U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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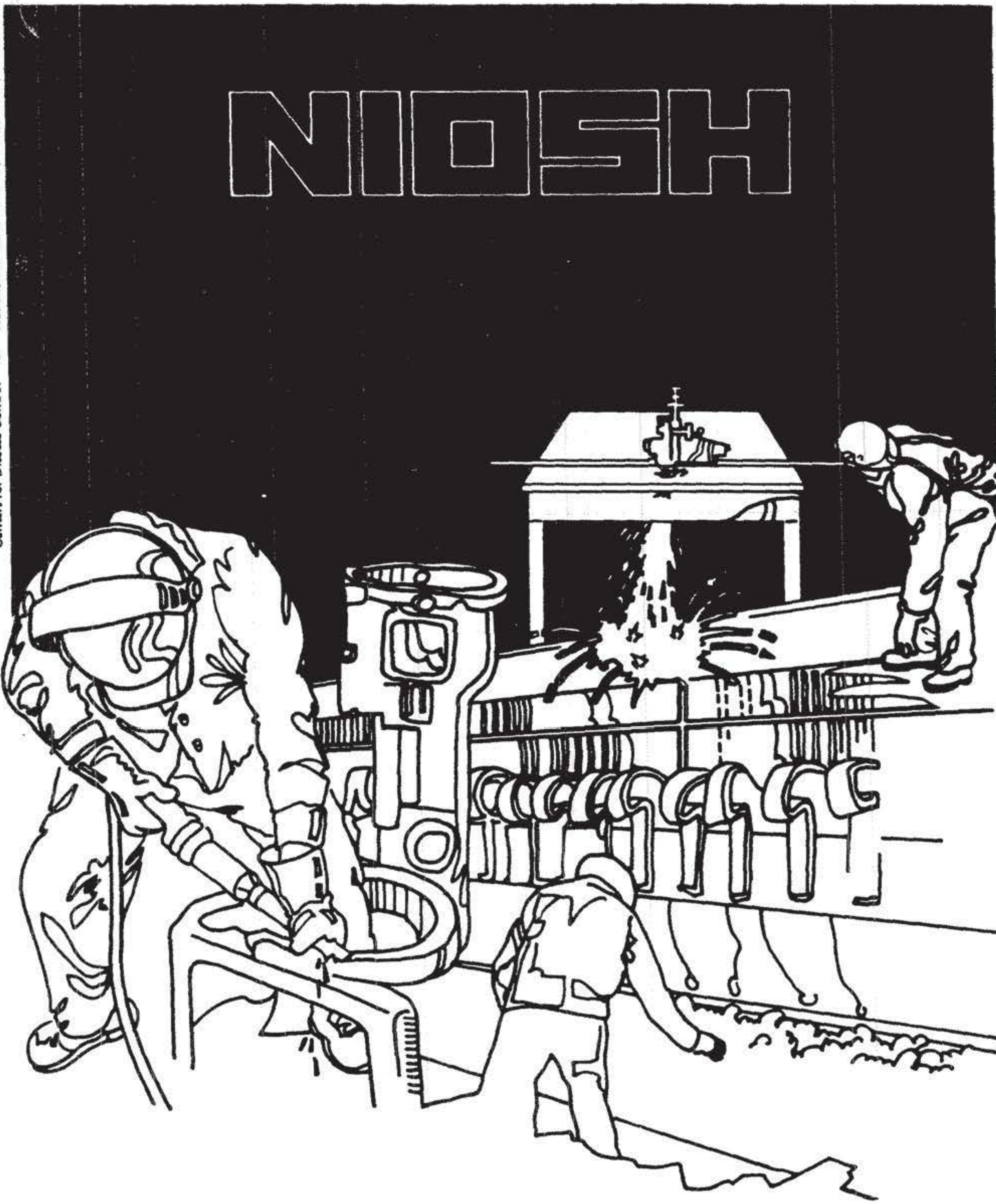

Health Hazard Evaluation Report

HETA 82-094-1195
VETERANS ADMINISTRATION
MEDICAL CENTER
BRONX, NEW YORK

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 82-094-1195
SEPTEMBER 1982
VETERANS ADMINISTRATION
MEDICAL CENTER
BRONX, NEW YORK

NIOSH INVESTIGATOR:
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I. SUMMARY

On January 4, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at the Veterans Administration Medical Center in Bronx, New York. The request was submitted by hospital officials, because of alledged headache, nausea, and dizziness among workers in spinal Ward 1E and Operating Room Suite 2E at the hospital.

In response to this request, two NIOSH industrial hygienists conducted a survey including a walk-through of the facility and environmental sampling, on February 8-10, 1982.

A total of 40 waste anesthesia gas samples were collected in various locations of 1E and 2E Operating Room Suites; 12 personal breathing zone (PBZ) and eight area air samples for nitrous oxide (N_2O); five PBZ and six area samples for halothane and enflurane. PBZ N_2O exposure levels ranged from 2 to over 280 parts per million parts of air (ppm), including six that exceeded the NIOSH recommended criteria of 25 ppm during one anesthesia administration period. Area N_2O levels ranged from 2 to 85 ppm, two of which exceeded the NIOSH recommended criteria. PBZ enflurane exposure levels ranged from non-detectable to 0.006 ppm, and area enflurane levels ranged from non-detectable to 0.0003 ppm. Both PBZ and area enflurane levels were below the NIOSH recommended standard of 0.50 ppm. All halothane levels were non-detectable.

Twenty-six mercury measurements were conducted using a Johnson and Williams (Model No. MV-2) mercury sniffer in the hospital dental wards. All measurements showed that mercury levels were non-detectable. Hospital officials requested these measurements, because no previous mercury monitoring had been conducted at the hospital. Six carbon monoxide (CO) and oxides of nitrogen (NO_x) samples were collected in 1E, Spinal Wards; and 2E, Operating Room Suites using colorimetric detector tubes. Both CO and NO_x levels were non-detectable, indicating that exhaust fumes were not present.

One E and 2E employees feel that headaches occur more often, when exhaust fume smells are noticed in their area. No exhaust fume smells were noticed on the survey day, and headaches were not a problem with all employees. Hospital officials think that air handling unit location, with respect to the loading docks, is the reason for exhaust fume smells in 1E and 2E. In certain weather conditions this is a possibility, but on the survey day prevailing winds were such that any loading dock truck fumes would have been carried away from the area.

It appears that headaches among hospital employees are a problem in 1E and 2E areas of the hospital, and that they occur more often when exhaust fume smells are noticed in the areas. Based on the survey, loading dock trucks are a potential source for exhaust fumes, because of the hospital's air handling unit locations with respect to the loading dock. In addition, several N_2O exposure levels in the operating room were in excess of those recommended by NIOSH. Recommendations aimed at reducing exposure levels have been included in Section VII of this report.

KEYWORDS: SIC 2519, Nitrous Oxide, halothane, enflurane, anesthesia gases.

II. INTRODUCTION/STATEMENT OF REQUEST

On January 4, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation at the Veterans Administration Medical Center in Bronx, New York. The request was submitted by hospital officials because of alledged headache, nausea, and dizziness among workers in the Spinal Ward 1E and the Operating Room Suite 2E at the hospital.

In response to this request, two NIOSH industrial hygienists conducted a survey including a walk-through of the facility and environmental sampling on February 8-10, 1982.

Interim survey results were submitted to the hospital in a letter dated March 8, 1982.

III. BACKGROUND

A. Process Description and Work Force

The VAMC is approximately 2 years old and employs about 2,000 people. Only three areas were covered during the survey; 1E spinal ward, 2E operating rooms, and the dental wards.

1E spinal ward is a typical hospital ward located on the first floor, containing 16 rooms where patients are housed and treated for periods of time ranging from several months to several years depending on the individual case. Approximately 80 staff members including nurses, aides, technicians, and maintenance personnel are employed in the area.

2E is the operating room (OR) area located in the same hospital wing one floor above 1E and contains 10 operating rooms of which only 6 are functional. Approximately 80 staff members including nurses, technicians, and anesthesists, assist surgeons and anesthesiologists in various types of operations which range in length from 2 hours to over 6 hours. A typical surgical team in an operating room consists of a surgeon, an anesthesiologist, a circulating nurse, a scrub nurse, and a technician.

Anesthetic gases used in the operating rooms include Nitrous Oxide (N_2O) in combination with halothane or enflurane.

There are two basic components making up the anesthetic circuit of the anesthetic gas machine; the anesthesis mechanism and the breathing system. The anesthesis mechanism vaporizes the anesthetics (halothane or enflurane) and combines them with nitrous oxide and oxygen. The breathing system contains a soda lime canister for absorbing exhaled carbon dioxide, a breathing bag (ventilator), control valves for regulating gas flow, flexible hoses, and "Y" fitting for attaching the face mask or endotracheal tube. The endotracheal tube is used over 90% of the time at the VAMC.

Prior to the operation, an anesthetic gas mixture is administered to the patient, via the anesthetic circuit, at a rate greater than the patient's metabolic needs. A pop-off valve (also called expirator pressure relief valve) on the anesthetic circuit was adapted to vent off excess gases into a scavenging hose, which is connected to the hospital's central exhaust system.

The pop-off valve could be a major source of waste gas leakage. Other sources of leakage would include face mask and endotracheal tubes, worn or rotted hoses, improper fitting of seals or connections, and spillage of liquid anesthetics.

The dental ward consists of 13 examining/treatment rooms, where typical dental procedures are performed. Mercury exposure levels had not been measured in the past; therefore, officials requested that NIOSH conduct sampling during the survey.

B. Ventilation

Each hospital area is serviced by its own air-handling unit. 1E's air-handling is located directly above the hospital loading dock, and 2E's directly above 1E's. Each air-handling unit can move around 25,000 cubic feet per minute of air (CFM), both servicing approximately 200,000 square feet of floor space. 1E's ventilation system delivers 25% fresh air to the area, while 2E operating rooms are supplied with 100% fresh air maintaining a positive pressure throughout.

A major concern of hospital officials is the fact that air-handling unit intakes serving 1E and 2E are located directly above the hospital loading dock, where all shipments to and from the hospital are handled. It is felt that idling trucks loading and unloading at the docks produce exhaust fumes which could be picked up by the air-handling units and carried into 1E and 2E; and therefore, account for employee complaints concerning fumes in these areas.

C. Monitoring

The hospital had records of environmental monitoring for N_2O in the operating rooms and anesthetic equipment maintenance checks, both conducted by a private consulting company. Their records were briefly reviewed. Maintenance checks were done on a regular basis, and N_2O levels typically ranged between 20 and 100 ppm.

IV. EVALUATION DESIGN AND METHODS

Initially, a review of recent literature dealing with anesthetic waste gases was conducted, and information was obtained on demographic data, hospital procedures, work force and schedules, and health effects prior to the site visit. Based on this and additional information collected during the walk-through of the facility, a sampling protocol was developed and conducted. Since the symptoms reported in the request are characteristic of anesthetic waste gas and exhaust fume exposures; and the fact that they both potentially exist at the hospital, environmental sampling was conducted for both.

A. Nitrous Oxide

Twelve personal breathing zone and eight area air samples for nitrous oxide (N_2O) were collected in 20 liter mylar bags, using personal sampling pumps, in 1E and 2E areas. When time permitted, personal samples on the anesthesiologist were taken during each operational procedure. Area samples typically covered more than one procedure because of time constraints in collection of samples.

Analyses of these samples were performed using a Wilks Miran Model 1A infrared analyzer. The range of detection was 2 to 280 parts of N_2O per million parts of air (ppm).

B. Halogenated Agents

Five personal breathing zone and six area air samples for halothane and enflurane were collected on charcoal tubes, using personal sampling pumps operating at 200 cubic centimeter per minute (cc/min), in 1E and 2E areas. Personal samples on the anesthesiologist typically were taken during individual operations. Area samples sometimes covered more than one operation, because of time constraints. Laboratory analyses was performed on these samples, using a gas chromatograph with a flame ionization detector, according to NIOSH Method No. P&CAM 127[1], with modification as follows:

1. Desorption Process: One hour minimum in 1 mL carbon disulfide containing 1 microliter/milliliter n-hexane as an internal standard.

2. Gas Chromatograph: Hewlett-Packard Model 5731 equipped with a flame ionization detector and accessories for capillary column use.

3. Column: 60 m x 0.32 mm I.D. fused silica WCOT capillary coated internally with 0.25 micrometers OV-351.

4. Oven Conditions: 60°C isothermal.

5. Other: Helium was used as the carrier gas in the split mode of operation. The split ratio used was 10:1.

C. Mercury

Twenty-six mercury measurements were taken, using the direct-reading Johnson & Williams (Model No. MV-2) mercury sniffer, in 13 rooms of the dental wards. The lower limit of detection for the mercury sniffer is 0.02 milligrams of mercury per cubic meter of air (mg/m^3). In each room measurements were conducted in two locations; beside the spit bowl, and the amalgum shaker. These shakers were not in use during the sampling. However the shakers are enclosed and it is unlikely that they would disseminate mercury vapor. The primary purpose of the twenty-six air samples was to determine if there was any waste mercury in the areas from previous spills.

D. Carbon Monoxide and Oxides of Nitrogen

Afternoon carbon monoxide (CO), Oxides of Nitrogen (NO_x), and colorimetric direct reading detector tube measurements were taken in five locations of the hospital: specific areas include; operating rooms 4 and 6 in 2E, and Rooms 01 and 10, and at the end of the hallway be side the window that is located be side the air handling unit in 1E area. The lower detection limit for the CO_2 and NO_x tubes are 5 ppm and 2 ppm, respectively. In addition information on schedules, production, and work practices for the loading dock, where CO_2 and NO_x are thought to be originating, were collected.

E. Ventilation

Air changes per hour for the operating rooms were calculated using ventilation information supplied by the medical center.

V. EVALUATION CRITERIA

A. Anesthetic Waste Gases

In the NIOSH Criteria Document for a recommended standard for occupational exposure to anesthetic gases, NIOSH states: "Current scientific evidence obtained from human and animal studies suggests that chronic exposure to anesthetic gases increases the risk of both spontaneous abortion among female workers and congenital abnormalities in the offspring of female workers and the wives of male workers. Risks of hepatic and renal diseases are also increased among exposed personnel. In addition, physiological function may be impaired. Effects on the central nervous system due to acute exposures to anesthetic gases have been associated with headaches, nausea, fatigue, irritability, etc." Control procedures and work practices presented in that document, however, should prevent the effects caused by acute exposure and significantly reduce the risk associated with long-term, low-level exposure. A dose/response relationship for halogenated anesthetic toxicity has not been defined.[2]

That same NIOSH publication recommends maximum exposures to 25 parts per million (ppm) nitrous oxide (time-weighted average concentration during anesthetic administration) and 2 ppm halogenated anesthetic when used alone, or 0.5 ppm when used with nitrous oxide. These recommendations are based upon available technology in reducing waste anesthetic gas levels.

B. Carbon Monoxide

Health effects caused by carbon monoxide (CO) inhalation are primarily acute including headache, nausea, dizziness, rapid breathing, unconsciousness, and death. The current OSHA standard is 50 parts of CO per million parts of air (ppm) averaged over a 10-hour workshift. NIOSH has recommended that the permissible exposure limit, reduced to 35 ppm, averaged over a 10-hour workshift, with a ceiling of 200 ppm.[3]

C. Oxides of Nitrogen

Inhalation of oxides of nitrogen (NO_x) can cause irritation to the eyes, nose, throat, and severe respiratory pulmonary edema when in high enough concentrations. The current OSHA standard for nitrogen dioxide is a ceiling of 5 ppm. NIOSH has recommended that the permissible exposure limit be reduced to a ceiling level of 1 ppm average over a 15-minute period.[4]

D. Mercury

Inhalation of mercury vapor may cause acute effects, such as headaches, cough, chest pain, chest tightness, and difficulty in breathing. Chronic or prolonged exposure to lower levels of mercury vapor cause effects on the central nervous system, which manifest themselves as tremors of the hand, eyelids, lips, tongue, or jaw. Other symptoms include skin rash, headache, sores in the mouth, sore and swollen gums, loose teeth, insomnia, excess salivation, personality change, irritability, indecision, loss of memory, and intellectual deterioration. The current OSHA standard for mercury is a ceiling level of 0.1 milligrams of mercury per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 0.05 mg/m^3, averaged over an 8-hour workshift.[5]

VI. RESULTS AND DISCUSSION

A. Nitrous Oxide

Results of the 20 nitrous oxide (N_2O) samples taken in 1E and 2E were variable (See Table I). The 12 personal breathing zone (PBZ) levels ranged from 2 to over 280 ppm, including 6 that exceeded the NIOSH-recommended standard of 25 ppm. Area N_2O levels ranged from 2 to 85 ppm, 2 of which exceeded NIOSH recommended criteria.

This extreme variability in N_2O levels can be attributed to several factors. During the time period between 1130 and 1230 the N_2O exposure level was very low (3 ppm) in OR 3, because local anesthesia was being administered, and all N_2O flow was shut down. Low levels (2 to 3 ppm), were found in Room 2E-20 (secretary's office) indicating that general ventilation was maintaining a negative pressure in the operating rooms, thus eliminating high background levels in 2E offices. The two excessively high N_2O level measured (above 280 ppm) occurred in OR 4, because a broken scavenging hose was allowing free flowing N_2O into the OR. Inspection of scavenging equipment in the other operating rooms also indicated that hoses were improperly connected to exhaust vents, and that short hoses were pieced together with medical gauze tape in order to reach the exhaust vents. Since 280 ppm N_2O level is the maximum limit of our analytical instrument, it is not certain exactly how high exposure levels actually were. N_2O levels of 2 ppm measured in Room 1E-10 indicates that nitrous oxide is not migrading from 2E OR floor down to 1E spinal wards. Levels measured in the recovery room and by the nurses desk are low, indicating that general ventilation is adequate.

B. Halogenated Agents

All 11 halothane and enflurane sample analysis showed extremely low levels (See Table II). The six PBZ exposure levels to enflurane ranged from non-detectable to 0.006 ppm. All area levels of enflurane were non-detectable, except one which was 0.0003 ppm measured in OR 6. All halothane levels (both area and PBZ) were non-detectable.

C. Mercury

Twenty-six mercury measurements conducted in 13 rooms of the dental ward showed levels were below the limit of detection of the Johnson and Williams mercury sniffer (Model No. MV-2), which is 0.02 mg/m^3. This indicates that there is no waste mercury in the rooms of the dental wards.

D. Carbon Monoxide (CO) and Oxides of Nitrogen (NOx)

Six colorimetric detector tube measurements taken for CO and NOx in the 2E OR's and in 1E spinal wards, showed no detectable levels of contamination present. Employees stated that they had not detected any exhaust fumes odors on the day of sampling in 1E and 2E hospital areas. They also felt that on the days when headaches were more prevalent they could smell exhaust fumes in the area, which seem to correspond with weather conditions and loading dock schedules. On the sampling day, 15 trucks were received in at the dock, and the weather was cool and dry with wind speeds of 10 to 20 miles per hour.

E. Ventilation

Based on calculation, there are approximately 4.8 air change-per hour in the operating rooms at the hospital. This value agrees with the suggested minimum rate of 5 air changes per hour for operating rooms supplied with 100% fresh air by Minimum Requirements of Construction and Equipment for Hospital and Medical Facilities (HEW Publication No. 74-4000, 1978 ed., Rockville, Md.)

VII. RECOMMENDATIONS

Based on the evaluation, it does not appear that any major adverse health effects are occurring due to occupational exposure to anesthetic waste gases, but that occasional problems with exhaust fume infiltration into 1E and 2E appears to increase headache complaints. Since environmental measurements did show exposure levels in excess of those currently recommended by NIOSH, several recommendations aimed at reducing exposures to anesthetic waste gases, as well as exhaust fumes, are listed below:

1. Presently used scavenging hoses should be replaced with ones long enough to reach the exhaust vents. Tape presently used to connect scavenging hoses to OR exhaust vents should be replaced with proper connections.

2. Scavaging equipment should always be used in all operating rooms to remove the contaminant from the area of the pop-off valve. Additionally, it is also important to reduce gas escape from other parts of the anesthesia machine by checking and maintaining anesthesia equipment on a regular basis. Face masks, tubing, breathing bags, and endotracheal tubes should be visually checked for cracks and other leak sources. Both high and low pressure components should be leak tested. The high pressure components, from N_2O and O_2 supply up to flow meter control valves, can be tested by applying soap solution to all connections. This should be done frequently. Low pressure components, including breathing bags and tubing, can be tested using the procedure presented in Appendix I of the NIOSH criteria document on waste anesthetic gases[2] and are shown below:

   a. Assemble the anesthesia machine as in the usual manner for clinical anesthesia with breathing tubes, Y-piece, breathing bag, and high pressure hoses or cylinders connected.

   b. Occlude the Y-piece securely with the thumb or palm of hand.

   c. Pressurize the breathing system to 30 cm water, observed on the absorber pressure gauge. This may be accomplished by using the oxygen flush valve.

d. Add a sufficient flow of oxygen through the low-range flow meter to maintain a constant pressure of 30 cm water in the breathing system. The oxygen flow required to maintain the pressure is a measure of the leak rate. This test may be abbreviated by using an oxygen flow rate of 100 mL/minute. If pressure in the system increases, the breathing system is below the maximum allowed leak rate.

e. Determine the presence of check valves downstream from the flow meters by consulting the manufacturer or a serviceman. These valves must be tested differently. With oxygen flowing as described in d., briefly turn off, in turn, each flow meter which is equipped with a check valve, until there is a rise in pressure on the absorber gauge. An increase in pressure indicates absence of leakage in the circuit tested.

The low pressure leak rate should be below 100 mL per minute.

Small components such as breathing bags and hoses can be leak tested separately by pressurization, immersion in water, and observation of any bubbles. In situations where this is not practical, it is recommended that fittings and seals be checked periodically to make sure gaskets and o-rings are in place properly, that connections are tight and not worn, and that moisture or chemical action has not caused corrosion or degradation of materials. Typical places to check, and where leaks have been found in other studies, include the seals at the domed unidirectional valves, seals at the top, bottom, and center of the CO_2 absorber, and fittings where the breathing tubes connect to the machine and to the Y-piece.

In addition to a scavaging system and proper equipment maintenance, the anesthetists can reduce exposure by good work practices. Improper practices, such as poor choice of face mask, insufficiently inflated endotracheal tubes, and spillage of volatile anesthetic agents when filling vaporizers, are chief contributors to exposure.

3. A surveillance system should be established and implemented to record dock traffic as well as headache and exhaust fume smell problems in 1E and 2E. If a correlation between the two can be documented, appropriate control measures should be taken. In the interim, it would be advisable to have dock officials instruct truck drivers to allow trucks to idle no longer than is necessary, when loading and unloading at the dock.

VIII. REFERENCES

1. National Institute for Occupational Safety and Health. Manual of Analytical Methods, 2nd ed. Vol. 1-7.

2. NIOSH criteria for a recommended standard--occupational exposure to waste anesthetic gases and vapors. Cincinnati, Ohio: National Institute for Occupational Safety and Health, 1977. (DHEW publication no. (NIOSH) 77-140).

3. NIOSH criteria for a recommended standard--occupational exposure to carbon monoxide. NIOSH Publication no. 73-11000.

4. NIOSH criteria for a recommended standard--occupational exposure to oxides of nitrogen. NIOSH Publication no. 76-149.

5. NIOSH criteria for a recommended standard--occupational exposure to mercury. NIOSH Publication no. 73-11024.

6. Occupational Safety and Health Administration. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised 1980.

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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1. Safety Officer, Veterans Administration Medical Center
2. NIOSH, Region II
3. OSHA, Region II

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TABLE I

Personal and Area Air Samples for Nitrous Oxide

Veterans Administration Medical Center
Bronx, New York
HETA 82-094

February 9, 1982

Area/Job	Sampling Time	Nitrous Oxide (TWA)* Concentration (ppm)**	Anesthesia Administration Method
		Personal Samples	
OR 4 Anesthesiologist (2E)	0830-1130	170	trachea tube
OR 4 Anesthesiologist (2E)	1130-1330	>280	trachea tube
OR 4 Anesthesiologist (2E)	1500-1530	>280	trachea tube
OR 3 Anesthesiologist (2E)	1330-1430	50	trachea tube
OR 6 Anesthesiologist (2E)	1430-1500	55	face mask
OR 6 Anesthesiologist (2E)	0900-0935	23	trachea tube
OR 6 Anesthesiologist (2E)	0935-1050	20	trachea tube
OR 6 Anesthesiologist (2E)	1030-1130	20	trachea tube
OR 6 Anesthesiologist (2E)	1130-1230	3	local
OR 3 Anesthesiologist (2E)	0915-1130	90	trachea tube
Room 20 Secretary (2E)	0850-1212	3	---
Room 20 Secretary (2E)	1212-1553	2	---
		Area Samples	
Nurse's Desk (2E)	1000-1130	20	---
Nurse's Desk (2E)	1130-1230	5	---
Recovery Room (2E)	1420-1510	4	---
Room 1E-10	1353-1545	2	---
Room 2E-02	1357-1545	2	---
OR 6	0820-1040	30	trachea tube
OR 6	1040-1130	4	trachea tube
OR 3	0930-1330	85	trachea tube

* TWA - Time-weighted average
** ppm - Parts of N_2O per million parts of air

TABLE II

Personal and Area Air Samples for Halogenated Anesthetic Waste Gases

Veterans Administration Medical Center
Bronx, New York
HETA 82-094

February 9, 1982

Location	Job Title	Sample Time	Halothane (ppm)	Enflurane (ppm)
OR 3	Anesthesiologist	0915-1130	ND	0.0008
OR 6	Anesthesiologist	0900-1130	ND	0.0003
OR 3	Anesthesiologist	1330-1430	ND	ND
OR 4	Anesthesiologist	1130-1430	ND	0.006
Room 2E-20	Secretary	0920-1553	ND	ND
OR 3	Area	0930-1330	ND	ND
OR 6	Area	0820-1130	ND	0.0003
Room 1E-10	Area	1253-1545	ND	ND
Room 1E-02	Area	1407-1545	ND	ND
Recovery Room 2E	Area	1420-1510	ND	ND
Nurse's Desk 2E	Area	1000-1500	ND	ND
OSHA Standard			-	-
NIOSH Criteria			0.5	0.5*

* NIOSH criteria applies when the halogenated anesthetic agent is being used in combination with N_2O.

ND - Indicates level that is below the detection limit of the analytical method.

TABLE III

Anesthetic Gas Flows

Veterans Administration Medical Center
Bronx, New York
HETA 82-094

February 9, 1982

Operating Room Number	Total Anesthetic Gas Flow LPM*	% N_2O	% O_2	% Enflurane	% Halothane
3	5	48.5	50	1.5	0
4	5	49.3	50	0.7	0
6	3	48.5	50	1.5	0

* Liters per minute

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