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. 77-112-447

THE HOSPITAL FOR SPECIAL SURGERY
NEW YORK CITY, NEW YORK 10021

DECEMBER 1977

I. TOXICITY DETERMINATION

A health hazard evaluation was conducted in the operating suite of The Hospital for Special Surgery during September 20-22, 1977. The purpose of the evaluation was to determine whether exposures to nitrous oxide, halothane, and enflurane (anesthetic gases) and methyl methacrylate (bone cement) were posing health hazards to hospital employees. On the basis of environmental sampling, and comparison with environmental criteria, it is concluded that exposures to anesthetic gases at The Hospital for Special Surgery do pose a hazard to exposed operating room personnel. In contrast, also on the basis of environmental sampling and criteria, it is concluded that exposures to methyl methacrylate vapors do not constitute a health hazard for operating room employees. Recommendations for the control of waste anesthetic gases and vapors in operating rooms are given in the text of this report.

II. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from the National Institute for Occupational Safety and Health (NIOSH), Division of Technical Services, 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 the NIOSH Publications Office at the Cincinnati address.

Copies have been sent to:

1. The Hospital for Special Surgery
2. U.S. Department of Labor, Region II
3. NIOSH, Region II

To inform the approximately 30 affected employees, copies of this report shall be posted in a place prominent to these employees for a period of 30 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 a request for a health hazard evaluation from the Director of Engineering at the Hospital for Special Surgery. Concern was expressed that, although scavenging systems had been installed, a quantitative analysis of operating room employee exposures to anesthetic gases was not available. Also, operating room personnel had inquired on several occasions about exposures to methyl methacrylate vapors which result from the mixing of bone cement.

IV. HEALTH HAZARD EVALUATION

A. Process Description

The Hospital for Special Surgery is a 200 bed hospital specializing in orthopedic surgery. The operating suite consists of 3 major and 1 minor operating rooms, recovery room, etc. A typical operating team would include the surgeon, 1 or 2 residents, 1 circulating nurse, 1 scrub nurse, 1 anesthesiologist, and an orderly if needed. The O.R. Department employs about 30 people, keeping the O.R.'s in continuous activity from about 8:00 am until late afternoon. During the survey an average of 18 people per day were scheduled for surgery.

According to the engineering department, the three major operating rooms are provided with 12-14 air changes per hour (fresh air). In addition, operating room No. 1 has a laminar flow system (with high efficiency particulate arrestor (HEPA) filtration) superimposed on the general ventilation system. Operating Room No. 4 has only radiant heat and a window air-conditioner.

The anesthetic gases used at the hospital are nitrous oxide (N_2O), halothane (2-bromo-2-chloro-1,1,1,-trifluoroethane), and enflurane (2-chloro-1,1,2-trifluoroethyl difluoromethyl ether). About 4-6 liters of gases per minute are provided to the patient via face mask or endotracheal tube. A typical gaseous mixture contains oxygen, about 50% nitrous oxide, and 1 to 1½% halothane or enflurane. Intravenous medications are often used.

The anesthetic circuit is composed of the anesthesia machine and the breathing system. The anesthesia machine vaporizes the potent anesthetic (halothane or enflurane) and combines it with nitrous oxide and oxygen, which are supplied from cylinders affixed to the machine. The breathing system consists of a soda lime canister (to absorb entailed carbon dioxide), breathing bag or ventilator, valves for assuring unidirectional gas flow, flexible hoses, and a "Y" piece terminating in an endotracheal tube or face mask.

The anesthetic gas mixture is delivered at a rate higher than the patient's metabolic needs. When a breathing bag is used, excess gases are vented out of the breathing system through the pop off valve. The volume of gases and vapors escaping through the pop-off valve is variable since it depends on the patient's breathing pattern and metabolic rate. When a ventilator is in use the pop-off valve on the anesthetic machine is closed and the ventilator assumes the function of the pop-off valve. As the system is now designed, the pop-off valve and the ventilator are the major sources of waste anesthetic gases. Other sources are the face mask or endotracheal tube, cracks or holes in the hoses, tube fittings or seals, or from spilled liquid anesthetic.

The exposures to methyl methacrylate vapors result from the use of radiopaque bone cement. The cement is prepared just prior to insertion into the patient by hand mixing (with a spatula) in a small open bowl for about 4 minutes. It is during this mixing that maximum employee exposure occurs. The two prepackaged components are: (1) an ampule holding 20 ml of liquid which consists of methyl methacrylate monomer (97.4%), N,N-dimethyl-paratoluidine (2.6%) and hydroquinone (75 ppm); and (2) a 40 gram packet of sterile powder consisting of polymethylmethacrylate (6.0 g), methyl methacrylate-styrene-copolymer (30.0 g), and barium sulfate (4.0 g). Judgment on the basis of percent composition, physical properties, and toxicity, predicts that the only potential vapor hazard to the employees would be that due to methyl methacrylate monomer.

B. Evaluation Methods and Results

The air samples for N_2O were collected using 30-liter mylar bags and MSA Model G* personal sampling pumps modified for bag filling. The analyses for N_2O were performed shortly after sampling using a Wilks Miran I Infrared Analyzer operating at a wavelength of 4.48 or 4.52 micrometers and a path length of 5.25 meters. Sample results are presented in Table 1.

The air samples for halothane and enflurane were collected using personal air sampling pumps operating at air flows of about 50 cc/minute and commercially available 150 mg charcoal tubes. The samples were analyzed by gas chromatograph with a flame ionization detector (NIOSH Method No. 127). Sample results are presented in Table 1.

*Mention of trade names or commercial products does not constitute endorsement by the National Institute for Occupational Safety and Health.

The air samples for MMA were collected in groups of four in the breathing zone of the mixer by two sampling methods: 1) using "modified" pumps and 30 liter mylar bags (samples were analyzed shortly after collection using the Wilks Infrared analyzer operating at a wave length of 5.72 micrometers and a pathlength of 17.25 meters); and 2) using personal air sampling pumps operating at air flows of 1.0 liters per minute (lpm) and 150 mg charcoal tubes (samples were analyzed by gas chromatograph with a flame ionization detector -NIOSH Method No. 127). Since exposure durations were limited (e.g. about 8 minutes per hip) the air flow rate of 1.0 liters/minute was used for the charcoal tube sampling. Normally, air flows of 50 to 200 cc/min are used for charcoal tube sampling. Sample results are presented in Table 2.

C. Evaluation Criteria

1. Anesthetic Gases

In the Criteria for a Recommended Standard for Occupational Exposure to Waste Anesthetic Gases and Vapors it is stated that: "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 the document should prevent the effects caused by acute exposure and significantly reduce the risk associated with long term, low level exposure.

For halogenated anesthetic agents, NIOSH recommends that no employee should be exposed to time-weighted average (TWA) concentrations greater than 2.0 ppm. When N_2O is the sole anesthetic agent, NIOSH recommends that no workers should be exposed to TWA concentrations greater than 25 ppm. In most hospital situations, control of N_2O to a TWA concentration of 25 ppm during the anesthetic administration period will result in levels of about 0.5 ppm of the halogenated agent.

2. Methyl Methacrylate (MMA)

The only criteria available for this determination is the Threshold Limit Value (TLV) as published by the American Conference of Governmental Industrial Hygienists (ACGIH).[2] In 1965 the ACGIH recommended an exposure value of 100 parts of methyl methacrylate per million parts of air by volume (ppm) referring to a time-weighted average concentration for a 7 or 8 hour work day and a 40 hour work week. This recommended value is still current (1977). Documentation for the adopted value states: The TLV of 100 ppm is considered sufficiently low to protect against discomfort from irritation and is well below the level giving rise to any systemic effects.[3] The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) has promulgated the TLV of 100 ppm as the federal occupational health standard for methyl methacrylate.[4]

MMA vapor is an irritant to the skin and respiratory tract. Both the monomer and the polymer are reportedly capable of causing an allergic skin reaction. Dust produced from mechanically processing polymethyl methacrylate may also be irritating to the skin or may enter the eyes.[5] A recent study has suggested that MMA causes certain alterations in blood and urine biochemical parameters but at exposures to vapor concentrations higher than those measured at The Hospital for Special Surgery.[6]

Current literature does not implicate MMA as a known carcinogen. The odor threshold of MMA is less than 1.0 ppm,[7] a value which is just a fraction of the environmental criteria (100 ppm).

D. Discussion of Results - Conclusions

1. Anesthetic Gases

The air sample results (Table 1) indicate operating room N_2O concentrations ranging from 10 to >1000 ppm. For specific operations the average N_2O concentrations ranged from 17 to >1000 ppm with a mean of 310 ppm. Since such individuals as the anesthesiologists and residents could have more than 8 hours per day operating room exposure, it is clear that the NIOSH criteria for N_2O (25 ppm) is being exceeded.

The air sampling for the combined halogenated gases (Table 1) indicated individual results ranging from non-detectable to 6.3 ppm with an average of 1.8 ppm. Based on a comparison with the NIOSH recommended criteria of 2.0 ppm it is judged that while the employees are probably not being over-exposed to the halogenated gases, the exposures are none-the-less significant.

2. Methyl Methacrylate

For the bag sampling, the MMA sample results ranged from 3 to 77 ppm with a mean of 42 ppm. For the charcoal tube sampling, the MMA sample results ranged from 2 to 44 ppm with a mean of 15 ppm (Table 2). For the air sampling of this study it is felt that the bag sampling/Wilks Miran analyses most accurately reflect actual air levels. When using a charcoal tube method, the desorption coefficient must be considered, particularly for a monomer such as methyl methacrylate. It is possible that the monomer will partially polymerize on the charcoal substrate. The desorbing process, prior to gas chromatograph analysis, would then underestimate the amount of MMA collected on the charcoal.

If one assumes a maximum exposure to MMA of 32 minutes per day (4 hips) and an average air concentration of 42 ppm, the 8-hour time weighted average exposure of the surgical assistant would be 3 ppm (compared to the TLV of 100 ppm for an 8-hour time weighted average exposure). Consequently, it is not felt that inhalation of MMA vapors would pose a health hazard to the individuals who do the mixing or to others in the operating suite.

The surgical assistants, who mix the MMA, cite the odor and an occasional transient irritation to the eyes as being characteristic of working with MMA. The pungent odor does not, in itself, constitute a health hazard. Since the odor threshold is less than 1.0 ppm (the OSHA standard is 100 ppm), it is not surprising that the presence or detection of odors prompts the logical question of whether there may be hazardous exposures.

Methyl methacrylate does have an irritative toxicity and it is upon this basis that the TLV of 100 ppm (OSHA standard) has been set. Apparently there is a degree of acclimatization to this irritative nature of MMA. Within the Documentation for the ACGIH TLV's it is stated "The investigators noted irritation at 170 to 250 ppm, but workers tolerated without complaint levels approximating 200 ppm". It is felt that the momentary transient irritation, experienced by the individuals who mix the bone cement, is minor and does not constitute a hazard to the health of these employees.

As stated earlier in this report, bulk MMA monomer and polymer are reportedly capable of causing an allergic skin reaction in certain individuals. For those rare individuals who exhibit an allergic reaction to MMA, there is but one remedy -- they simply must avoid any physical contact with the MMA. If it is of necessity that a reacting individual handle MMA, an allergic skin reaction can most likely be avoided by the use of gloves which are impermeable to the MMA.

E. Recommendations

Several actions should be initiated to reduce the concentrations of waste anesthetic gases in the operating rooms and other areas of the operating suite. The scavenging equipment should be carefully examined and tested to determine whether it is providing the degree of control desirable. The ventilation systems should meet (if they do not) the criteria found in: "Minimum Requirements of Construction and Equipment for Hospitals and Medical Facilities" (HEW Publication No. 74-4000, Rockville, Maryland 1974).

Work practices should be reviewed to assure minimum waste of anesthetic gases. One means to accomplish this is to reduce the flow to the patient. Some anesthesiologists feel this is a valid practice since the patient's metabolic rate requires only a fraction of the oxygen provided by currently popular techniques. Other anesthesiologists feel that the excess of oxygen (and therefore of anesthetic gases, since all agree that the proportions should remain roughly constant) is necessary to provide a margin of safety. Other possible revisions in work practices, as stated in the NIOSH criteria document on anesthetic gases include:

1. Prior to the beginning of administration of an anesthetic agent, waste gas disposal systems shall be connected and proper operation determined.

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

3. 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.

4. Low pressure leak tests for the complete anesthetic machine shall be conducted daily.

5. Anesthetic gas flow shall not be started prior to induction of anesthesia.

6. 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.

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

Anesthesia equipment should be checked and maintained on a regular basis. Both high and low pressure components should be leak tested. Face masks, tubing, breathing bags and endotracheal tubes should be visually inspected for cracks and other leak sources.

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. American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Substances in Workroom Air. Adopted by ACGIH for 1977. Cincinnati, Ohio 1977

3. American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Ed. 3, Cincinnati, Ohio 1971

4. U.S. Department of Labor, Occupational Safety and Health Administration. OSHA Safety and Health Standards (29 CFR 1910) OSHA 2206 (Revised January 1976) p. 507

5. Encyclopedia of Occupational Health and Safety. Volume I, International Labour Office, Geneva, Switz., 1971, pp. 34-36

6. Cromer, J. and Kronoveter, K. A study of Methyl Methacrylate Exposures and Employee Health. DHEW (NIOSH) Publication No. 77-119, Cincinnati, Ohio, Nov. 1976, 54 p.

7. Compilation of Odor and Taste Threshold Values Data. ASTM. W.H. Stahl, Editor. May 1973, p. 113

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Table 1

Results of Air Sampling for Nitrous Oxide, Halothane, and Enflurane

The Hospital for Special Surgery
New York City, New York

Date	Sample Type	Sample Time	Sample Description	Operation	Anesthetic	Air Concentrations Halothane ppm*	Enflurane ppm	Nitrous Oxide ppm
9-20-77	Personal	0845-1247	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	N.D.	N.D.	--
"	Area	0845-0945	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	--	--	290
"	Area	0925-0956	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	--	--	20
"	Area	0956-1033	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	--	--	150
"	Area	1033-1123	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	--	--	30
"	Area	1123-1215	O.R.#1 - Anesthesiologist	Hand Reconstruction	N_2O	--	--	20
"	Personal	1225-1445	O.R.#1 - Circulating Nurse	Mitchell Procedure	N_2O-Halothane	0.7	N.D.	--
"	Personal	1310-1525	O.R.#1 - Anesthesiologist	Mitchell Procedure	N_2O-Halothane	1.7	0.1	--
"	Area	1310-1403	O.R.#1 - Anesthesiologist	Mitchell Procedure	N_2O-Halothane	--	--	20
"	Area	1403-1440	O.R.#1 - Anesthesiologist	Mitchell Procedure	N_2O-Halothane	--	--	20
"	Area	1440-1525	O.R.#1 - Anesthesiologist	Mitchell Procedure	N_2O-Halothane	--	--	10
"	Personal	0845-1153	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	3.7	0.1	--
"	Area	0845-0928	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	--	--	> 1000
"	Area	0928-1000	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	--	--	> 1000
"	Area	1000-1030	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	--	--	> 1000

Table 1 (Continued)

Date	Sample Type	Sample Time	Sample Description	Operation	Anesthetic	Air Concentrations Halothane ppm*	Enflurane ppm	Nitrous Oxide ppm
9-20-77	Area	1030-1120	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	--	--	> 1000
"	Area	1120-1153	O.R.#2 - Anesthesiologist	Spine Fusion	N_2O-Halothane	--	--	> 1000
"	Personal	1206-1351	O.R.#2 - Anesthesiologist	Palmar Fasciectomy	Local	N.D.	N.D.	--
"	Area	1207-1300	O.R.#2 - Anesthesiologist	Palmar Fasciectomy	Local	--	--	180
"	Area	1300-1350	O.R.#2 - Anesthesiologist	Palmar Fasciectomy	Local	--	--	70
"	Personal	1251-1545	O.R.#2 - Circulating Nurse	Fasciectomy & Graft	N_2O-Halothane	0.5	0.2	--
"	Personal	1408-1658	O.R.#2 - Anesthesiologist	Reduction - Graft	N_2O-Halothane	1.9	0.2	--
"	Area	1408-1511	O.R.#2 - Anesthesiologist	Reduction - Graft	N_2O-Halothane	--	--	140
"	Area	1511-1615	O.R.#2 - Anesthesiologist	Reduction - Graft	N_2O-Halothane	--	--	180
"	Area	1615-1658	O.R.#2 - Anesthesiologist	Reduction - Graft	N_2O-Halothane	--	--	190
"	Personal	0948-1230	O.R.#3 - Anesthesiologist	Rotator - cuff-knee	N_2O-Halothane	1.8	0.2	--
"	Personal	1232-1608	O.R.#3 - Anesthesiologist	Knee Ligament	N_2O-Enflurane	N.D.	2.3	--
"	Area	0948-1058	O.R.#3 - Anesthesiologist	Rotator cuff-knee	N_2O-Halothane	--	--	290
	Area	1058-1214	O.R.#3 - Anesthesiologist	Rotator cuff-knee	N_2O-Halothane	--	--	620
"	Area	1234-1342	O.R.#3 - Anesthesiologist	Knee Ligament	N_2O-Enflurane	--	--	170
"	Area	1342-1449	O.R.#3 - Anesthesiologist	Knee Ligament	N_2O-Enflurane	--	--	230
"	Area	1450-1551	O.R.#3 - Anesthesiologist	Knee Ligament	N_2O-Enflurane	--	--	190

Table 1 (Continued)

Date	Sample Type	Sample Time	Sample Description	Operation	Anesthetic	Air Concentrations Halothane ppm*	Enflurane ppm	Nitrous Oxide ppm
9-20-77	Personal	0838-1230	O.R.#4 - Anesthesiologist	3-minor procedures	N_2O,Halothane,Enflurane	0.8	2.5	--
"	Area	0840-0950	O.R.#4 - Anesthesiologist	3-minor procedures	" " "	--	--	690
"	Area	0950-1024	O.R.#4 - Anesthesiologist	3-minor procedures	" " "	--	--	600
"	Personal	1518-1638	O.R.#4 - Anesthesiologist	3-minor procedures	N_2O-Enflurane	N.D.	6.3	--
"	Area	1518-1559	O.R.#4 - Anesthesiologist	3-minor procedures	N_2O-Enflurane	--	--	140
"	Area	1600-1638	O.R.#4 - Anesthesiologist	3-minor procedures	N_2O-Enflurane	--	--	200
"	Area	1035-1433	Recovery Room - By Desk	--	--	0.2	0.3	--
"	Area	1027-1127	Recovery Room - By Desk	--	--	--	--	80
"	Area	1127-1229	Recovery Room - By Desk	--	--	--	--	110
"	Area	1229-1327	Recovery Room - By Desk	--	--	--	--	50
"	Area	1327-1426	Recovery Room - By Desk	--	--	--	--	70
"	Area	1427-1530	Recovery Room - By Desk	--	--	--	--	60
"	Area	1530-1625	Recovery Room - By Desk	--	--	--	--	70
9-21-77	Personal	1005-1112	O.R.#1 - Anesthesiologist	Skin Graft	N_2O-Enflurane	N.D.	3.2	--
"	Personal	1010-1349	O.R.#2 - Circulating Nurse	Bilateral Hip Rep.	?	1.1	.3	--
"	Personal	1009-1215	O.R.#2 - Visiting Physician	Bilateral Hip Rep.	?	1.6	.2	--
"	Personal	1148-1535	O.R.#3 - Anesthesiologist	Wrist Flexor Slide	N_2O-Halothane	0.8	0.4	--

Table 1 (Continued)

Date	Sample Type	Sample Time	Sample Description	Operation	Anesthetic	Air Concentrations Halothane ppm*	Enflurane ppm	Nitrous Oxide ppm
9-21-77	Personal	1012-1405	O.R.#3 - Circulating Nurse	Wrist Flexor Slide	N_2O-Halothane	0.4	N.D.	--
"	Personal	1101-1501	O.R.#3 - Circulating Nurse	--	--	3.4	0.4	--
"	Area	1120-1513	Recovery Room - On Desk	--	--	0.9	N.D.	--
"	Area	1030-1050	Suite Aisle - By Sterile Supply Cabinet	--	--	--	--	140
"	Area	1053-1126	Suite Aisle - By Sterile Supply Cabinet	--	--	--	--	150
"	Area	1034-1153	Scrub Area - O.R.#3 & 4	--	--	--	--	50
"	Area	1153-1350	Scrub Area - O.R.#3 & 4	--	--	--	--	90
9-22-76	Personal	0846-1237	O.R.#1 - Anesthesiologist	Supracondylar Osteotomy	?	N.D.	2.8	--
"	Personal	0837-1237	O.R.#3 - Circulating Nurse	Arthrotomy Knee	N_2O	N.D.	N.D.	--
"	Personal	0833-1222	O.R.#4 - Anesthesiologist	Arthrotomy Knee	N_2O-Halothane	2.2	0.7	--
"	Area	0839-1235	O.R. Supervisor's Office	--	--	0.3	N.D.	--
"	Area	0929-1057	Suite Aisle - By Sterile Supply Cabinet	--	--	--	--	35
"	Area	1057-1144	Suite Aisle - By Sterile Supply Cabinet	--	--	--	--	50

* ppm = Parts of Halothane, Enflurane, or Nitrous Oxide per million parts of air by volume.

Table 2

Results of Air Sampling for Methyl Methacrylate

The Hospital for Special Surgery
New York City, New York

Date	Method of Sampling	Time of Sampling	Sample Location*	Methyl Methacrylate Concentration (ppm)**
9-21-77	Teflon Bag	0926-0930, 0945-0949	O.R.#2	--
"	Teflon Bag	" "	O.R.#2	57
"	Charcoal Tube	" "	O.R.#2	12
"	Charcoal Tube	" "	O.R.#2	19
"	Teflon Bag	1124-1128, 1146-1150	O.R.#2	48
"	Teflon Bag	" "	O.R.#2	40
"	Charcoal Tube	" "	O.R.#2	8
"	Charcoal Tube	" "	O.R.#2	23
"	Teflon Bag	1344-1348, 1408-1412	O.R.#1	3
"	Teflon Bag	" "	O.R.#1	3
"	Charcoal Tube	" "	O.R.#1	3
"	Charcoal Tube	" "	O.R.#1	2
"	Teflon Bag	1600-1604, 1631-1635	O.R.#1	75
"	Teflon Bag	" "	O.R.#1	77
"	Charcoal Tube	" "	O.R.#1	34
"	Charcoal Tube	" "	O.R.#1	44

Table 2 (Continued)

Date	Method of Sampling	Time of Sampling		Sample Location*	Concentration (ppm)**
9-22-77	Teflon Bag	1008-1012,	1056-1100	O.R.#2	40
"	Teflon Bag	"	"	O.R.#2	35
"	Charcoal Tube	"	"	O.R.#2	2
"	Charcoal Tube	"	"	O.R.#2	2
Environmental Criteria (ACGIH-TLV)					100

*All samples were collected in the breathing zone of the individual doing the mixing.
**ppm = Parts of methyl methacrylate per million parts of air by volume.