associated with long term exposure is reproductive disorders. Numerous studies indicate increased risks of spontaneous abortions and congenital abnormalities in the offspring of men and women occupationally exposed to anesthetic gases. Increased liver and kidney disease are also found. Presently it is not known at what exposure level these health hazards present themselves. Therefore prudence dictates that exposure to anesthetic gases be limited to the lowest achievable level.

Acute effects of low level exposure are well documented. A study published by NIOSH in 1976 shows that, "nitrous oxide and halothane in respective concentrations as low as 50 ppm and 1.0 ppm, caused measurable decrements in performance on psychological performance tests taken by healthy male graduate students. Nitrous oxide alone caused similar effects. The functions apparently most sensitive to these low concentrations of anesthetics were visual perception, immediate memory, and a combination of perception, cognition, and motor responses..." However, similar decrements were not observed at 25 ppm nitrous oxide and 0.5 ppm halothane.

Existing control technology can readily achieve operating room exposure levels of 25 ppm nitrous oxide and 0.5 ppm halogenated agent used concurrently and 25 ppm and 2.0 ppm respectively when either gas is used alone. These concentrations can be achieved through the proper use and maintenance of specialized local exhaust ventilation systems called scavenging systems.

VI. RESULTS

A. Large Animal Surgery

The results of halothane sampling conducted in Large Animal Surgery are contained in Table 1. Area samples indicate higher exposure levels in the recovery rooms (2.2 and 4.8 ppm) than in the operating rooms (1.4 and 1.7 ppm). Yet operating room personal breathing zone samples show that anesthetists in particular are consistently overexposed. As a group, anesthetists had a mean exposure level of 3.0 ppm and six out of six of those sampled exceeded the NIOSH standard. Surgeons as a group had an average* exposure of 1.4 ppm with no one overexposed. Other students present in the operating room had an overall exposure of 1.9 ppm with one out of three or 33% exposed above the 2.0 ppm level. Operating room personnel had an overall exposure of 2.4 ppm and seven out of twelve or 58% were overexposed.

B. Student Surgery Laboratory

Results of methoxyflurane samples taken in the Student Surgery Laboratory are best summarized in tabular form as follows. Complete sampling results are tabulated in Table 2.

Function	No. of Samples	Average Exposure in ppm	Percentage Overexposed
Assistants	9	1.7	11%
Surgeons	7	2.0	43%
Anesthetists	8	2.4	63%
Totals	24	2.0	38%

C. Client Surgery

Results of sampling for halogenated anesthetics in the Client Surgery Area are found in Table 3. In only one case was the recommended standard exceeded. This case involved the unscavenged use of halothane and nitrous oxide concurrently. The nitrous oxide level of 75 ppm exceeded the 25 ppm standard and the halothane concentration of 1.1 ppm exceeded the

* All averages are simple arithmetic averages unless specifically identified as time weighted averages.

recommended standard of 0.5 ppm when nitrous oxide and halothane are used simultaneously. The other four exposure levels were within acceptable limits.

Results of nitrous oxide sampling in the Client Surgery Area, presented in Table 4, graphically demonstrate the value of scavenging. The eight samples taken in the presence of scavenging average approximately 15 ppm - well within acceptable limits. The six samples taken in the absence of scavenging average 56 ppm - more than twice the recommended standard of 25 ppm.

VII. DISCUSSIONS AND CONCLUSIONS

A. Discussion of Results

1. Large Animal Surgery

It was hoped that the rebreathing method of administering anesthesia would minimize personal exposures even in the absence of scavenging. The rationale being that rebreathing of anesthetic gas should keep the gas dissolved in the animal's bloodstream preventing its release into the atmosphere. The highest levels of exposure would then occur in the recovery room when anesthetic gas comes out of solution and is exhaled as the animal regains consciousness. Since the animal is left alone in a padded room to recover, no personnel are exposed and the recovery room exposure levels are not occupationally significant. Area samples indicate that the hypothesis does have merit since recovery room area concentrations were twice the operating room area concentrations. However, the area samples are not indicative of personal exposure levels. Because of their proximity to the source of contamination, anesthetists are consistently overexposed. Every anesthetist sampled was overexposed. The fact that, overall, 58% of those sampled were overexposed demonstrates the need for scavenging even when the anesthesia equipment is operated in the recirculating mode.

2. Student Surgery Laboratory

Sampling results of the June survey are consistent with samples taken in December in the Student Surgery Laboratory. The 24 samples taken in June averaged 2.0 ppm; the 12 samples taken in December averaged 2.1 ppm. Such consistency attests to the continuing need for scavenging within this area.

3. Client Surgery

Between December 1979 and June 1980 the Small Animal Surgery Department had located and reconditioned a number of scavenging systems. Sampling results demonstrate the effectiveness of this action. Of the eight samples taken while these systems were in use, only one sample approached the recommended standard and no sample exceeded the standard. Of the six samples taken where these systems were not in use, five samples exceeded the recommended standard. Although scavenging is not always convenient, it is always necessary if acceptable exposure limits are to be maintained.

B. Importance of Results

Since the primary health effects are miscarriages and birth defects and the students and faculty are of child-bearing age, the potential hazards of overexposure to anesthetic gases are obvious. It is imperative that the use of scavenging equipment and techniques be ingrained in the student from the beginning of his training since good habits developed as a student may have a significant impact on a veterinarian's total lifetime exposure.

Acute effects on the central nervous system due to low level exposure to anesthetic gases should not be overlooked. The decrements in performance, noted earlier (see Section V, Evaluation Criteria) can only detract from the surgeon's performance.

VIII. RECOMMENDATIONS

Four recommendations were made in the report of the December 1979 survey. Briefly they called for the following:

1. Installation and utilization of scavenging equipment
2. Teaching of "low leakage" anesthetic techniques
3. A rigorous program of preventive maintenance of anesthetic equipment
4. The educating of students and staff to the hazards associated with waste anesthetic gas and appropriate protective measures.

Following the December 1979 survey the Department took action on two fronts to remedy the situation. As an interim measure, an effort was made to find and overhaul as many scavenging units as possible. The effectiveness of this action is demonstrated in the Client Surgery sampling results of June 24 (Table 4). As a long term corrective measure, the Department used NIOSH sampling results to characterize and document the overexposures and petitioned the University to install a scavenging system. The University responded favorably and has budgeted funds for the installation of such a system to correct the problem areas identified by sampling results. The system is being designed at the time of this report and among other features will include a quick-connect capability. This added convenience feature should maximize student acceptance and usage of scavenging techniques. The prompt implementation of NIOSH recommendations by the Department and the University is commendable.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:

Richard Patnode
Industrial Hygienist
Industrial Hygiene Section

Assisted By:

Steven Lee
Industrial Hygienist
Industrial Hygiene Section

Stanley Salisbury
Regional Industrial Hygienist

Lee Greeley
Industrial Hygienist COSTEP
Region IV
Atlanta, Georgia

Originating Office:

Hazard Evaluations and
Technical Assistance Branch
Division of Surveillance, Hazard
Evaluations and Field Studies
Cincinnati, Ohio

Report Typed By:

O. Brown
Clerk-Typist

X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Technical Services, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio, 45226. After 90 days, this report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

Copies of this report have been sent to:

1. Campus Safety Engineer, Auburn University
2. Chief, Department of Small Animal Surgery, Auburn University
3. U.S. Department of Labor, Region IV
4. NIOSH, Region IV

For the purpose of informing those affected, it is requested that this report be promptly "posted" for a period of 30 days in a prominent location near the workplace of those exposed.

Table 1

Halothane Exposure in Large Animal Surgery

Location	Function	Sample Period	Exposure in ppm
		June 24, 1980	
Room 140	Bovine Anesthesia Research Student	8:50-10:20 am	3.6
		10:20-11:20 am	1.2
		(8:50- 11:20 am Time Weighted Average = 2.6)	
Room 140	Student Anesthetist	1:30-2:30 pm	2.6
	Anesthetist	1:30-2:30 pm	4.8
	Surgeon	1:50-2:50 pm	1.0
		June 25, 1980	
Room 140	Graduate Student	9:28-11:42 am	1.6
	Anesthesia Technician	9:30-11:54 am	2.5
	Area Sample	9:32-11:49 am	1.4
Room 127	Anesthetist	9:35-10:52 am	2.1
	Surgeon	9:38-10:37 am	1.9
Recovery Room for OR 127	Area Sample (No personnel exposed)	9:37-10:52 am	1.6
		10:58-11:57 am	2.9
		(9:37- 11:57 Time Weighted Average = 2.2)	
Recovery Room for OR 140	Area Sample (No personnel exposed)	11:58am-12:32pm	4.8
		June 26, 1980	
Room 140	Student 1	8:49-10:30 am	1.8
	Student 2	8:53-10:30 am	2.2
	Anesthetist	8:57-10:30 am	3.7
	Area Sample	8:45-10:30 am	1.7

Summary of Personnel Exposures

Group	Average Exposure for Group	Percent of Group Overexposed
Anesthetists	3.0 ppm	$\frac{6}{6}$ = 100%
Surgeons	1.4 ppm	$\frac{0}{2}$ = 0%
Other Students	1.9 ppm	$\frac{1}{3}$ = 33%
Overall	2.4 ppm	$\frac{7}{12}$ = 58%

Table 2

Personal Breathing Zone Exposure to Methoxyfluorane in Student Surgery Laboratory

Function	Sample Period	Exposure in ppm	Mean Exposure	% of Group Overexposed
Anesthetists				
	June 24, 1980			
	9:33-11:14 am	1.9		
	9:47-11:10 am	2.9	2.4 ppm	$\frac{5}{8}$ = 62%
	9:57-11:30 am	1.9		
	10:01-11:24 am	3.3		
	10:04-11:25 am	1.6		
	June 26, 1980			
	9:10-10:40 am	2.5		
	9:15-10:40 am	2.6		
	9:20-10:40 am	2.8		
Surgeons				
	June 24, 1980			
	9:36-11:14 am	1.8		
	9:41-11:21 am	1.8		
	9:43-11:20 am	2.3		
			2.0 ppm	$\frac{3}{7}$ = 43%
	June 26, 1980			
	9:09-10:40 am	2.1		
	9:16-10:40 am	2.5		
	9:20-10:40 am	1.7		
	9:21-10:40 am	1.7		
Assistants				
	June 24, 1980			
	9:34-11:14 am	1.8		
	9:43-11:20 am	1.5		
	9:48-11:08 am	1.9		
	9:50-11:09 am	1.8	1.7 ppm	$\frac{1}{9}$ = 11%
	10:03-11:25 am	1.4		
	10:06-11:25 am	1.8		
	June 26, 1980			
	9:05-10:40 am	1.6		
	9:14-10:40 am	2.3		
	9:19-10:40 am	1.3		
All Groups	Both Days		2.0 ppm	$\frac{9}{24}$ = 38%

Table 3

Exposure to Halogenated Anesthetics in Client Surgery Area
June 25, 1980

Room Number	Type of Sample	Scavenging Yes	Scavenging No	Sampling Period From	Sampling Period To	Concentration in ppm	Anesthetic Halothane	Anesthetic Methoxyflurane
OR #2*	Area		X	1:57 -	2:22 pm	1.1	X	
OR #1	Personal-anesthetist		X	2:34 -	3:56 pm	0.3		X
	Personal-assistant		X	2:35 -	3:57 pm	0.2		X
OR #2	Personal-anesthetist		X	2:48 -	4:00 pm	1.4	X	
	Area		X	2:54 -	3:59 pm	1.1	X	

*Halothane used concurrently with nitrous oxide at 75 ppm exposure level

Table 4

Nitrous Oxide Exposure in Client Surgery Area
June 24 & 25, 1980

Room	Type of Sample	Scavenging Yes	Scavenging No	Sampling Period From	Sampling Period To	Concentration in ppm
June 24						
OR #3	Personal-anesthetist	X		2:15	2:32	15
OR #3	Personal-surgeon	X		2:15	2:28	10
OR #2	Personal-anesthetist	X		2:20	2:55	20
OR #2	Personal-surgeon	X		2:21	2:54	10
OR #3	Area	X		2:30	2:59	10
OR #2	Area	X		2:33	3:14	10
Post-Op	Area		X	2:37	3:15	7
Prep.	Area		X	2:40	3:18	40
OR #2	Personal-anesthetist	X		2:56	3:24	15
OR #2	Personal-surgeon	X		2:57	3:23	25
June 25						
OR #2*	Area		X	1:50	2:21	75
Spec. Surg.	Area		X	3:00	3:45	85
Prep.	Area		X	2:10	3:10	75
Prep.	Area		X	3:15	3:48	55

*Nitrous oxide used concurrently with halothane at 1.1 ppm exposure level

DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
ROBERT A. TAFT LABORATORIES
4676 COLUMBIA PARKWAY, CINCINNATI, OHIO 45226

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

Third Class Mail

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF HHS
HHS 396