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WEST SEATTLE COMMUNITY HOSPITAL
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I. SUMMARY

On October 27, l986, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate exposures to waste anesthetic gases and vapors in the operating rooms of West Seattle Community Hospital, Seattle, Washington. The requester was concerned with potential exposures to waste anesthetic gases from the anesthesia equipment used during surgical procedures.

In November 1986, NIOSH investigators conducted an environmental investigation at the hospital. Environmental sampling for nitrous oxide (N_20), ethrane, halothane and isoflurane, was conducted in the three operating rooms (OR's) where general anesthesia was being administered, as well as the recovery room and OR reception area. In addition, environmental monitoring for ethylene oxide (EtO) was conducted in the adjacent Central Services area where a gas sterilizer was located.

Analysis of l5 personal breathing zone and general area air samples collected for N_20 in the three OR's revealed nine samples to be below the limit of detection (LOD) of 5 parts of contaminant per million parts of air (ppm). The remaining six samples showed time-weighted average concentrations (TWA's) of N_20 ranging from 20 to 65 ppm, with a mean concentration of 46 ppm. Five of these samples exceeded the NIOSH Recommended Exposure Limit (REL) of 25 ppm for N_2O. Nitrous oxide was found to be below the LOD in two personal samples collected in the recovery room, as well as in two area samples collected in the reception area outside of the OR's. Leak testing for N_2O conducted in the OR's using direct reading instrumentation identified a number of leaks from high pressure gas supply fittings, anesthetic cart components, and the scavenging system.

Of 12 personal and area samples collected in the three OR's for the halogenated anesthetic agents, isoflurane was found in all 12 samples at concentrations ranging from 0.09 to 1.96 ppm, with a mean of 1.02 ppm; ethrane was found in three of the 12 samples at concentrations ranging from 0.36 to 0.96 ppm, with a mean of 0.62 ppm; and in all 12 samples halothane was found to be below the LOD of 0.01 milligrams per sample. Isoflurane was also detected in a personal sample collected in the recovery room, and in an area sample collected in the OR reception area at TWA concentrations of 0.69 and 0.65 ppm respectively. Two of the samples for ethrane, and three of the samples collected for isoflurane exceeded the NIOSH REL of 0.5 ppm for halogenated anesthetic agents when used in combination with N_2O. There are currently no Occupational Safety and Health Administration (OSHA) standards for N_2O or the halogenated anesthetic agents.

Results of one personal and one area sample collected for EtO in the Central Services area revealed TWA concentrations of 0.ll and 0.02 ppm, respectively. NIOSH recommends exposure to EtO be reduced to the lowest feasible level, while the OSHA standard is 1.0 ppm as a TWA.

On the basis of environmental data obtained during this investigation, it was determined that a health hazard existed from overexposures to nitrous oxide, ethrane, and isoflurane. Recommendations are included in this report to assist the hospital in the reduction of these exposures .

Key Words: SIC 8062 (General Medical and Surgical Hospitals) Nitrous oxide, ethrane, halothane, isoflurane, ethylene oxide, halogenated anesthetics, scavenging.

II. INTRODUCTION

On October 27, l986, NIOSH received a request from an authorized representative of the West Seattle Community Hospital, Seattle, Washington, for a health hazard evaluation in the surgery department. The requester was concerned with the adequacy of the scavenging system in the hospital's three operating rooms.

On November 17-20, 1986, NIOSH investigators conducted an environmental evaluation at the hospital. This evaluation consisted of an initial meeting with representatives of the hospital and the OR nursing staff, followed by the collection of environmental samples for nitrous oxide and halogenated anesthetics during surgical procedures conducted on two separate days. In addition, samples for ethylene oxide were collected in the Central Services area adjacent to the OR's. Results of the environmental samples were discussed with the anesthesiologist during the course of the evaluation and later by telephone following the receipt of sample results from the laboratory.

III. BACKGROUND

West Seattle Community Hospital, located in Seattle, Washington, has four operating rooms which were built in 1974. Operating room No. 1 is used for minor surgery, OR's No. 2 and No. 3 for major surgery, with OR No. 4 no longer in use at the time of the survey. A variety of procedures are routinely performed in these OR's, using both general and local anesthesia. As a minimum, each procedure will usually involve a surgeon, an anesthesiologist or anesthetist, a scrub nurse, and a circulating nurse. The anesthetic carts in each of the OR's are equipped with a waste anesthetic scavenging system which uses the central vacuum system for waste gas disposal.

IV. EVALUATION DESIGN AND METHODS

The environmental survey was designed to assess employee exposures to N_2O and the halogenated anesthetic agents during the course of the surgical procedures, as well as to identify potential sources of waste anesthetic gas exposure through leak detection using direct reading instrumentation. Environmental samples collected for the assessment of employee exposures included both personal (collected in the vicinity of the employees breathing zone) and general area samples (collected at personnel locations where the collection of personal samples was not feasible). Samples were collected using battery-powered sampling pumps operating at approximately 100 to 200 cubic centimeters of air per minute (cc/min) attached via Tygon tubing to an appropriate collection device or media. For N_2O, the collection device consisted of a 20 or 40 liter Tedlar bag. These bag samples are analyzed immediately following the surgical procedure using an infrared analyzer (Foxboro Miran 103 Specific Vapor Analyzer) in accordance with NIOSH analytical method 6600.[1] For the halogenated anesthetic agents, the collection media consisted of an activated charcoal tube. These samples were later analyzed according to NIOSH method l003, for ethrane, halothane, and isoflurane.[1] A complete listing of information pertinent to sample collection is included in Tables 1 and 2.

Leak detection of high pressure N_2O gas supply system was conducted prior to surgery in each of the OR's. This included measurements taken in the vicinity of the gas supply fittings on the ceiling, along the length of the supply hose, and at the point of connection to the anesthetic cart. In addition, leak testing was conducted during the surgery

procedures in one of the OR's. This included measurements taken directly at the various components of the anesthetic cart and scavenging system. These measurements were made using a flexible sampling probe attached to the portable infrared analyzer. A complete listing of the locations of these measurements is provided in Table 3.

Since a gas sterilizer (3M Sterivac Gas Sterilizer 400 B) was also present in a central supply area adjacent to the OR's, samples for EtO were collected by the previously described method, using treated charcoal tubes as the collection media. These tubes were later analyzed for EtO according to NIOSH Method l64l. A listing of other information pertinent to sample collection is provided in Table 4.

In addition to the collection of environmental samples, ventilation design specifications were reviewed with a representative of the hospital's facilities department in order to assess the adequacy of the general ventilation system in the OR's and recovery area.

V. EVALUATION 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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations [Recommended Exposure Limits or REL's], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) [Threshold Limit Values or TLV's], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits or PEL's]. 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 exposure limits 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 required by the Occupational Safety and Health Act of 1970 (29 USC 65l, et seq.) 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.

A. Anesthetic Gases

Reports by Vaisman and Askrog and Harvald 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.[2,3] In 1974, the American Society of Anesthesiologists (ASA) published the results of a study indicating "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 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.[6]

In a study published by NIOSH in 1976, "N_2O 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.[5] 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.[6,7]

Mortality and other epidemiologic studies have raised the question of possible carcinogenicity of anesthetic gases, but sufficient data are presently lacking to list N_2O or halothane as suspected carcinogens.

In a study of dentists, Cohen et al. compared exposed persons who used inhalation anesthetic more than 3 hours per week with a control group who used no inhalation anesthetic. The exposed group reported a rate of liver disease of 5.9 percent, in comparison with a rate of 2.3 percent in the control group. Spontaneous abortions were reported in 16 percent of pregnancies of the wives of exposed dentists, in comparison with 9 percent of the nonexposed. This difference was statistically significant; however, it should be noted that the rate of spontaneous abortions for all pregnancies ranges from 10 to 20 percent.[8] This study did not identify the specific anesthetic being used by the dentists surveyed, that is, whether they used N_20 alone or in combination with a halogenated agent.[9] However, in a review of that study, NIOSH concluded that "the halogenated anesthetics alone do not explain the positive findings of the survey and N_20 exposure must be an important contributing factor, if not the principal factor".[10] This conclusion is based on a calculation which assumed that as many as 1 in 10 of the dentists using an inhalation anesthetic employed a halogenated agent. If the actual fraction is less than 1 in 10, the conclusion has added strength.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH recommended a maximum exposure of 50 ppm N_2O on a time-weighted average basis during the anesthetic administration in dental offices.[6] This recommendation is based primarily on available technology in reducing waste anesthetic gas levels in these environments.

When N_2O is used as the sole anesthetic agent in medical procedures, NIOSH recommends that occupational exposure 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 be controlled so that no worker is exposed at concentrations greater than 2 ppm of any halogenated anesthetic agent during the period of anesthetic administration. When used in combination with N_2O, halogenated anesthetic agents should be controlled to 0.5 ppm, which, generally, can be arrived at by controlling N_2O to a TWA concentration of 25 ppm during the period of anesthetic administration.[6] There are presently no OSHA standards or ACGIH TLV's for nitrous oxide or the halogenated anesthetic agents. However, in it's "Notice of Intended Changes" for 1986-87, ACGIH has proposed TLV's of 75 ppm for ethrane, and 50 ppm for halothane.

B. Ethylene Oxide (Et0)

The acute toxic effects of Et0 in humans and animals include acute skin, respiratory, and eye irritation; skin sensitization; nausea, vomiting, and diarrhea; and nervous system effects. Nonmalignant chronic effects in humans include anemia and respiratory irritation, with susceptibility to secondary respiratory infection. Further, occupational exposure to Et0 may increase the frequency of mutations in human populations as noted in a 1977 NIOSH Criteria Document.[11] More recently, cases of peripheral neuropathy among exposed workers have been reported.[12]

A recent study demonstrates that EtO induces cancer in experimental animals.[23] A dose-related increase in mononuclear cell leukemia was established in that study; exposures as low as 10 ppm increased the proportion of female rats with the leukemia. Also, experiments indicate that Et0 exposure to either male or female animals results in adverse effects on reproduction.[14,15]

In humans, epidemiologic investigations of cancer mortality among Swedish workers exposed to Et0 suggest an increased risk of leukemia and other cancers.[16,17] Recent information also suggests that Et0 is associated with chromosomal abnormalities in peripheral lymphocytes of exposed workers.[18]

Based on this information, NIOSH recommended in a 198l Current Intelligence Bulletin that Et0 be regarded in the workplace as a potential occupational carcinogen, and that exposure be reduced to the extent possible.[19] An 8-hour TWA below 0.1 parts per million (ppm), and a ceiling limit not to exceed 5 ppm during any 10 minute period in a working day is recommended by NIOSH.[20] The current OSHA standard for Et0 is 1 ppm as an 8-hour TWA, with an action level of 0.5 ppm which triggers employee exposure monitoring and medical surveillance provisions.[21]

VI. RESULTS

A. Nitrous Oxide

The results of the environmental samples collected for N_2O are presented in Table 1. As evidenced by these data, of the l5 personal breathing zone and area air samples collected for N_20 in the three OR's, 9 samples were found to be below the limit of detection (LOD) of 5 parts of contaminant per million parts of air (ppm). The remaining six samples showed time-weighted average concentrations (TWA's) of N_20 ranging from 20 to 65 ppm, with a mean concentration of 46 ppm. Five of these samples exceeded the NIOSH Recommended Exposure Limit (REL) of 25 ppm for N_2O. There is currently no OSHA standard or ACGIH TLV for N_2O. In addition to the OR's, concentrations of nitrous oxide were found to be below the LOD in two personal samples collected in the recovery

room, as well as in two area samples collected in the reception area outside of the OR's.

B. Halogenated Anesthetic Agents

The results of the environmental samples collected for halogenated anesthetic agents are presented in Table 2. Of 12 personal and area samples collected in the three OR's for the halogenated anesthetic agents, isoflurane was found in all 12 samples at concentrations ranging from 0.09 to 1.96 ppm, with a mean of 1.02 ppm; ethrane was found in three of the 12 samples at concentrations ranging from 0.36 to 0.96 ppm, with a mean of 0.62 ppm; and in all 12 samples halothane was found to be below the LOD of 0.01 milligrams per sample. Isoflurane was also detected in a personal sample collected in the recovery room, and in an area sample collected in the OR reception area at TWA concentrations of 0.69 and 0.65 ppm respectively. Two of the samples for ethrane, and three of the samples collected for isoflurane (all in OR No. 3) exceeded the NIOSH REL of 0.5 ppm for halogenated anesthetic agents used in combination with N_2O. The determination of whether or not the anesthetic agent was used in combination with nitrous oxide was based on the results of the N_2O analysis (Table 1). There are currently no Occupational Safety and Health Administration (OSHA) standards for halogenated anesthetic agents.

C. Leak Detection

The results of the leak detection testing for nitrous oxide are presented in Table 3. As evidenced by this data, a number of leaks in both the the high pressure gas supply system (OR's No. 1, 3, and 4) and and the low pressure gas delivery system (Or No. 3) were identified. It should be noted that the concentrations presented in this Table are measurements taken in close proximity to anesthetic supply and delivery apparatus, and therefore do not directly relate to employee exposures . However, these readings do provide a relative index of the magnitude of the leakage, and indirectly would be expected to contribute to overall employee exposures.

D. Ethylene Oxide

Results of the one personal and one area sample collected for EtO in the Central Services area revealed TWA concentrations of 0.ll and 0.02 ppm, respectively. These values are both below the OSHA standard and ACGIH TLV of 1.0 ppm as a TWA. NIOSH recommends exposure to EtO be reduced to the lowest feasible level.

E. General Ventilation

A review of the design specifications for the general ventilation in the OR's revealed the following number of air changes per hour (ACH); 15 ACH for OR No. 1, 17 ACH for OR's 2 through 4, and 4 ACH for the Recovery Room. While there are no NIOSH criteria for general ventilation, the Department of Health and Human Services "Guidelines for Construction and Equipment of Hospital and Medical Facilities" currently recommends a minimum of 20 total ACH for operating rooms, and 6 total ACH for recovery rooms.[22] In all cases, the amount of air supplied to the rooms exceeded the amount of air exhausted, thus creating a positive pressure, as is generally required in OR's.[22] It should be noted that the calculated ACH values are based on "design" specifications, since actual ventilation measurements were not made at the time of the survey.

VII. DISCUSSION AND CONCLUSIONS

Exposures to nitrous oxide, ethrane and isoflurane were found to exceed the NIOSH REL in personal breathing zone and area samples collected in OR No. 3. However, in OR No. 1, concentrations of isoflurane ranged from 55 to 98% of the NIOSH REL, and in OR No. 2 concentrations of isoflurane ranged from 66 to 94% of the NIOSH REL. Therefore, although OR 3 was the only OR where the NIOSH REL was actually exceeded, exposures in the remaining two active OR's were substantial and came very close to exceeding the evaluation criteria for halogenated anesthetics when used by themselves.

In addition to the personal breathing zone and area air samples which were collected, the leak detection survey revealed a number of leaks in both the high pressure gas supply system and the anesthetic delivery system. Of primary importance in maintaining waste anesthetic concentrations within acceptable levels is the regular maintenance of equipment in order to prevent leakage. Recent data indicates that leaks from the high pressure portion (which includes the N_2O supply lines, the connections at and between the ceiling and anesthesia machine, and the connector-control valve from the flowmeter) and low pressure portion (including the flowmeter, vaporizer, reservoir bag, popoff valve, endotracheal tube, automatic ventilator, and CO_2 absorber) of the anesthetic delivery system resulting from poor maintenance of the anesthetic unit is a primary source of employee exposures in the OR.[23]

Proper work practices are also a key element in controlling waste anesthetic gas exposures. One study estimated that 94 to 99 percent of all waste gas exposure in OR's equipped with properly designed scavenging components may be the result of poor work practices of the anesthetist.[24] Improper work practices include the use of poorly fitting face masks, insufficient inflation of endotracheal tubes, and spillage of volatile anesthetic agents while filling vaporizers. While no instances of poor work practices were noted during this survey, it is important to continually emphasize to staff anesthesiologists and nurse anesthetists the need for using proper anesthetic techniques aimed at reducing waste gas exposure.

While local exhaust ventilation (such as scavenging) is the preferred means of eliminating waste gases at their point of generation, general room ventilation also plays an important role in maintaining acceptable waste gas levels in the OR. Reasons for maintaining good general ventilation exchange rates include the rapid removal of waste gases generated by anesthesia induction, poorly fitting face masks, improperly inflated endotracheal tubes, or low or high pressure leaks which may occasionally develop in the system. As evidenced by the detectable levels of isoflurane in the personal sample collected in the recovery room, and in the area sample collected at the OR reception desk, maintaining good general ventilation is also necessary in related areas. Since scavenging systems are not present in these areas, general ventilation is relied on to remove the waste gases expired by the patient in the recovery room, or in the case of the OR reception area, leakage resulting from the outward direction of airflow from the OR's.

VIII. RECOMMENDATIONS

In order to effectively control employee exposures to waste anesthetics in the operating rooms and adjacent areas, a comprehensive program is necessary which addresses exposure monitoring, anesthetic equipment maintenance, work practices, and medical surveillance. A detailed discussion of these recommendations is provided in the NIOSH criteria for a recommended standard....occupational exposure to waste anesthetic gases and vapors.[6] A copy of this document has been provided separately to a hospital representative. Due to the length of these recommendations they are not repeated in their entirety in this report. However, based on the findings of the environmental survey, select recommendations which are considered particularly applicable to this facility are presented below.

l. Inspection and maintenance of all the nitrous oxide supply hoses and connections should be initiated in all 4 of the operating rooms.

2. Employees should continue to check all components of the anesthetic gas delivery system for wear and possible leakage.

3. Periodic air monitoring should be conducted in all operating rooms to insure that employee exposures are properly controlled.

4. All employees should be kept informed of the current toxicological information related to waste anesthetic gases and ethylene oxide.

5. Ventilation should be checked and modified if necessary to meet Department of Health and Human Services recommendations of at least 20 air changes per hour.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office, at the Cincinnati address.

Copies of this report have been sent to:

1. West Seattle Community Hospital
2. U.S. Department of Labor/OSHA - Region X
3. NIOSH - Denver Region
4. Seattle State Health Department
5. State Designated Agency

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

Table 1

Breathing Zone and General Room Air Concentrations of Nitrous Oxide

West Seattle Community Hospital, Seattle, Washington

November 18 & 20, 1986

SAMPLE TYPE	LOCATION (OR No.)	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION NITROUS OXIDE (PPM)
Personal	1	Scrub Nurse	7:50a - 9:38a	< LOD
Personal	1	Scrub Nurse	9:38a - 11:03a	< LOD
Personal	1	Circ. Nurse	7:58a - 9:38a	< LOD
Personal	1	Circ. Nurse	9:38a - 11:00a	< LOD
Personal	1	Anesthetist	8:00a - 9:35a	< LOD
Personal	1	Anesthetist	9:35a - 11:05a	< LOD
Personal	2	Anesthetist	8:05a - 9:32a	< LOD
Personal	2	Scrub Nurse	8:07a - 9:28a	< LOD
Personal	2	Circ. Nurse	8:15a - 9:32a	< LOD
Personal	3	Anesthetist	9:32a - 11:09a	50
Personal	3	Scrub Nurse	9:28a - 10:56a	40
Personal	3	Circ. Nurse	9:32a - 10:52a	20
Area	3	On Anest. Cart	12:35p - 1:30p	65
Personal	3	Scrub Nurse	12:30p - 1:30p	50
Personal	3	Circ. Nurse	12:35p - 1:30p	50
Personal	Recovery	Nurse	8:12a - 9:20a	< LOD
Personal	Recovery	Nurse	9:20a - 10:50a	< LOD
Area	Reception	On Desk	8:25a - 10:00a	< LOD
Area	Reception	On Desk	10:00a - 11:07a	< LOD

Evaluation Criteria - NIOSH REL - 25 ppm during the period of administration.

< LOD - Less than the limit of detection of 5 ppm.

Table 2

Breathing Zone and General Room Air Concentrations of Halogenated Anesthetic Agents

West Seattle Community Hospital, Seattle, Washington

November 18 & 20, 1986

SAMPLE TYPE	LOCATION (OR No.)	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION ETHRANE (PPM)	TWA CONCENTRATION HALOTHANE (PPM)	TWA CONCENTRATION ISOFLURANE (PPM)
Personal	1	Circ. Nurse	7:58a - 11:00a	< LOD	< LOD	1.09*
Personal	1	Scrub Nurse	7:50a - 11:03a	< LOD	< LOD	1.96*
Area	1	On Anest. Cart	8:00a - 11:05a	< LOD	< LOD	1.42*
Personal	2	Scrub Nurse	8:07a - 9:29a	< LOD	< LOD	1.52*
Personal	2	Circ. Nurse	8:15a - 9:32a	< LOD	< LOD	1.87*
Area	2	On Anest. Cart	9:15a - 10:32a	< LOD	< LOD	1.32*
Personal	3	Scrub Nurse	9:29a - 10:56a	< LOD	< LOD	0.09**
Personal	3	Circ. Nurse	9:32a - 10:52a	< LOD	< LOD	0.32**
Area	3	On Anest. Cart	10:32a - 11:09a	< LOD	< LOD	0.17**
Area	3	On Anest. Cart	12:35p - 1:30p	0.36**	< LOD	1.07**
Personal	3	Scrub Nurse	12:30p - 1:30p	0.54**	< LOD	0.67**
Personal	3	Circ. Nurse	12:30p - 1:30p	0.96**	< LOD	0.72**
Personal	Recovery	Nurse	8:21a - 10:50a	< LOD	< LOD	0.69*
Area	Reception	On desk	8:25a - 11:07a	< LOD	< LOD	0.65*

EVALUATION CRITERIA

*NIOSH REL - Halogenated Anesthetics, 2.0 ppm when used alone.

**NIOSH REL - Halogenated Anesthetics, 0.5 ppm when used in conjunction with N_20.

< LOD - Less than the limit of detection of 0.02 mg/tube for ethrane, and 0.01 mg/tube for halothane and isoflurane.

Table 3

Results of Leak Detection Survey for Nitrous Oxide

West Seattle Community Hospital

Seattle, Washington

November 18 & 20, 1986

LOCATION (OR NO.)	SAMPLE DESCRIPTION	PEAK CONCENTRATION OF NITROUS OXIDE (PPM)
High Pressure Leak Tests of Gas Supply Lines - No Surgery Occurring		
1	N_20 Female Gas Supply Connector	> 1000
2	All High Pressure Fittings	< LOD
3	Southwall N_20 Gas Supply Fittings	> 1000
3	N.E. Corner N_20 Female Gas Supply Fittings	> 1000
4	N.E. Corner N_20 Female Gas Supply Fittings	> 1000
Anesthetic Cart Testing - During Surgical Procedures		
3	Background at Anest. Cart	50
3	Scavenging Connection - Lg. hose to sm. hose	40
3	"Y" piece on scavenging hose	40
3	Top of Ventilator	125
3	Pop-off Valve	50
3	Hose from Anest. Cart to Patient	800
3	Return Hose to Anest. Cart from Face Mask	50
3	Breathing Zone of Anesthesiologist	50
3	High Pressure Slip Conn. at N_20 Supply	> 1000

< LOD - Less than the limit of detection of 5 ppm

Table 4
Breathing Zone Air Concentrations of Ethylene Oxide
West Seattle Community Hospital
Seattle, Washington
November 18 & 20, 1986

SAMPLE LOCATION	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION ETHYLENE OXIDE (PPM)
Central Services	Personal Supply Technician	5:00 - 10:40	0.11
Central Services	General Area Mid-Room	5:00 - 10:40	0.02

Evaluation Criteria: OSHA Standard - 1.0 ppm TWA
NIOSH REL - Lowest Feasible Level

Limit of Detection: .0013 mg/sample