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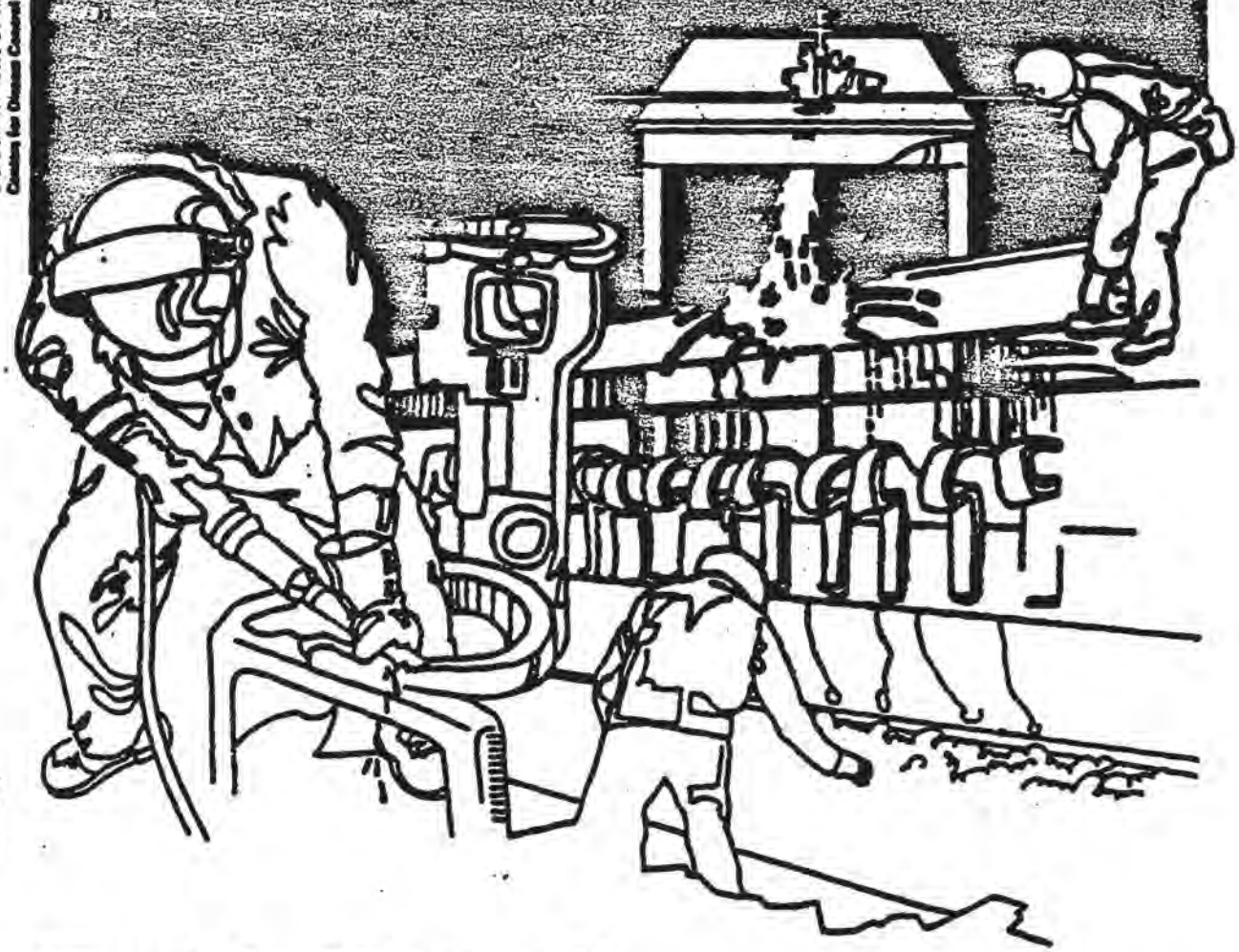

Health Hazard Evaluation Report

HETA 84-145-1604
PORTER MEMORIAL HOSPITAL
VALPARAISO, INDIANA

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 84-145-1604
JULY 1985
PORTER MEMORIAL HOSPITAL
VALPARAISO, INDIANA

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I. SUMMARY

On January 19, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Indiana Occupational Safety and Health Administration (IOSHA) to conduct a health hazard evaluation at the Porter Memorial Hospital in Valparaiso, Indiana. IOSHA asked that NIOSH evaluate the exposure of operating room personnel to waste anesthetic gases. In addition, the hospital administration requested an evaluation of the exposure of central supply employees to the sterilant, ethylene oxide.

On April 23-24, 1984, NIOSH performed an environmental survey of operating rooms for nitrous oxide and halogenated anesthetic gas exposure and of central supply operations for ethylene oxide exposure.

Of the five breathing zone samples collected for nitrous oxide, two exceeded the NIOSH recommended level of 25 ppm on a time-weighted average basis during anesthetic administration. These overexposures were to anesthesiologists in two of the four operating rooms surveyed. Four of the twenty-two area samples taken for nitrous oxide were greater than 25 ppm. One area sample for forane and one personal sample for halothane were above the NIOSH recommended criterion of 0.5 ppm for halogenated anesthetic gases when used in combination with nitrous oxide.

The personal exposures of central supply employees to ethylene oxide were below or equal to the NIOSH recommended level of 0.1 ppm as an 8-hour time-weighted average concentration.

The data collected during this investigation indicated that exposures of some of the operating room personnel to nitrous oxide and halogenated anesthetic gases were in excess of the NIOSH recommended maximum levels. Ethylene oxide concentrations in the central supply area were at or below the NIOSH recommended level. Recommendations to reduce exposures are given in Section VII of this report.

KEYWORDS: SIC 8062, nitrous oxide, forane, halothane, waste anesthetic gases, ethylene oxide, hospitals

II. INTRODUCTION

On January 19, 1984 the National Institute for Occupational Safety and Health recieved a request from the Indiana Occupational Safety and Health Administration to conduct a health hazard evaluation at the Porter Memorial Hospital in Valparaiso, Indiana for exposure of operating room personnel to anesthetic gases. Later, the hospital administration also requested evaluation of the exposure of central supply employees to the sterilant, ethylene oxide.

On April 23-24, 1984, NIOSH investigators visited this hospital and performed an environmental survey of operating rooms for nitrous oxide and halogenated anethestic gas exposure and of central supply operations for ethylene oxide exposure. The afternoon of April 24, 1984, the representatives of the operating room and central supply employees and hospital administration were verbally informed of the preliminary results for nitrous oxide and ethylene oxide sampling.

III. BACKGROUND

The request from Indiana OSHA stated that a compliance inspection of the Porter Memorial Hospital had been generated by a complaint from a worker alleging spontaneous abortions and birth defects among surgical team workers related to anesthetic gas exposure. Based on quarterly monitoring of anesthetic gases by a private consulting group, the hospital administration did not consider that operating room employees were being overexposed. After reviewing reports of these quarterly monitoring activities, it was decided that NIOSH should assist Indiana OSHA in evaluating anesthetic gas exposure at this hospital.

On the afternoon of April 23, 1984, the four NIOSH investigators met with representatives of the hospital administration, operating room personnel, and central supply employees. Equipment and sampling procedures were set up for the next day's activities. On April 24, 1984 air sampling of the operating rooms and central supply areas was conducted.

Porter Memorial Hospital has eight operating rooms of which six were scheduled for operations using anesthetic gases on April 24, 1984. Usually five to six people work in an operating room depending on the operative procedure being performed. This group could include, for example, a couple of surgeons, an anesthesiologist, and three nurses. At this hospital the anesthesiologists own and maintain their equipment with the assistance of the hospital bioengineering department. The equipment is connected to a closed exhaust system which is dedicated to eliminating waste anesthetic gases from the operating rooms.

Most operations occur in the morning of the day shift although some operations are scheduled for the afternoon of the day shift and the evening shift. Only emergency procedures usually occur during the third shift. Forty-one full time equivalent positions were used at the time of this survey to work the three shifts. Twenty to twenty-five of these positions covered day shift.

In the central supply department one person works the sterilizer which uses ethylene oxide as a sterilant. In addition, at least three other employees, titled central service aids, are potentially exposed to ethylene oxide from the opening and closing of this sterilizer and gassing-off of freshly sterilized supplies.

IV. METHODS AND MATERIALS

Area and personal breathing zone samples for nitrous oxide were collected in inert, plastic bags and analyzed on site with an infrared analyzer. Samples for halogenated anesthetic gases, such as forane, halothane and ethrane, were collected on 150 milligram charcoal tubes and submitted for analysis to a NIOSH contract laboratory. Four of the six operating rooms using anesthetic gases on the day of the survey were sampled for nitrous oxide and halogenated anesthetic gases.

In operating room number seven, two operations occurred during the morning. Before these operations started a short-term sample for nitrous oxide was collected with a high flow pump to determine if there were significant background levels. For the duration of the two operations, a long term sample for nitrous oxide was collected at a flow rate of 50 cubic centimeters per minute. Also during each operation one personal and three area samples for nitrous oxide were obtained at a flow rate of 0.2 liters per minute. A personal and an area sample for halogenated anesthetic gases were taken during each operation and one personal sample over both operations. A flow rate of 50 cubic centimeters per minute was used for these samples.

In operating room six during the morning, six operations took place in four and a half hours. For each of the first five operations, two area samples for nitrous oxide were obtained and for the first four operations personal samples from the breathing zone of the anesthesiologist were collected. For these short-term nitrous oxide samples a high flow pump operating at a flow rate of 1.0 to 1.5 liters per minute was used. A short-term sample before the operations began was also obtained. For halogenated anesthetic gases two personal and two area samples were collected at a flow rate of 50 cubic centimeters per minute throughout the duration of the six operations.

In the afternoon, an operation in room 4 was sampled producing two area samples for nitrous oxide and two personal samples for halogenated anesthetic gases. In room one, an operation in the afternoon was sampled by collecting three area and one personal sample for nitrous oxide and one area and two personal samples for halogenated anesthetic gases. For both of these operating rooms, nitrous oxide was collected with high flow pumps operating for less than 45 minutes and the halogenated anesthetic gases were collected with low flow pumps at a flow rate of 50 cubic centimeters per minute.

All samples for nitrous oxide were analyzed on-site using a long pathlength infrared spectrophotometer (Wilks-Miran 103 Gas Analyzer) at an analytical wavelength of 4.48 micrometers. The method used was the same as that described in the NIOSH Manual of Analytical Methods.[1]

The charcoal tube samples for halogenated anesthetic gases were analyzed for halothane, forane and ethrane according to NIOSH Method P&CAM 127 with modifications.[2] The limit of detection for halothane is 0.1 milligrams per sample and for forane and ethrane is 0.03 milligrams per sample.

Exposure of central supply employees to ethylene oxide was determined by using two methods. The first method used low flow pumps connected to 400 milligram and 200 milligram charcoal tubes in series. Four breathing zone and two area samples were obtained by this method. These samples were analyzed for ethylene oxide according to a modification of the NIOSH Method S-286[3] which is more sensitive. The lower limit of detection for this modified analytical method is 0.15 micrograms per sample.

The second method used a portable gas chromatograph to analyze on-site the levels of ethylene oxide found in air samples collected by syringe. This portable gas chromatograph has a photoionization detector operating at room temperature with air as a carrier gas. For this gas chromatograph the limit of detection for ethylene oxide is 0.5 ppm.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment 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 primarily 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 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.

Anesthetic Gases

A. Toxicological

Reports by Vaisman[4] and Askrog and Harvald[5] were among the first to identify an increased incidence of spontaneous abortion in women exposed to anesthetic gases and in wives of men exposed to anesthetic gases. Results of a more recent and comprehensive nationwide survey of occupational disease among operating personnel

were published in 1974 by the American Society of Anesthesiologists (ASA)[6]. The results of this study indicate "that female members of the operating room-exposed group were subject to increased risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease." This report also showed an increased risk of liver disease and congenital abnormalities in offspring of male operating room personnel. No increase in cancer was found among the exposed males, but an increased incidence of hepatic disease similar to that in the female was found.

In a study published by NIOSH[7], "nitrous oxide and halothane in respective concentrations as low as 50 parts per million (ppm) and 1.0 ppm caused measurable decrements in performance on psychological 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 required in a task of divided attention to simultaneous visual and auditory stimuli." Headache, fatigue, irritability, and disturbance of sleep were also reported[8,9].

Mortality and epidemiological studies have raised the question of possible carcinogenicity of anesthetic gases, but sufficient data are presently lacking to list nitrous oxide or halothane as suspected carcinogens.

B. Environmental

At present there is no Occupational Safety and Health Administration (OSHA) standard for nitrous oxide. When nitrous oxide is used as the sole anesthetic agent in medical procedures, NIOSH recommends that occupational exposure shall be controlled so that no worker is exposed at TWA concentrations greater than 25 ppm during the period of administration. NIOSH recommends that occupational exposure to halogenated anesthetic agents shall be controlled so that no worker shall be exposed at concentrations greater than 2 ppm of any halogenated anesthetic agent during the period of anesthetic administration. When used in combination with nitrous oxide, halogenated anesthetic agents should be controlled to 0.5 ppm, which can generally be arrived at by controlling nitrous oxide to a TWA concentration of 25 ppm during the period of anesthetic administration.

Ethylene Oxide

A. Toxicological

Ethylene oxide (EtO) is a major industrial chemical. It is used primarily as an intermediate in the production of other industrial chemicals such as ethylene glycol. Ethylene oxide is used also as a gas sterilant for heat-sensitive items in the health care industry, and as a fumigant for such items as spices, books, and furniture.

Ethylene oxide is a highly exothermic and potentially explosive substance. As a result, the handling, storage, and use of EtO presents potentially serious problems. EtO is a gas at room temperature and a liquid below 55°F. The liquid is relatively stable; however, vapor concentrations greater than 3% are highly flammable, and air mixtures of EtO will explode when exposed to heat or open flames[10].

Acute Effects

The primary mode of exposure to ethylene oxide is through inhalation (breathing). Ethylene oxide is an irritant of the eyes, respiratory tract, and skin. Early symptoms of EtO exposure include irritation of the eyes, nose, and throat and a peculiar taste. The delayed effects of exposure include headache, nausea, vomiting, pulmonary edema, bronchitis, drowsiness, weakness, and electrocardiograph abnormalities[11]. There have also been reports of cases of neurotoxicity induced by ethylene oxide exposure[12-14].

Dermal (skin) contact with solutions of ethylene oxide as low as 1% can cause burns with edema (swelling) and erythema (redness). Although skin contact with undiluted EtO does not cause burns, it can cause frostbite as a result of rapid evaporation[15]. The severity of skin burns from solutions of ethylene oxide appears to be influenced by both the length of contact with the skin and the strength of the solutions, with solutions around 50% appearing to be the most hazardous[10]. Both the undiluted liquid and solutions of EtO may cause severe eye irritation or damage[16], and there have been case reports of cataracts among workers exposed to high levels of EtO[17].

Carcinogenic Effects

Ethylene oxide has been shown to be carcinogenic to animals. Inhalation of EtO has induced excess leukemia in female rats and peritoneal mesothelioma and leukemia in male rats. An increase in the number of gliomas, a rare malignant tumor of the central nervous system, was also observed[18,19]. There is also some limited evidence which suggests that workers exposed to ethylene oxide may experience an increased risk of leukemia as compared to unexposed workers[20,21].

Mutagenic Effects

Ethylene oxide has been shown to cause changes in the genetic material of lower biological species including Salmonella[22] and fruit flies[23] as well as mammals, including rabbits[24] and monkeys[19]. These genetic changes have been shown to be heritable (passed from one generation to the next) in experiments with mice[25]. Several studies have demonstrated that genetic changes can also occur among humans exposed to EtO. Workers exposed to EtO have been found to have significantly increased numbers of chromosomal aberations and sister chromatid exchanges as compared to workers unexposed to EtO[26,27].

Reproductive Effects

Animal experiments with ethylene oxide have indicated adverse reproductive effects from EtO exposure. A decrease in the number of pups born per litter was observed among female rats exposed to EtO prior to mating and during gestation (pregnancy)[28], and an increase in the number of malformed fetuses per litter was observed among female mice administered EtO intravenously during gestation[29]. Male monkeys exposed to ethylene oxide have been shown to have reductions in sperm count and sperm motility[19]. There is also some human evidence which suggests that women exposed to EtO during their pregnancies may experience increased rates of spontaneous abortions, although this information is not conclusive[30].

B. Environmental

NIOSH recommends that ethylene oxide be regarded as a potential occupational carcinogen and that exposure to EtO be controlled to less than 0.1 part per million (ppm) determined as an 8-hour time-weighted average with a short-term exposure limit not to exceed 5 ppm for a maximum of 10 minutes per day. This recommendation is based on the available risk assessment data which show that even at an exposure level of 0.1 ppm, the risk of excess mortality is not completely eliminated[31]. Effective as of August 21, 1984, the standard of the Occupational Safety and Health Administration (OSHA) for occupational exposure to ethylene oxide was revised downward from 50 ppm to 1 ppm calculated as a time-weighted average concentration for an 8-hour workshift. This downward revision in the standard was based on the animal and human data showing that exposure to EtO presents a carcinogenic, mutagenic, reproductive, neurologic, and sensitization hazard to workers. Included in the present OSHA standard are requirements for methods of controlling EtO, personal protective equipment, measurement of employee exposures, training, and medical surveillance of the exposed employees[32].

VI. RESULTS AND DISCUSSION

Table I contains the results of sampling for nitrous oxide and Table II the results for halogenated anesthetic gases. Concentrations of nitrous oxide in operating rooms 6 and 7 exceeded the NIOSH recommended maximum exposure of 25 ppm on a time weighted average basis during the period of anesthetic administration.

For both operations in room 7, in the morning, the anesthetic was administered by intubation. All of the personal and area samples for nitrous oxide taken during the first operation were greater than 25 ppm. The area sample near the anesthetic equipment was highest at 138 ppm. Nitrous oxide levels during the second and shorter operation were below 25 ppm except for an area sample near the anesthetic equipment where the level was measured as 73 ppm. Most likely a leak in the anesthetic equipment contributed to the excessive levels of nitrous oxide during these operations in room 7. Also, one sample, again near the anesthetic equipment, showed a forane gas concentration of 1 ppm. NIOSH recommends that halogenated anesthetic gases be controlled to 0.5 ppm when used in combination with nitrous oxide.

In operating room 6 the first four operations involved similar surgical procedures to the ears of patients. A mask was used to administer anesthetic gases. Only the fourth of these operations showed an excessive level of nitrous oxide in the breathing zone of the anesthesiologist at 80 ppm. Also a personal sample on the anesthesiologist during all six morning operations showed a concentration of halothane, a halogenated anesthetic gas, at 2 ppm. This concentration exceeds the NIOSH recommended criteria for halogenated anesthetic gases including among them, halothane. This level is greater than would be expected if nitrous oxide exposure was being controlled adequately. All of the area samples for nitrous oxide were well below the 25 ppm criteria and no halogenated anesthetic gases were detected in area samples.

The higher level of nitrous oxide during one operation in room 6 may be attributable to a variation in anesthetic administration which allowed nitrous to escape via the mask or movement of the patients head. The fact that halothane was not detected in area samples suggests that the anesthesiologist's excessive halothane exposure occurred at the same time that the anesthesiologist was overexposed to nitrous oxide.

In the afternoon area samples for nitrous oxide in room 4 were below 25 ppm and in room 1 no nitrous oxide was detected. In addition, personal and area samples taken in these rooms showed no detectable levels of halogenated anesthetic gases.

Results of air sampling for ethylene oxide are given in Tables III and IV. Table III is for sampling by charcoal tubes and Table IV for sampling using a portable gas chromatograph. On a time weighted average basis the breathing zone samples for central service employees did not exceed the NIOSH recommended level of 0.1 ppm assuming the sterilizer was not used again that day. Usually, the sterilizer which uses ethylene oxide is operated once a day. If it were operated more than once the exposures of employees would be likely to be above the recommended level. The measurements taken by using the gas chromatograph can be considered short-term area samples. For both sampling methods the area samples from points near to the sterilizer door were greater than 0.5 ppm. At points away from the sterilizer door the levels were generally lower.

In conclusion, the exposures of central service employees, on the day of this survey, were at or below the NIOSH recommended level of 0.1 ppm on an 8-hour time-weighted average basis.

VII. RECOMMENDATIONS

1. The design of the anesthesia equipment is adequate but the maintenance of this equipment could be improved. A consistent and regular program to check for and repair leaks should be supported. Leaks in the anesthesia equipment should be identified by periodic monitoring. By the time of this investigation a monitoring contractor had been engaged who was able to identify leakage of waste anesthetic gases from the equipment.

2. Good work practices by the anesthesiologists can reduce exposures to themselves and those who work nearby. Particular attention should be given to the use of face masks. Improper technique can cause escape of anesthetic gases from around the mask and into the operating room.

3. Warning signs should be posted on the entrance to the recess room for the ethylene oxide sterilizer which restrict access while the sterilizer is discharging.

4. The ethylene oxide sterilizer system should be checked regularly for leaks and any need for repair or maintenance.

5. When removing objects from the sterilizer the employees should attempt to keep their faces as far from the objects as is practically feasible.

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 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. Indiana Occupational Safety and Health Administration
2. Administrator, Porter Memorial Hospital
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 I

Nitrous Oxide Sampling Results

Porter Memorial Hospital
Valparaiso, Indiana
HETA 84-145

April 24, 1984

Operating Room No.	Type of Anesthetic Procedure	Type of Sample	Description or Location	Sampling Time (from am to pm)	Concentration (ppm)
7	Intubation	Area	Taken before morning operations began-center of room	8:05-8:20	0
7	Intubation	Personal	Breathing zone of anesthesiologist	8:55-10:35 11:23-12:25	66 12
7	Intubation	Area	Wall opposite of anesthetic equipment, side nearer to door	8:48-2:10	12
7	Intubation	Area	Next to anesthetic equipment	8:48-10:35 11:20-12:25	138 73
7	Intubation	Area	Wall behind and nearest to anesthetic equipment	8:48-10:00 11:20-12:25	31 6
7	Intubation	Area	Wall opposite of anesthetic equipment, side farthest from door	8:48-10:00 11:20-12:25	31 6
6	Mask	Area	Taken before morning operations began-center of room	8:10-8:25	0
6	Mask	Personal	Breathing zone of anesthesiologist	8:51-9:22 9:45-10:10 10:30-10:46	21 3 80

(Continued)

Table I (Cont.)

Operating Room No.	Type of Anesthetic Procedure	Type of Sample	Description or Location	Sampling Time (from am to pm)	Concentration (ppm)
6	Mask	Area	Wall opposite to anesthetic equipment and near to exhaust vents	8:48-9:08	0
				9:10-9:28	7
				9:38-10:03	3
				10:05-10:30	3
				10:31-11:00	8
6	Mask	Area	Wall behind anesthetic equipment and opposite to exhaust vents	8:48-9:08	0
				9:10-9:28	6
				9:38-9:50	2
				10:05-10:30	3
				10:31-11:00	8
4	Intubation	Area	Next to and behind anesthetic equip.	12:34-1:13	11
4	Intubation	Area	Wall opposite to anesthetic equipment and near to exhaust vents	12:35-1:12	8
1	Intubation (no nitrous oxide used)	Area	Next to anesthetic equipment	1:50-2:50	0
1	Intubation (no nitrous oxide used)	Area	Wall behind anesthetic equipment	1:50-2:50	0
1	Intubation (no nitrous oxide used)	Area	Wall opposite anesthetic equipment	1:50-2:50	0

Table II

Sampling Results for Halogenated Anesthetic Gases

Porter Memorial Hospital
Valparaiso, Indiana
HETA 84-145

April 24, 1984

Operating Room No.	Type of Anesthetic Procedure	Type of Sample	Description or Location	Sampling Time (am to pm)	Concentration (ppm) Forane	Halothane	Ethrane
7	Intubation	Personal	Breathing zone of anesthesiologist	8:30-10:45	ND*	ND	ND
				11:03-12:25	ND	ND	ND
7	Intubation	Personal	Breathing zone of circulating nurse	8:25-12:35	ND	ND	ND
7	Intubation	Area	Next to anesthetic equipment	8:48-10:36	1	ND	ND
				11:20-12:25	ND	ND	ND
7	Intubation	Area	Wall opposite to location of anesthetic equipment	8:48-2:10	ND	ND	ND
6	Mask	Personal	Breathing zone of anesthesiologist	8:51-1:03	ND	2	ND
6	Mask	Personal	Breathing zone of circulating nurse	8:52-12:20	ND	ND	ND
6	Mask	Area	Wall behind anesthetic equipment and opposite to exhaust vents	8:48-12:19	ND	ND	ND
6	Mask	Area	Wall opposite of anesthetic equipment and near to exhaust vents	8:48-12:19	ND	ND	ND
4	Intubation	Personal	Breathing zone of anesthesiologist	12:24-1:32	ND	ND	ND
4	Intubation	Personal	Breathing zone of circulating nurse	12:21-1:27	ND	ND	ND
1	Intubation	Personal	Breathing zone of anesthesiologist	1:30-2:55	ND	ND	ND
1	Intubation	Personal	Breathing zone of circulating nurse	1:22-2:55	ND	ND	ND
1	Intubation	Area	Next to anesthetic equipment	1:50-2:50	ND	ND	ND

* ND = None detected, less than 0.03 mg/sample or approximately 0.6 ppm for forane; less than 0.1 mg/sample or approximately 1.8 ppm for halothane; and less than 0.03 mg/sample or approximately 0.6 ppm for ethrane.

Table III

Air Sampling for Ethylene Oxide Using Charcoal Tubes

Porter Memorial Hospital
Valparaiso, Indiana
HETA 84-145

April 24, 1984

Job Title or Location	Sample Type	Sampling Time (am to pm)	Concentration (ppm) Front	Back
			Sections	
Sterilizer Operator	Personal	10:30-2:15	Trace*	N.D.**
Central Service Aid	Personal	10:32-2:15	0.1	N.D.
Central Service Aid	Personal	10:34-2:18	0.2	N.D.
Central Service Aid	Personal	10:38-2:18	0.2	N.D.
About 6 Inches in Front of Sterilizer at Breathing Zone Level	Area	11:14-2:15	0.15	N.D.
Breathing Zone Level at the Door to Sterilizer	Area	1:27-2:12	2.2	N.D.

* Trace = Between the limit of detection and the limit of quantification.

** N.D. = None detected, less than 0.1 micrograms per sample or approximately 0.014 ppm.

Table IV

Air Sampling for Ethylene Oxide Using Portable Gas Chromatograph

Porter Memorial Hospital
Valparaiso, Indiana
HETA 84-145

April 24, 1984

Description	Ethylene Oxide Concentration (ppm)
Above sterilizer door, 25 minutes before end of cycle	<0.5
In cylinder closet, 20 minutes before end of cycle	0.3
Above sterilizer, in recess room	0.5
Above sterilizer, in recess room	<0.5
Above closed sterilizer door, during cycle	1.0
Above closed sterilizer door, during cycle	0.5
Above sterilizer door, when seal broken	0.5
Inside sterilizer	200*
Near sterilizer door, when opened wide	5
Operators breathing zone during transfer of materials out of sterilizer	<0.5
General room air after sterilization procedure finished	<0.5

* Estimated Value

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