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CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
MORGANTOWN, WEST VIRGINIA

HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT NO. TA 77-13

WEST VIRGINIA UNIVERSITY MEDICAL CENTER
MORGANTOWN, WEST VIRGINIA

JULY 1980

Study Requested By:	Director of The Operating Room West Virginia University Medical Center
Report Prepared By:	Steven W. Lenhart, Industrial Hygiene Engineer Environmental Investigations Branch Morgantown, West Virginia
Study Dates:	March 16-17, 1977 April 3-4, 1979

I. SUMMARY

In response to a request made by the Director of the Operating Room of the West Virginia University Medical Center School of Medicine, personnel of The National Institute for Occupational Safety and Health (NIOSH) performed environmental evaluations to determine the extent of exposure experienced by operating room personnel to nitrous oxide and halogenated anesthetic agents. A preliminary study was conducted before installation of a waste anesthetic gas and vapor evacuation system and a follow-up study was conducted to determine the effectiveness of the completed system. Criteria used for this evaluation are NIOSH recommended standards for occupational exposure to waste anesthetic gases and vapors. A time weighted average concentration of 25 parts per million (ppm) during administration is advised as the upper boundary for exposure to nitrous oxide. Halogenated anesthetic agents are advised to be controlled so as not to exceed 2 ppm when used alone and 0.5 ppm when used with nitrous oxide.

Personal samples taken during the follow-up study substantiate the vast improvement of the operating room working environment created by the installation of a waste gas and vapor evacuation system. More improvement will be realized with initiation of a routine equipment maintenance program and a minimization of gas leakage as a result of improved individual anesthesiologist work practices.

II. INTRODUCTION

A request was made by The Director of the Operating Room of the West Virginia University Medical Center School of Medicine that the National Institute for Occupational Safety and Health determine the extent of exposure experienced by operating room personnel to nitrous oxide and halogenated anesthetic agents. Prior to the request, plans had been submitted for a state bid to install a waste gas and vapor evacuation system. A preliminary study was conducted March 16 and 17, 1977 to evaluate exposure concentrations before installation of the system and a follow-up study was conducted April 3 and 4, 1979 to determine the effectiveness of the completed system.

III. EVALUATION

A. Facility Description

West Virginia University Medical Center, located on a 140 acre tract two miles north of Morgantown, West Virginia, has 441 beds and 1,600 full-time employees. Since opening in 1960, total patient visits have increased from 49,342 in 1962 to 158,301 in 1978. Operating room procedures have increased from 2,769 in 1962 to 7,248 in 1978. The operating room floor includes nine operating rooms, one bronchoscopy room and two cystoscopy rooms. Inhalation anesthetics used are nitrous oxide, halothane (2-bromo-2-chloro-1,1,1-trifluoroethane), enflurane (2-chloro-1,1,2-trifluorethyl difluoromethyl ether) and cyclopropane (1,1-dichloro-2,2-bis (p-ethoxyphenyl)-cyclopropane).

B. Process Description

A rebreathing anesthetic circuit is composed of an anesthesia machine and breathing system. The anesthesia machine vaporizes the anesthetic (halothane or enflurane) and combines it with nitrous oxide and oxygen, which are supplied from cylinders attached to the machine or piped in from a centralized location. The breathing system consists of a soda lime canister to absorb exhaled carbon dioxide, breathing bag or ventilator, valves to assure unidirectional gas flow, flexible tubing, and a "Y" terminating at an endotrachael tube, nasal tube or facemask.

The anesthetic gas mixture is delivered at a higher rate than the metabolic needs of a patient. When a breathing bag is used, excess gases are vented from the breathing system through a pop-off valve with the volume of escaping gases and vapors dependent upon the breathing pattern and metabolic rate of each patient. When a ventilator is used the pop-off valve is closed and the ventilator assumes the valves function. Sources of waste anesthetic gas leakage are pop-off valve, ventilator, facemask or endotrachael tube, holes or cracks in tubing, tubing fittings and seals, cylinder yokes and spilled liquid anesthetic.

C. Evaluation Design

A preliminary study was conducted prior to installation of a waste anesthetic gas and vapor evacuation system for the operating rooms of the West Virginia Medical Center. The study involved the collection of air samples using 30 liter mylar bags and MSA* model G personal sampling pumps modified for bag filling. Generally, area samples were collected, although it was possible to collect a few personal samples. Area samples were obtained by attaching sampling equipment to I.V. stands placed as near as possible to the anesthesiologist in a particular operating room. Nitrous oxide analysis of bag samples was performed shortly after collection in a room away from possible nitrous oxide exposure. A Wilks* Miran IA infrared spectrophotometer operating at a 4.47 micrometer wavelength, a 5.25 meter

*Mention of company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

pathlength and a 0.5 millimeter slit width was used to analyze bag samples for nitrous oxide.

The follow-up study to determine the effectiveness of the completed waste anesthetic gas and vapor system involved the collection of air samples on a personal basis only. Air samples were collected for nitrous oxide analysis using 20 liter multi-layer gas sampling bags and Dupont* P-4000 personal sampling pumps operated at flows of 800 cubic centimeters per minute (cc/min.). Nitrous oxide analysis of bag samples was performed using a Wilks* Miran IA infrared spectrophotometer operating at a 4.48 micrometer wavelength, a 17.25 meter pathlength and a 1.0 millimeter slit width. Personal samples to evaluate exposure to halothane and enflurane were also collected as part of the follow-up study. Samples were collected using Dupont* P-200 personal sampling pumps operated at flows of 50 cc/min. and commercially available 150 milligram charcoal tubes. Tubes were changed approximately every two hours. Tube samples were analyzed using a gas chromatograph with flame ionization detector.

D. Evaluation Criteria

Authors of the NIOSH recommended standard for occupational exposure to waste anesthetic gases and vapors (1) suggest that occupational exposure to nitrous oxide be controlled so as not to exceed a time weighted average concentration of 25 parts per million (ppm) during its administration. Available information (2,3,4,5,6,7) to suggest adverse reproductive effects from exposure to nitrous oxide, when used as a sole agent, is not definitive. However, the main health effects seen with consistency are an increased incidence of spontaneous abortions and an increased incidence of congenital malformations among the children of exposed females and wives of exposed males. Studies reporting toxic effects on the liver and kidneys (2,3,8) after high level exposures have raised the question of whether the same effects will occur following exposure to levels associated with the occupational environment. Adverse effects involving decrements in performance cognition, audiovisual ability and in dexterity during exposures to nitrous oxide have been observed at 500 ppm. Audiovisual decrements have been observed in exposed volunteers at levels as low as 50 ppm, which demonstrates the potential for impaired functional capacities of exposed workers. Similar decrements have not been observed at 25 ppm with 0.5 ppm halothane and it is upon this information (9,10,11) that the recommended exposure level is based.

Occupational exposures to halogenated anesthetic agents are suggested to be controlled so as not to exceed 2 ppm. When used with nitrous oxide occupational exposure to halogenated anesthetic agents are suggested to be controlled so as not to exceed 0.5 ppm.

Adverse health effects have not been completely defined for exposure to mixed anesthetic gases or to halogenated agents used alone. For this reason, recommended exposures to halogenated anesthetic agents are based upon the lowest level detectable using NIOSH recommended sampling and analysis techniques (1).

The permissible exposures recommended in this section cannot be defined as safe levels since information on adverse health effects is not completely definitive and many unknown factors still exist. Therefore, the environmental limits presented should be regarded as the upper boundary of exposure, and every effort should be made to maintain exposures as low as is technically feasible.

E. Evaluation Results

Table I contains the data of the preliminary study, which evaluated exposure concentrations in the West Virginia University Medical Center operating rooms prior to the installation of a waste anesthetic gas and vapor evacuation system. The value of each nitrous oxide sample is reported only. Because individual values are so obviously in excess of the NIOSH recommended standard for occupational exposure to nitrous oxide, no attempt was made to calculate exposure concentrations during anesthetic administration.

Table II through V contain the data of the follow-up study. Tables II and IV relate occupational exposures associated with anesthesiologists, while Tables III and V relate occupational exposures associated with circulating nurses. The last column of both Table II and Table III contains average values of nitrous oxide exposure during inhalation anesthetic administration (the second column of Tables II and III). These time weighted average values are to be used for comparison to the NIOSH recommended standard of 25 parts per million for occupational exposure to nitrous oxide. A dash within the last two columns of either Table IV or V indicates that the sample contained either none of the substance or less than the detectable limit of the analytical technique.

Between the initial study and the follow-up study a waste anesthetic gas scavenging system was installed to serve the nine operating rooms. Scavenging has been defined as the capture of waste anesthetic gases and vapors at the site of overflow and the disposal of them. The system installed at the WVU hospital is of the low velocity specialized duct system. In this system, a fan having a low fan static pressure is used to provide sufficient negative pressure and air flow to induce capture of the released gases and vapors and to discharge them to the outdoors. The piping or duct systems terminates in the operating rooms in a stainless steel conical transition piece open to the atmosphere. The flexible exit tubing from the pop-off valve and ventilator are branched together and inserted just inside the stainless steel transition piece and held in place by a friction-fit holder. This type of arrangement eliminates the need for pressure relief valves or pressure balancing devices.

Vast improvement in operating room working conditions is obvious when personal exposure concentrations to nitrous oxide collected during the follow-up study are compared to those concentrations collected during the preliminary study. However, follow-up concentrations compared to the NIOSH recommended standard for occupational exposure to nitrous oxide indicates that further improvement is still possible and desirable through initiation of leak testing and preventive maintenance of anesthesia machines, and improvement of work practices and pediatric anesthesia techniques.

IV. RECOMMENDATIONS

A. Routine leak testing of anesthesia equipment should be implemented as outlined in Appendix A, with the repair of any leaks found. Such procedures will assist in lowering the operating room concentrations of waste anesthetic gases and vapors. Anesthesiology personnel should be informed of acceptable work practices aimed at preventing the escape of waste anesthetic gases and vapors. Acceptable work practices are outlined in Appendix B.

B. Consideration should be given to implementing a waste anesthetic gas and vapor monitoring program for the operating rooms of the West Virginia University Medical Center. A good monitoring program will not only assure continued proficient work practices by individual anesthesiologists, but also will limit unnecessary leakage of waste anesthetic gases by identifying particular equipment parts in need of maintenance. Should an in-house monitoring program be unacceptable to the administration of West Virginia University Medical Center, contract services are available to handle the task.

C. All personnel exposed to waste anesthetic gases should be included in a medical surveillance program as soon as possible. The medical surveillance program should, as a minimum, include the procedures outlined below:

1. Comprehensive preplacement medical and occupational histories shall be obtained and maintained in the employees' medical records, with special attention given to the outcome of pregnancies of the employee or spouse, and to the hepatic, renal, and hematopoietic systems which may be affected by agents used as anesthetic gases. This information should be updated at least yearly and at any other time considered appropriate by the responsible physician.

2. Preplacement and annual physical examinations of employees exposed to anesthetic gases are recommended and, when performed, the results shall be maintained in the employees' permanent medical records.

3. Employees shall be advised of the potential undesirable effects of exposure to waste anesthetic gases, such as spontaneous abortions, congenital abnormalities in their children, and effects on the liver and kidneys.

4. Any abnormal outcome of the pregnancies of employees or of the spouses of employees exposed to anesthetic gases shall be documented as part of the employees' medical records, and the records shall be maintained for the period of employment plus 20 years.

V. REFERENCES

1. Criteria for a Recommended Standard ..... Occupational Exposure to Waste Anesthetic Gases and Vapors. U.S. Department of Health, Education and Welfare, PHS, NIOSH, 1977. Publication No. 77-140.

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

3. Cohen, E. N., Brown, B. W., Bruce, D. L., Cascorb, H. F., Corbett, T. H., Jones, T. W., Whitcher, C. E.: A Survey of Anesthetic Health Hazards Among Dentists. J. A. Dent. Assoc. 90:1291-96, 1975.

4. Cohen, E. N. Belvill, J. W., Brown, B. W., Jr.: Anesthesia, Pregnancy, and Miscarriage -- A Study of Operating Room Nurses and Anesthetists. Anesthesiology 35:343-47.

5. Knill-Jones, R. P., Moir, D. D., Ridrigues, L. V., Spence, A. A.: Anesthetic Practice and Pregnancy -- Controlled Survey of Women Anesthetists in the United Kingdom. Lancet 1:1326-28, 1972.

6. Corbett, T. H., Cornell, R. G., Endres, J. L., Lieding, K.: Birth Defects Among Children of Nurse-Anesthetists. Anesthesiology 41:341-44, 1974.

7. Knill-Jones, R. P., Newman, B. J., Spences, A. A.: Anesthetic Practice and Pregnancy -- Controlled Survey of Male Anesthetists in the United Kingdom. Lancet 2:807-09, 1975.

8. Uhlirova, A., Pokorny, J.: Results of Questionnaire Survey of Health Damage to Anesthesiologists. Rozhl. Chir. 53:761-70, 1974 (Cze).

9. Bruce, D. L., Bach, M. J., Arbit, J.: Trace Anesthetic Effects on Perceptual Cognitive, and Motor Skills. Anesthesiology 40-453-58, 1974.

10. Bruce, D. L., Bach, M. J.: Psychological Studies of Human Performances as Affected by Traces of Enflurane and Nitrous Oxide. Anesthesiology 42:194-96, 1975.

11. Bruce, D. L., Bach, M. J.: Trace Effects of Anesthetic Gases on Behavioral Performance of Operating Room Personnel, HEW Publication No. NIOSH 76-169. U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1976, 32 pp.

VI. ACKNOWLEDGMENTS

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TABLE I

Nitrous Oxide Concentrations
West Virginia University Medical Center
Morgantown, West Virginia

March 16, 1977

Operating Room	Nitrous Oxide Usage	Sample Description	Sampling Period	Nitrous Oxide Concentration (ppm)
1	0730-1010 1100-1130	Personal, Anesthesiologist	0845-0910	1250
		Area	1054-1129	194
4	0740-0905 0950-1015	Personal, Circulating Nurse	0730-0830	105
			0830-0918	140
		Area	1010-1103	72
6	1025-1205	Area, Sample 1, near anesthesiologist	1016-1058	89
			1105-1145	190
			1145-1215	205
		Area, Sample 2	1027-1115	72
			1115-1200	72
7	0815-1410	Area	0825-0900	300
			0915-1006	325
			1006-1055	320
			1100-1141	332
			1142-1215	320
			1216-1306	458
			1307-1350	350
			1351-1435	218
9	0750-1205	Personal, Anesthesiologist	0751-0951	130
			0951-1120	228
		Area	0800-0852	70
			0852-0934	60
			0934-1020	65
			1025-1125	68
			1125-1214	70
			1215-1246	75*

TABLE I (continued)

Nitrous Oxide Concentrations
West Virginia University Medical Center
Morgantown, West Virginia

March 17, 1977

Operating Room	Nitrous Oxide Usage	Sample Description	Sampling Period	Nitrous Oxide Concentration (ppm)
1	0735-0935 1035-1330	Area	0728-0814	80
			0815-0850	40
			0851-0929	45
			0930-1009	55
			1009-1045	80
			1046-1124	205
			1128-1204	135
			1204-1243	130
			1243-1325	125
			1325-1430	45
4	1255-1435	Area	1245-1450	490
6	1030-1125 1325-1715	Area	0753-0854	10*
			0854-0950	10*
			0950-1042	10
			1042-1140	35
			1140-1235	5*
			1235-1326	95
			1326-1421	80
7	0735-1110	Area	0750-0828	85
			0828-0910	90
			0910-0957	165
			0957-1038	165
			1038-1130	95
			1130-1225	5*
			1225-1245	10*
8	1215-1350	Area	1213-1300	190
			1300-1414	40
			1414-1435	25*
9	0755-1210 1330-1845	Area	0740-0816	175
			0816-0855	450
			0855-0936	440
			0936-1015	360
			1015-1055	350
			1100-1136	370
			1136-1216	365
			1216-1256	40*
			1256-1331	0*
			1331-1417	255
			1417-1456	355

TABLE I (continued)

Nitrous Oxide Concentrations
West Virginia University Medical Center
Morgantown, West Virginia

<u>March 17, 1977</u> (continued)

Operating Room	Nitrous Oxide Usage	Sample Description	Sampling Period	Nitrous Oxide Concentration (ppm)
Storeroom	None	Area	0825-0907	5*
			0907-0950	5*
			0950-1026	5*
			1026-1134	5*
			1134-1223	5*
			1223-1310	5*
			1310-1356	5*
			1356-1445	5*

* Sample was not taken during anesthetic administration.

TABLE II

Nitrous Oxide Concentrations (Anesthesiologists)
West Virginia University Medical Center
Morgantown, West Virginia

April 3, 1979

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (ppm)
1	0745-0835	0727-0753	15.0	9.2
	0930-1105	0753-0817	6.5	13.5
		0817-0835	6.0	
		0859-0920	5.5	
		0920-0945	23.0	
		0945-1010	8.5	
		1010-1033	10.0	
		1033-1058	8.5	
		1058-1125	17.0	
2	1230-1535	1215-1239	22.0	14.7
		1239-1301	14.5	
		1301-1327	15.0	
		1327-1351	12.5	
		1351-1411	10.0	
		1411-1433	10.5	
		1433-1454	8.0	
		1454-1523	21.5	
7	0745-1130	0745-0812	43.5	32.8
		0812-0835	40.0	
		0835-1854	10.0	
		1854-0916	40.0	
		0916-0940	63.0	
		0940-1002	21.5	
		1002-1028	31.0	
		1028-1050	22.0	
		1050-1112	24.0	
		1112-1131	24.0	
		1131-1156	10.0	

April 4, 1979

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (ppm)
4	0735-0825	0800-0821	2.0	3.7
	1010-1015	0821-0847	5.0	28.5
	1040-1045	0847-0909	2.0	14.0
		0909-0932	2.5	
		0932-0956	3.0	
		0956-1022	28.5	
		1022-1049	14.0	
		1049-1117	7.0	
		1117-1137	9.0	

TABLE II (continued)

Nitrous Oxide Concentrations (Anesthesiologists)
West Virginia University Medical Center
Morgantown, West Virginia

April 4, 1979 (continued)

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (ppm)
9	0825-1550	0934-0955	15.5	37.2
		0955-1019	22.0	
		1019-1040	20.0	
		1040-1102	30.0	
		1102-1122	62.0	
		1122-1143	40.5	
		1143-1153	32.0	
		1250-1311	48.0	
		1311-1334	76.0	
		1334-1401	36.0	
		1401-1422	36.5	
		1443-1503	28.0	
Bronchoscopy	1200-1225	1202-1227	16.5	16.5
	1330-1425	1329-1352	65.0	68.5
		1352-1420	88.0	
		1420-1437	41.0	

TABLE III

Nitrous Oxide Concentrations (Circulating Nurses)
West Virginia University Medical Center
Morgantown, West Virginia

April 3, 1979

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (pp
1	0745-0835	0724-0747	5.5	5.5
	0930-1105	0747-0809	3.5	7.8
		0809-0830	6.0	
		0830-0854	7.0	
		0854-0922	3.5	
		0922-0945	5.5	
		0945-1010	6.0	
		1010-1033	5.5	
		1033-1057	11.0	
		1057-1122	10.5	
2	1230-1535	1218-1239	4.0	5.9
		1239-1301	4.5	
		1301-1320	5.5	
		1320-1343	6.5	
		1343-1404	7.0	
		1404-1424	8.5	
		1424-1445	5.5	
		1445-1511	6.0	
7	0745-1130	0738-0802	8.5	8.2
		0802-0820	12.5	
		0820-0842	7.0	
		0842-0905	4.0	
		0905-0925	8.5	
		0925-0950	10.0	
		0950-1013	4.0	
		1013-1036	8.5	
		1036-1059	12.0	
		1134-1158	5.0	

April 4, 1979

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (pp
5	None Used*	0755-0817	1.0	
		0829-0854	1.0	
		0854-0915	1.0	
		0915-0937	1.0	
		0937-0959	1.0	
		0959-1027	1.0	
		1027-1050	1.0	
		1050-1111	1.0	
		1111-1132	1.0	
		1132-1151	1.0	

TABLE III (continued)

Nitrous Oxide Concentrations (Circulating Nurses)
West Virginia University Medical Center
Morgantown, West Virginia

April 4, 1979 (continued)

Operating Room	Nitrous Oxide Usage	Sampling Period	Nitrous Oxide Concentration (ppm)	Nitrous Oxide Concentration During Administration (pp
5 (con't.)		1151-1215	1.0	
		1215-1241	1.5	
		1241-1303	1.0	
		1303-1323	1.0	
		1323-1344	1.0	
		1344-1408	1.0	
7	0720-0745	0735-0759	5.0	5.0
	1025-1130	0759-0820	34.0	27.2
	1225-1315	0820-0845	30.0	8.5
		0845-0907	14.0	
		0907-0928	8.0	
		0928-0948	5.0	
		0948-1012	2.0	
		1012-1035	39.5	
		1035-1057	40.5	
		1057-1117	12.0	
		1117-1140	15.5	
		1140-1201	5.5	
		1201-1225	2.0	
		1244-1308	9.0	
		1308-1331	8.0	
		1331-1400	3.5	
9	0825-1550	0815-0836	15.5	12.8
		0836-0856	16.5	
		0910-0930	19.0	
		0930-0952	17.0	
		0952-1016	10.0	
		1016-1037	11.0	
		1037-1100	10.0	
		1100-1121	12.0	
		1121-1142	12.0	
		1142-1150	13.0	
		1236-1300	13.0	
		1300-1319	13.0	
		1319-1341	14.0	
		1341-1404	5.0	
		1404-1426	13.0	
		1426-1446	13.0	

* No anesthetic gases or vapors used entire day; exposure concentrations of study participant in this operating room were used as controls.

TABLE IV

Halothane and Enflurane Concentrations (Anesthesiologists)
West Virginia University Medical Center
Morgantown, West Virginia

April 3, 1979

Operating Room	Halothane Usage	Enflurane Usage	Sampling Period	Halothane Concentration (ppm)	Enflurane Concentration (ppm)
1	0745-0835	0935-1045	0727-0944	-	-
			0944-1125	-	-
2	1220-1500	None Used	1215-1532	0.59	-
7	None Used	None Used	0745-1003	-	-
			1003-1156		

April 4, 1979

Operating Room	Halothane Usage	Enflurane Usage	Sampling Period	Halothane Concentration (ppm)	Enflurane Concentration (ppm)
4 and Broncho-scopy *	0735-0820	None Used	0736-0956	0.33	-
	1010-1015		0956-1329	1.71	-
	1040-1115		1329-1437	1.42	
	1200-1225				
	1330-1425				
9	0825-1510	None Used	0934-1153	1.34	-
			1250-1504	1.39	-

* The anesthesiologist of operating room 4 worked in the bronchoscopy room in the afternoon (Halothane Usage 1200-1225 and 1330-1425).

APPENDIX A

LEAK TEST PROCEDURES FOR ANESTHETIC EQUIPMENT

1. LOW-PRESSURE COMPONENTS: FLOWMETERS TO Y-PIECE

a. This test measures the leak rate of low-pressure components in a carbon dioxide absorption system, beginning at the flowmeters and extending forward to the Y-piece. The test is easily performed with the breathing system connected in the usual manner for clinical anesthesia. The breathing bag and tubing are included and require no special testing. The total contribution of the gas machine to nitrous oxide levels in the room air can be estimated by performing this test in combination with the high-pressure component test.

b. The low-pressure leak rate should be less than 100 ml/min; if it is greater than 1 liter/min the machine should not be used.

(1) 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.

(2) Occlude the Y-piece securely with the thumb or palm of hand.

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

(4) Add a sufficient flow of oxygen through the low-range flowmeter 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/min. If pressure in the system increases, the breathing system is below the maximum allowed leak rate.

(5) Determine the presence of check valves downstream from the flowmeters by consulting the manufacturer or a serviceman. These valves must be tested differently. With oxygen flowing as indicated in (4), briefly turn off, in turn, each flowmeter 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.

2. HIGH-PRESSURE COMPONENTS: HOSE CONNECTIONS AT WALL TO FLOWMETERS. High-pressure components include wall connectors, supply hoses, connectors at rear of gas machine, and plumbing within the machine up to the flowmeter control valves. Potential leak sites are numerous and leak

testing with conventional methods (soap solution) is cumbersome. A convenient method for rapidly testing all rooms in the suite employs the infrared N_2O analyzer. The principle of the test is that a given fresh air exchange rate, provided by the air-conditioning system and assuming perfect mixing of gases, a given leak rate of N_2O into the room air equilibrates at a predictable concentration. A relatively leak-free, high-pressure system will contribute less than 1 ppm N_2O to the room concentration. Room concentrations in excess of 5 ppm N_2O indicate excessive leakage, which should be corrected. High-pressure leak tests should be conducted quarterly.

a. Do not use the machine for at least 1 hour prior to the test. High pressure hoses must be attached.

b. Use a N_2O analyzer in each room to determine and record the N_2O concentration.

3. SCAVENGING TUBING. Scavenging tubing leading from relief (pop-off) valve to interface, if used, to disposal system is leak tested quarterly.

a. Pressurize the tubing to 10 millimeters of mercury.

b. No pressure drop, except for the initial fall due to stretching of materials, should be noticeable during a 15-second observation period.

4. VENTILATORS AND MISCELLANEOUS EQUIPMENT

a. No reasonably simple rapid method has been developed to screen ventilators for leakage. Careful assembly following cleaning and quarterly preventive maintenance by qualified servicemen will minimize leakage. When unexpectedly high N_2O concentrations are detected during surgery, the ventilator should be suspected. In cases involving excess leakage, connect the ventilator to the anesthesia machine in conjunction with a test lung, and search for leakage using a gas analyzer, soap solution, etc.

b. Other equipment such as special bags, not associated with the circle system, tubing, and miscellaneous accessories, should be inspected at least quarterly.

5. ACCESSORY FLOWMETER: PRESSURE-GAUGE METHOD. If the anesthetic machine is not equipped with a low-range flowmeter or pressure gauge, they can be applied at the anesthetic gas outlet by attaching a "T" connector in the gas delivery tubing. The low-pressure leak test procedures are then completed, with the precaution that the tubing be occluded between the absorber and the "T".

6. IMMERSION METHOD FOR LOCALIZING LEAKAGE IN ABSORBER. Employ immersion testing to identify leakage not found by less cumbersome methods. Prepare the machine according to the first three steps in the low pressure test. Precaution must be taken concerning pressurization and the possibility of subsequent damage to the pressure gauge. Caution: the gauge must be kept dry, and screening should be installed, if necessary, to prevent soda lime from entering the breathing-hose connectors.

7. TESTS TO DETERMINE LEAKAGE IN MISCELLANEOUS EQUIPMENT

a. Equipment such as breathing bags, hoses, and devices with metal-to-metal connections suspected of leakage are tested by standard procedures (standard soap solution, leak detectors, and pressurization-immersion).

b. Leakage from ventilators exists when trace gas concentrations increase when ventilators are in use. After cleaning, inspect the components and assemble with care, checking that all gaskets are in place and properly fitted.

APPENDIX B

RECOMMENDED WORK PRACTICES TO REDUCE OCCUPATIONAL EXPOSURE TO WASTE ANESTHETIC GASES

The major responsibility for the reduction of waste anesthetic gases in the operating room environment falls to the individual administering the anesthetic agents. In one study, using effective scavenging systems and properly tested low leakage anesthesia equipment, the work practices of the individual anesthetist contributed 99 percent of the total N_2O released into the room during a facemask technique and 94 percent with an endotracheal tube case. Recommended work practices to minimize waste anesthetic gas exposure include:

a. Where available, connect the waste gas scavenging system to the anesthetic machine and ensure it is operating properly prior to the beginning of administration of an anesthetic agent.

b. If a facemask is to be used for administration of anesthetics, it shall provide as effective a seal as possible against leakage into the ambient air.

c. Vaporizers shall be filled in a ventilated area and in a manner to minimize spillage of the liquid agent. When feasible, vaporizers should be filled when the location where the anesthetic will be administered is not in use. The vaporizers shall be turned off when not in use.

d. Low-pressure leak tests, specified in Appendix A, shall be conducted daily for the complete anesthetic machine. All leaks shall be corrected to the extent specified in Appendix A before use of the anesthetic delivery system.

e. Starting anesthetic gas flow before induction of anesthesia shall be prohibited.

f. When the breathing circuit is disconnected from the patient after administration of the anesthetic agent has started, anesthetic flowmeters shall be turned off or the Y-piece sealed.

g. The breathing bag shall be emptied into the scavenging system before it is disconnected from the anesthetic delivery system.