U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 77-100-468

PORTER MEMORIAL HOSPITAL
DENVER, COLORADO

FEBRUARY 1978

I. TOXICITY DETERMINATION

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at Porter Memorial Hospital, Denver, Colorado, on September 20, 21, and 22, 1977. Environmental breathing zone samples were collected to determine concentrations of halothane, ethrane, and nitrous oxide in the operating rooms.

Atmospheric concentrations of halothane, ethrane, and nitrous oxide indicate that a potential health hazard existed to all three of these anesthetic gases during this evaluation. Since information on adverse health effects due to exposure to halothane, ethrane, and nitrous oxide are not completely defined, and many unknown factors still exist, recommended permissible levels of exposure are not defined as safe levels but rather as levels which are attainable under current technology. NIOSH recommends an 8-hour exposure limit of 25 parts per million (ppm) for nitrous oxide and 2 ppm for the halogenated anesthetics (halothane and ethrane). Throughout this evaluation, nitrous oxide was used in conjunction with either ethrane or halothane. When used in this manner, the recommended standard of 0.5 ppm for halogenated anesthetic agents should be followed. These levels should prevent both chronic and acute effects. Nine out of 34 halothane breathing zone samples exceeded the NIOSH recommended level of 0.5 ppm; 11 out of 34 ethrane breathing zone samples exceeded the NIOSH recommended level of 0.5 ppm. The nitrous oxide NIOSH recommended level of 25 ppm was exceeded in 24 out of 50 breathing zone samples. The scavenging system which has been installed on all anesthetic carts at this hospital is capable of exhausting the waste anesthetic gases. The high levels of waste anesthetic gases found during this survey were presumably caused by difficulty in administering the gas to small patients, improperly fitted face masks, and the technique of administration by the anesthesiologist.

II. DISTRIBUTION AND AVAILABILITY

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services, Information 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. Porter Memorial Hospital
2. U.S. Department of Labor/OSHA - Region VIII
3. NIOSH - Region VIII

For the purpose of informing the approximately 70 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.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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.

NIOSH received such a request from hospital administration at Porter Memorial Hospital. There were no specific health problems at the time of this request. The recognition by operating room personnel of the potential health hazards associated with chronic exposures to anesthetic gases was responsible for the health hazard evaluation request.

HEALTH HAZARD EVALUATION

A. Process Description

Porter Memorial Hospital has 11 operating rooms. Three operating rooms are located in day surgery and eight on the main operating floor. These operating rooms operate basically from 7 a.m. until 5 or 6 p.m. However, they are open 24 hours a day, and emergency surgery is performed in these rooms. During this evaluation all operating rooms were monitored for waste anesthetic gas exposures. There are 70 workers covering three shifts in the operating rooms, with approximately 40 of these on the day shift. Surgery performed in these operating rooms includes almost any conceivable procedure from a simple bunionectomy to multiple coronary artery bypass grafts. The workload during the three days of this evaluation was typical of their normal workload. The operating rooms have a totally isolated ventilation system, with no recirculating air. The scavenging system on each anesthetic cart is plugged into the vacuum system, which feeds into the operating room ventilation system.

B. Evaluation Design

Nitrous oxide samples were collected in 20 liter mylar bags using a vacuum pump operated at 300 cubic centimeters (cc) per minute. These samples were analyzed immediately on the surgical floor by infrared spectrometry using a Wilks Miran 1A with a sensitivity of 5 ppm. Instrument settings were wave length 4.47 microns, path length 5.25 meters, and slit width 0.5 milliliters (mm). Breathing zone air samples of operating room personnel were collected during each surgical procedure for the above anesthetic gases. Halothane and ethrane samples were collected on charcoal tubes using vacuum pumps operated at 200 cc per minute. Analysis of these samples was performed using gas chromatography and P&CAM Method No. 127.

C. Evaluation Criteria

In the NIOSH criteria document for a recommended standard for occupational exposure to anesthetic gases, NIOSH states:[1] "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. A few studies have suggested increased risk of cancer. Effects on the central nervous system due to acute exposures of 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.

That same NIOSH publication recommends maximum exposures of 25 ppm nitrous oxide (eight-hour time-weighted average) 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.

Reports by Vaisman[2] and Askrog and Harvald[3] were among the first to identify 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).[4] 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 increased risk of congenital abnormalities was also present among the unexposed wives 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."

While several investigators have reported increased rates of resorption in animals, particularly rats, most of these studies involved concentrations of anesthetic gases well above the levels found in occupational exposure. One investigator[5] showed increased fetal death rates in two groups of rats following exposure of 1,000 and 100 ppm of nitrous oxide. Doenicke, et al.,[6] concluded from their study of anesthetized pregnant rats that halothane demonstrates an abortive effect directly proportional to the concentration inhaled, again referring to anesthetic concentrations; but nitrous oxide does not produce an abortive effect. Bruce[7] reports no significant difference, including implantations and resorptions per pregnancy, in his exposure of rats to 16 ppm halothane.

Several epidemiological studies that indicate increased spontaneous abortions also indicate an increased rate of congenital abnormalities. The ASA study[4] (as well as surveys by Knill-Jones, et al.,[8] and Corbett, et al.[9]) indicated

an increased rate of congenital abnormalities in children of women with occupational exposures to anesthetic gases and to wives of men with similar exposures. While most animal exposure studies have been conducted at anesthetic levels, one study[10, 11, 12] indicated liver, kidney, and brain tissue changes in pups born to rats exposed to sub-anesthetic concentrations of halothane during pregnancy.

The same epidemiological and toxicological studies that indicated an increase in spontaneous abortion and congenital abnormalities also indicated an increase in liver and kidney abnormalities. This increase, however, was less pronounced in both rate and severity.

In a study published by NIOSH,[13] "nitrous oxide and halothane in respective concentrations as low as 50 ppm and 1.0 ppm caused measurable decrements in performance on some psychological tests taken by healthy male graduate students. Nitrous oxide alone caused similar effects. The functions apparently most sensitive to these low concentrations on 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 have also been reported;[2, 14] and damage to cerebral cortical neurons has been seen in rats after sub-anesthetic exposure to halothane.[15] Quimby, et al.,[16] reported permanent learning deficits in rats exposed to anesthetic concentrations of halothane during early development (from conception).

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

Literature reviews regarding halothane[17, 18, 19, 20] indicate the most widely accepted mechanism of bio-transformation is the production of trifluoro-acetic acid with resulting urinary excretion of trifluoroacetic acid and bromide. The literature regarding enflurane[21, 22] does not indicate any one accepted mechanism, but increased serum and urinary fluoride levels were found in patients receiving enflurane anesthesia. While epidemiological and toxicological studies have indicated several symptoms apparently related to sub-anesthetic exposure to anesthetic gases, no cause and effect relationship has yet been shown.

D. Evaluation Results

Tables I, II, and III show the results of 34 samples taken for halothane and ethrane. Only one of the ethrane samples exceeded the standard of 2 ppm if used alone. However, since the ethrane and halothane were always used with nitrous oxide during this evaluation, the standard of 0.5 ppm was exceeded in 11 out of the 34 samples for ethrane and in 9 out of 34 samples for halothane. These results may be reviewed in Tables I, II, and III. Nitrous oxide concentrations exceeded the NIOSH recommended level of 25 ppm in 24 out of 50 samples. Nitrous oxide levels found during this evaluation may be reviewed in Tables IV, V, and VI.

E. Results and Discussion

Findings during this evaluation indicate that this hospital has done a lot of work in eliminating exposures to employees from waste anesthetic gases, even though the NIOSH recommended levels for nitrous oxide and the halogenated anesthetics were exceeded. The recommended standards were never grossly exceeded; and when they were exceeded, it was not due to the scavenging system or the hospital ventilation system. Reasons for the elevated levels of these gases were due to difficulty in administering the gas to small patients, improperly fitted face masks, and the technique of administration by the anesthesiologist. It is doubtful that there was a leak in any of the anesthetic gas-administering machinery, since levels during this survey were relatively low when compared with other NIOSH studies.[23] If there had been a leak in any of the anesthetic gas-administering machinery, concentrations would have been much higher than those found during this evaluation. All operating room personnel were interviewed, including surgeons and anesthesiologists. Most of the employees have very few complaints which could be attributed to waste anesthetic gases. Complaints consisted of facial acne, headaches, fatigue, chronic tiredness, irritability, and depression. Most of the employees, including surgeons, anesthesiologists, nurses, and operating room technicians, seemed to think that they were working in a safe place and that their work had no ill effects on their health.

Conclusions

The operating rooms at Porter Memorial Hospital were immaculate. There were scavenging systems on all anesthetic carts. All operating room personnel were aware of the hazards associated with chronic exposures to anesthetic gases. It is the Industrial Hygienist's opinion that concentrations found during this survey were extremely low and do not pose an immediate danger to the health of the operating room personnel. Every effort should be made to lower these concentrations to levels that are less than those recommended by NIOSH.[1]

V. RECOMMENDATIONS

1. Anesthetic equipment should be checked and maintained on a regular basis.

2. Face masks, tubing, and breathing bags should all be checked for cracks and other leaks.

3. All high pressure connections and valves should be checked periodically. Care should be taken when pouring the halogenated agents into the anesthetic gas-administering machinery so that they are not spilled on the floor.

4. Operating rooms should be monitored at least once a year to make sure that workers are not being overexposed to waste anesthetic gases.

V. REFERENCES

1. Criteria For a Recommended Standard...Occupational Exposure to Waste Anesthetic Gases and Vapors. NIOSH, 1977.

2. Vaisman, A. I. (Working conditions in surgery and their effect on the health of anesthesiologists). Eksp Khir Anest 3:44-49, 1967 (Rus).

3. Adkrog, V., and Harvald, B. (Teratogenic effect of inhalation anesthetics). Nord Med 83:498-504, 1970.

4. Cohen, E.N., Brown, B.W., Bruce, D.K., Cascorbi, H.F., Corbett, T.H., Jones, T.H., and Whitcher, C.E. Occupational Disease Among Operating Room Personnel--A National Study. Anesthesiology 41:321-40, 1974.

5. Corbett, T.H., Cornell, R.G., Endres, J.L., and Millard, R.I. Effects of Low Concentrations of Nitrous Oxide on Rat Pregnancy. Anesthesiology 39:299-301, 1973.

6. Doenicke, A., Wittmann, R., Heinrich, H., and Pausch, H. (Abortive effect of halothane). Anesth Analg (Paris) 32:47-51, 1975 (Fre).

7. Bruce, D. L. Murine Fetility Unaffected by Traces of Halothane. Anesthesiology 38:473-77, 1973.

8. Knill-Jones, R.P., Moir, D.D., Rodrigues, L.V., and Spence, A.A. Anesthetic Practice and Pregnancy--Controlled Survey.

9. Corbett, T.H., Cornell, R.G., Lieding, K., and Endres, J.L. Incidence of Cancer Among Michigan Nurse-Anesthetists. Anesthesiology 41:34-44, 1974.

10. Chang, L.W., Lee, Y.K., Dudley, A.W., Jr., and Katz, J. Ultrastructural Evidence of the Hepatotoxic Effect of Halothane in Rats Following In-Utero Exposure. Can Anaesth Soc J 22:330-37, 1975.

11. Chang, L.W., Dudley, A.W., Jr., Lee, Y.K., and Katz, J. Ultrastructural Studies on the Pathological Changes in the Neonatal Kidney Following In-Utero Exposure to Halothane. Environ. Res 10:174-89, 1975.

12. Chang, L.W., Dudley, A.W., Jr., Katz, J., and Martin, A.H. Nervous System Development Following In-Utero Exposure to Trace Amounts of Halothane. Teratology 9:A-15, 1974.

13. Bruce, D.L., and Bach, M. J. Trace Effects of Anesthetic Gases on Behavioral Performance of Operating Room Personnel. HEW Publication No. NIOSH 76-169, 1976, 33 pp.

14. Uhlirova, A., and Pokorny, J. (Results of questionnaire survey of health damage to anesthesiologists). Rozhl Chir 53:761-70, 1976 (Cze).

15. Chang, L.W., Dudley, A.W., Jr., Lee, Y.K., and Katz, J. Ultrastructural Changes in the Nervous System After Chronic Exposure to Halothane. Exp Neurol 45:209-19, 1974.

16. Quimby, K.L., Aschkenase, L.J., Bowman, R.E., Katz, J., and Chang, L.W. Enduring Learning Deficits and Cerebral Synaptic Malformation From Exposure to Ten Parts of Halothane Per Million. Science 185:625-27, 1974.

17. Rehder, K., and Sessler, A.D. Biotransformation of Halothane. Int Anesthesiol Clin 12:41-53, 1974.

18. Sawyer, D., and Eger, E., II. Hepatic Metabolism of Halothane. Int Anesthesiol Clin 12:55-62, 1974.

19. Cascorbi, H. F. Factors Causing Differences in Halothane Biotransformation. Int Anesthesiol Clin 12:63-71, 1974.

20. Van Dyke, R. A. Biotransformation of Volatile Anesthetics With Special Emphasis on the Role of Metabolism in the Toxicity of Anesthetics. Can Anesth Soc J 20:21-33, 1973.

21. Mazze, R.I., and Cousins, M.J. Biotransformation of Methoxyflurane. Int Anesthesiol Clin 12:93-105, 1974.

22. Cousins, M.D., and Mazze, R.I. Biotransformation of Enflurane (Ethrane) and Isoflurane (Forane). Int Anesthesiol Clin 12:111-119, 1974.

23. Hazard Evaluation Report 77-85. Mesa Veterinary Hospital, Golden, Colorado, 1977 (NIOSH).
Technical Assistance Report 77-31. Boulder Memorial Hospital, Boulder, Colorado, 1977 (NIOSH).

VII. AUTHORSHIP AND ACKNOWLEDGMENTS

Report Prepared By:
Bobby J. Gunter, Ph.D.
Regional Industrial Hygienist
NIOSH - Region VIII - Denver, Colorado

Originating Office:
Jerome P. Flesch, Acting Chief
Hazard Evaluation and Technical Assistance Branch (HETAB)
NIOSH - Cincinnati, Ohio

Survey Assistance:
Clifford Moseley and Paul Pryor
Industrial Hygiene Section, HETAB
NIOSH - Cincinnati, Ohio

Report Typed By:
Mary Margaret Fehrman
NIOSH - Denver, Colorado

Table I

ATMOSPHERIC CONCENTRATIONS OF HALOTHANE AND ETHRANE

Porter Memorial Hospital
Denver, Colorado

September 20, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Halothane (mg/M^3)	Ethrane (mg/M^3)
IV	Multiple Coronary Artery Bypass Grafts	7:10 AM - 8:10 AM	Circulating Nurse	*	0.52
IV	Multiple Coronary Artery Bypass Grafts	7:10 AM - 8:10 AM	Scrub Nurse	*	*
I	Adeno-tonsillectomy	7:20 AM - 9:50 AM	Circulating Nurse	0.68	0.77
IV	Multiple Coronary Artery Bypass Grafts	7:30 AM - 8:10 AM	Scrub Nurse	*	0.21
I	Adeno-tonsillectomy	7:20 AM - 9:50 AM	Scrub Nurse	0.29	0.61
Day Surgery	Laparoscopic Tubal Ligation	9:00 AM - 10:00 AM	Scrub Nurse	1.07	*
Recovery Room	-----	9:50 AM - 11:00 AM	Floating Nurse	*	*
Day Surgery	Bilateral Augmentation Mammoplasty	7:40 AM - 9:00 AM	Circulating Nurse	1.2	*
Day Surgery	Bilateral Augmentation Mammoplasty	7:40 AM - 9:00 AM	Anesthesiologist	1.2	*
Day Surgery	Bilateral Augmentation Mammoplasty	7:40 AM - 9:00 AM	Surgeon	1.2	*
Day Surgery	Bilateral Tympanotomy With Tubes	9:30 AM - 10:30 AM	Circulating Nurse	1.0	0.22
Day Surgery	Bilateral Tympanotomy With Tubes	9:30 AM - 10:30 AM	Anesthesiologist	*	*
			EVALUATION CRITERIA	0.5	0.5
			NIOSH LIMIT OF DETECTION	0.01 mg/tube	0.01 mg/tube

mg/M^3 = approximate milligrams of substance per cubic meter of air
* = below limit of detection
mg/tube = milligrams per tube

Table II

ATMOSPHERIC CONCENTRATIONS OF HALOTHANE AND ETHRANE

Porter Memorial Hospital
Denver, Colorado

September 21, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Halothane (mg/M^3)	Ethrane (mg/M^3)
Day Surgery	-----	9:10 AM - 12:15 PM	General Room Sample	*	*
I	Quadriceps Reconstruction Right Knee	7:15 AM - 8:30 AM	Scrub Nurse	0.12	0.80
I	Quadriceps Reconstruction Right Knee	7:20 AM - 9:00 AM	Circulating Nurse	0.21	0.22
IV	Closure of Septum Primum	7:20 AM - 9:20 AM	Circulating Nurse	*	0.14
VII	Exploratory Laparotomy	7:20 AM - 8:10 AM	Scrub Nurse	*	1.66
VII	Exploratory Laparotomy	7:20 AM - 8:10 AM	Circulating Nurse	*	1.03
II	Silastic Implant Left Finger With Nerve Graft From Left Forearm	7:20 AM - 8:30 AM	Circulating Nurse	0.61	*
II	Silastic Implant Left Finger With Nerve Graft From Left Forearm	7:20 AM - 8:30 AM	Scrub Nurse	0.11	*
Day Surgery	Dilatation and Curettage	7:35 AM - 8:30 AM	Anesthesiologist	0.41	*
Day Surgery	Dilatation and Curettage	7:35 AM - 8:30 AM	Circulating Nurse	*	*
Day Surgery	Dilatation and Curettage	7:40 AM - 8:40 AM	Scrub Nurse	0.74	0.80
II	Partial Right Patellectomy	10:15 AM - 11:15 AM	Scrub Nurse	*	*
VII	Bilateral Augmentation Mammoplasty and Abdominalplasty	11:40 AM - 12:50 PM	Circulating Nurse	*	*
			EVALUATION CRITERIA	0.5	0.5
			NIOSH LIMIT OF DETECTION	0.01 mg/tube	0.01 mg/tube

mg/M^3 = approximate milligrams of substance per cubic meter of air
* = below limit of detection
mg/tube = milligrams per tube

Table III

ATMOSPHERIC CONCENTRATIONS OF HALOTHANE AND ETHRANE

Porter Memorial Hospital
Denver, Colorado

September 22, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Halothane (mg/M^3)	Ethrane (mg/M^3)
IV	Mitral Valve Replacement	7:05 AM - 11:30 AM	Circulating Nurse	*	0.88
II	Left Caldwell Luc (Osteoma Left Maxilla)	7:15 AM - 9:00 AM	Scrub Nurse	1.08	0.99
II	Left Caldwell Luc (Osteoma Left Maxilla)	7:15 AM - 9:00 AM	Circulating Nurse	*	*
VII	Manipulation Right Knee	7:25 AM - 9:20 AM	Circulating Nurse	*	2.17
IV	Mitral Valve Replacement	7:25 AM - 1:00 PM	Circulating Nurse	*	0.26
VII	Manipulation Right Knee	7:25 AM - 8:30 AM	Scrub Nurse	*	0.94
VII	Reconstruction Right Chest	9:20 AM - 10:25 AM	Surgeon	*	0.31
IV	Mitral Valve Replacement	7:30 AM - 1:20 PM	Operating Room Technician	*	*
VII	Reconstruction Right Chest	9:20 AM - 10:25 AM	Anesthesiologist	*	*
			EVALUATION CRITERIA	0.5	0.5
			NIOSH LIMIT OF DETECTION	0.01 mg/tube	0.01 mg/tube

mg/M^3 = approximate milligrams of substance per cubic meter of air
* = below limit of detection
mg/tube = milligrams per tube

Tab. IV

ATMOSPHERIC CONCENTRATIONS OF NITROUS OXIDE (N_2O)

Porter Memorial Hospital - Denver, Colorado
September 20, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Nitrous Oxide (ppm)
I	Adeno-tonsillectomy	7:10 AM - 7:53 AM	Circulating Nurse	57
I	Adeno-tonsillectomy	7:20 AM - 8:25 AM	Nurse	40
I	Adeno-tonsillectomy	7:20 AM - 9:03 AM	Scrub Nurse	25
Day Surgery	Bilateral Augmentation Mammoplasty	7:40 AM - 8:40 AM	Circulating Nurse	88
Day Surgery	Bilateral Augmentation Mammoplasty	7:45 AM - 8:47 AM	Anesthesiologist	6
Day Surgery	Bilateral Augmentation Mammoplasty	7:50 AM - 8:55 AM	Surgeon	123
Day Surgery	Bilateral Tympanotomy With Tubes	9:30 AM - 10:00 AM	Anesthesiologist	180
Day Surgery	Bilateral Augmentation Mammoplasty	8:40 AM - 9:56 AM	Anesthesiologist	12
I	Cody Pack (Ear)	7:20 AM - 9:58 AM	Circulating Nurse	28
Day Surgery	Laparoscopic Tubal Ligation	9:30 AM - 10:53 AM	Scrub Nurse	65
Day Surgery	Laparoscopic Tubal Ligation	10:00 AM - 10:53 AM	Anesthesiologist	70
Day Surgery	Laparoscopic Tubal Ligation	10:00 AM - 11:15 AM	Circulating Nurse	25
Day Surgery	Laparoscopic Tubal Ligation	10:00 AM - 11:15 AM	Scrub Nurse	75
Day Surgery	Right Breast Biopsy	11:00 AM - 11:25 AM	Anesthesiologist	25
Day Surgery	Right Breast Biopsy	11:25 AM - 11:55 AM	Anesthesiologist	35
Day Surgery	Right Breast Biopsy	11:30 AM - 12:10 PM	Scrub Nurse	25
Day Surgery	Dilatation and Curettage	12:00 - 1:30 PM	Anesthesiologist	57
Day Surgery	Dilatation and Curettage	12:30 PM - 1:30 PM	Circulating Nurse	12
II	Ventral Hernia Repair	12:30 PM - 1:30 PM	Scrub Nurse	25
Day Surgery	Dilatation and Curettage	1:30 PM - 2:34 PM	Circulating Nurse	45
Day Surgery	Dilatation and Curettage	1:30 PM - 2:34 PM	Anesthesiologist	35
			EVALUATION CRITERIA	25
			NIOSH LIMIT OF DETECTION	0.8 ug/sample

ppm = parts per million
ug/sample = micrograms per sample

Table V

ATMOSPHERIC CONCENTRATIONS OF NITROUS OXIDE (N_2O)

Porter Memorial Hospital - Denver, Colorado
September 21, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Nitrous Oxide (ppm)
VII	Exploratory Laparotomy	7:15 AM - 8:50 AM	Scrub Nurse	15
I	Quadriceps Reconstruction Right Knee	7:20 AM - 8:15 AM	Circulating Nurse	15
VII	Exploratory Laparotomy	7:20 AM - 8:10 AM	Nurse	11
VII	Exploratory Laparotomy	7:20 AM - 8:10 AM	Circulating Nurse	15
II	Silastic Implant Left Finger With Nerve Graft From Left Forearm	7:20 AM - 8:09 AM	Circulating Nurse	4
I	Quadriceps Reconstruction Right Knee	7:50 AM - 8:40 AM	Scrub Nurse	5
II	Silastic Implant Left Finger With Nerve Graft From Left Forearm	7:30 AM - 8:03 AM	Scrub Nurse	*
VII	Exploratory Laparotomy	8:12 AM - 9:35 AM	Circulating Nurse	5
I	Quadriceps Reconstruction Right Knee	7:15 AM - 9:30 AM	Scrub Nurse	5
Day Surgery	Dilatation and Curettage	7:35 AM - 8:35 AM	Anesthesiologist	48
Day Surgery	Dilatation and Curettage	7:35 AM - 8:35 AM	Circulating Nurse	28
I	Quadriceps Reconstruction Right Knee	8:40 AM - 9:28 AM	Scrub Nurse	24
I	Quadriceps Reconstruction Right Knee	8:40 AM - 9:28 AM	Circulating Nurse	40
Day Surgery	Dilatation and Curettage	8:50 AM - 9:50 AM	Scrub Nurse	88
Day Surgery	Dilatation and Curettage	8:50 AM - 9:50 AM	Anesthesiologist	85
I	Right Bunionectomy	9:30 AM - 10:30 AM	Scrub Nurse	5
VII	Bilateral Augmentation Mammoplasty and Abdominalplasty	9:40 AM - 11:10 AM	Circulating Nurse	*

Table V

(continued)

Porter Memorial Hospital - Denver, Colorado
September 21, 1977

Recovery Room	-----	9:00 AM - 10:30 AM	Floating Nurse	18
Recovery Room	-----	10:30 AM - 12:15 PM	Floating Nurse	*
I	Cystoscopy, Internal Urethrostomy, Fulgeration Urethral Polyps	12:00 - 1:00 PM	Scrub Nurse	8
II	Debridement and Partial Amputation Fingers Left Hand	10:30 AM - 12:15 PM	Circulating Nurse	65
VII	Bilateral Augmentation Mammoplasty and Abdominalplasty	12:30 PM - 1:40 PM	Scrub Nurse	5
II	Partial Right Patellectomy	10:45 AM - 11:30 AM	Scrub Nurse	33
VII	Bilateral Augmentation Mammoplasty and Abdominalplasty	11:40 AM - 12:50 PM	Circulating Nurse	*
VII	Bilateral Augmentation Mammoplasty and Abdominalplasty	12:50 PM - 1:45 PM	Circulating Nurse	5
II	Sigmoid Colostomy	12:50 PM - 1:50 PM	Scrub Nurse	72
			EVALUATION CRITERIA	25
			NIOSH LIMIT OF DETECTION	0.8 ug/sample

ppm = parts per million

ug/sample = micrograms per sample

Table VI

ATMOSPHERIC CONCENTRATIONS OF NITROUS OXIDE (N_2O)

Porter Memorial Hospital - Denver, Colorado
September 22, 1977

Operating Room No.	Surgical Procedure	Time of Sample	Job Classification	Nitrous Oxide (ppm)
II	Left Caldwell Luc (Osteoma Left Maxilla)	7:15 AM - 9:55 AM	Scrub Nurse	71
II	Left Caldwell Luc (Osteoma Left Maxilla)	7:15 AM - 7:50 AM	Circulating Nurse	44
VII	Manipulation Right Knee	7:15 AM - 8:15 AM	Circulating Nurse	*
IV	Mitral Valve Replacement	7:05 AM - 8:11 AM	Circulating Nurse	32
VII	Manipulation Right Knee	7:25 AM - 8:15 AM	Scrub Nurse	44
II	Left Caldwell Luc (Osteoma Left Maxilla)	7:30 AM - 8:47 AM	Scrub Nurse	60
IV	Mitral Valve Replacement	7:50 AM - 8:40 AM	Circulating Nurse	8
VII	Reconstruction Right Chest	8:40 AM - 9:15 AM	Circulating Nurse	8
VII	Reconstruction Right Chest	8:40 AM - 9:15 AM	Scrub Nurse	*
IV	Mitral Valve Replacement	8:40 AM - 9:36 AM	Circulating Nurse	8
II	Delayed Closure Wounds Left Hand	9:30 AM - 10:50 AM	Circulating Nurse	71
VII	Reconstruction Right Chest	9:30 AM - 10:30 AM	Scrub Nurse	28
VII	Reconstruction Right Chest	9:40 AM - 10:25 AM	Circulating Nurse	*
II	Biceps Tenodesis Left	11:00 AM - 11:45 AM	Circulating Nurse	151
VII	Manipulation Right Knee	10:30 AM - 11:15 AM	Scrub Nurse	25
VII	Manipulation Right Knee	9:00 AM - 10:05 AM	Circulating Nurse	44
VII	Left Breast Biopsy With Frozen Section	10:00 AM - 11:05 AM	Scrub Nurse	*
VII	Reconstruction Right Chest	9:25 AM - 10:25 AM	Surgeon	75
VII	Reconstruction Right Chest	10:25 AM - 11:25 AM	Surgeon	25
VII	Left Breast Biopsy With Frozen Section	10:30 AM - 11:30 AM	Scrub Nurse	*
VII	Lumbar Laminectomy	12:00 - 1:00 PM	Scrub Nurse	38

Table VI

(continued)

Porter Memorial Hospital - Denver, Colorado
September 22, 1977

VII	Lumbar Laminectomy	12:00 - 1:00 PM	Circulating Nurse	59
II	Tenolysis and Neurolysis Left Hand	12:00 - 1:30 PM	Circulating Nurse	138
II	Biceps Tenodesis Left	11:00 AM - 12:00	Scrub Nurse	58
			EVALUATION CRITERIA	25
			NIOSH LIMIT OF DETECTION	0.8 ug/sample

ppm = parts per million

ug/sample = micrograms per sample