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New Alaska Native Medical Center
Anchorage, Alaska

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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.

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Health Hazard Evaluation Report 97-0062-2662
New Alaska Native Medical Center
Anchorage, Alaska
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SUMMARY

On December 10, 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Safety and Health Manager of the Alaska Native Medical Center for assistance in baseline chemical exposure monitoring for the New Alaska Native Medical Center, to be opened in June of 1997 in Anchorage, Alaska. The request specified that the survey be conducted in late June or early July 1997 (about one month after the hospital opened) and include exposure monitoring for ethylene oxide (ETO), waste anesthetic gases (isoflurane, desflurane, sevoflurane and nitrous oxide) in the operating room suites, cold sterilants (glutaraldehyde), dark room chemicals (acetic acid, hydroquinone, and glutaraldehyde), laboratory chemicals used in pathology (xylene and formaldehyde), nitrous oxide used in dental operatories, and general volatile organic compounds throughout the new building.

Air sampling was conducted June 30- July 3, 1997. Exposures to gluaraldehyde, acetic acid, and hydroquinone in two dark rooms (the Main Hospital and in the Primary Care Clinic); ethylene oxide in Central Supply; formaldehyde in Pathology and the Autopsy Room; xylene in Pathology; and volatile organic compounds (VOCs) in the Main Hospital and in the Primary Care Clinic were all well below any evaluation criteria. Almost all samples were at or below the respective analytical method's limit of detection. Only 3 of 50 samples for waste anesthetics in the Operating Room Suites were above the NIOSH REL (25 ppm for nitrous oxide and 2 ppm for halogenated anesthetics per procedure) for either nitrous oxide (one sample at 43 ppm) or halogenated anesthetics (two samples for sevoflurane at 3.4 and 10.2 ppm). The three elevated samples were all associated with pediatric dental rehabilitation cases in the OR where sevoflurane was used. The high nitrous oxide concentrations (100-225 ppm for a procedure) measured initially in the Dental Suites were reduced to acceptable concentrations (5-8 ppm) by some minor ventilation and room adjustments.

General recommendations include the creation of a negative pressure in the dark room area of the X-ray processors; a better storage system for tissue samples (in formalin); ventilation adjustments in the Dental Suites; that only originally designed slip fittings be used in the Operating Room for the high pressure nitrous oxide hoses; and drain trap filling on routine maintenance.

Chemical exposures throughout the new Alaska Native Medical Center were generally well below any evaluation criteria. Initially high exposures to nitrous oxide in the Dental Suites were controlled by making ventilation and minor room adjustments. Three of 50 samples in the Operating Room Suites were above the NIOSH REL for halogenated anesthetics and nitrous oxide. Recommendations are made to help with minor problems noted during the survey.

Keywords: SIC 8062 (General Medical and Surgical Hospitals), hospitals, acetic acid, desflurane, ethylene oxide, formaldehyde, glutaraldehyde, hydroquinone, isoflurane, nitrous oxide, sevoflurane, waste anesthetic gases, volatile organic compounds (VOCs)

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INTRODUCTION

On December 10, 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Safety and Health Manager of the Alaska Native Medical Center for assistance in baseline chemical exposure monitoring for the New Alaska Native Medical Center to be opened in June of 1997 in Anchorage, Alaska. The request specified that the survey be conducted in late June or early July 1997 (about one month after the hospital opened) and include exposure monitoring for ethylene oxide (ETO), waste anesthetic gases in the operating room suites (isoflurane, desflurane, sevoflurane and nitrous oxide), cold sterilants (glutaraldehyde), dark room chemicals (acetic acid, hydroquinone, and glutaraldehyde), laboratory chemicals used in pathology (xylene and formaldehyde), and nitrous oxide used in dental operatories.

BACKGROUND

The New Alaska Native Medical Center is a 5-story, 150 bed hospital in Anchorage, Alaska, which provides medical care to Native Americans from all over Alaska. This new state-of-the-art hospital which opened in early June 1997, includes a full range of medical facilities, such as 12 Operating Rooms, Pharmacy, Inpatient beds, Radiology, Pediatrics, Dentistry, Central Supply, Cafeteria, ENT, Internal Medicine, Mental Health, Morgue, Family Medicine, Administrative Offices, Orthopedics, and General Medicine. A two-story outpatient Primary Care facility is located adjacent to the hospital.

The areas of interest for monitoring included the Operating Rooms (ORs) for waste anesthetic gases (isoflurane, desflurane, sevoflurane, and nitrous oxide), Central Supply (ethylene oxide), X-ray Processing dark rooms (hydroquinone, glutaraldehyde, and acetic acid), the Pathology Laboratory (xylene and formaldehyde), Morgue (formaldehyde), Dental Operating suites (nitrous oxide), cold sterilant use throughout the hospital (glutaraldehyde), and general concerns about volatile organic compounds (VOCs) in a new building.

METHODS

Area air samples for acetic acid were collected on 150 milligram (mg) charcoal sorbent tubes at 0.2 liters per minute (Lpm) using Gilian LFS 113D C personal sampling pumps. The samples were desorbed with formic acid and analyzed by gas chromatography according to NIOSH Analytical Method #1603.[1]

Area air samples for ethylene oxide (EtO) were collected on hydrogen bromide-coated petroleum charcoal sorbent tubes at 0.1 Lpm using battery-operated Gilian model LFS 113D C personal sampling pumps. The samples were desorbed with dimethylformamide and analyzed by gas chromatography according to OSHA Method #50.[2] A direct-reading photoionization detector was used to detect any EtO leaks around the sterilizer during operation.

Area and personal air samples for formaldehyde were collected on treated XAD-2 sampling tubes at 0.1 Lpm using Gilian LFS 113D C personal sampling pumps. The samples were desorbed with toluene and analyzed by gas chromatography according to NIOSH Analytical Method 2541.[1]

Area air samples for glutaraldehyde were collected on coated silica gel tubes at 0.2 Lpm using battery-operated Gilian model LFS 113 D C personal sampling pumps. The samples were desorbed with acetonitrile and analyzed by high performance liquid chromatography (HPLC) according to NIOSH Analytical Method #2532.[1]

Area air samples for hydroquinone were collected on 0.8-micron (µm) cellulose ester membrane filters at 2 Lpm using Gilian model HFS 513A personal sampling pumps. The samples were

sonicated in 1% acetic acid in water and analyzed by HPLC according to NIOSH Analytical Method #5004.[1]

Personal and area air samples for isoflurane were collected on 150-mg charcoal sorbent tubes at 0.1 - 0.2 Lpm using Gilian LFS 113D C personal sampling pumps. The samples were desorbed with carbon disulfide and analyzed by gas chromatography according to NIOSH Analytical Method #1003.[1]

Personal and area air samples for desflurane and sevoflurane were collected on Anasorb 747 sorbent tubes at 0.05 Lpm using Gilian LFS 113D C personal sampling pumps. The samples were desorbed with toluene and analyzed by gas chromatography according to OSHA Analytical Method #106.[2]

Personal and area air samples for xylene were collected on 150-mg charcoal sorbent tubes at 0.2 Lpm using Gilian LFS 113D C personal sampling pumps. The samples were desorbed with carbon disulfide and analyzed by gas chromatography according to NIOSH Analytical Method #1501.[1]

Samples for N_2O were obtained using battery-powered portable sampling pumps operating at approximately 0.5 Lpm. A length of Tygon® tubing was attached near the breathing zone of the employee and connected to the inlet of the sampling pump. The exhaust port of each pump was attached via Tygon® tubing to an evacuated bag made of inert material. Samples were collected for the duration of the surgical procedures. Bags were immediately analyzed at a location outside of the operating room using an infrared analyzer (Foxboro Miran® 1A Specific Vapor Analyzer) in accordance with NIOSH Analytical Method 6600.[1]

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[3], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®)[4], and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[5]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA-approved job safety and health programs continue to

enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Acetic Acid

Inhalation of acetic acid can cause irritation of the nose and throat. Higher concentrations can cause inflammation of the airways and accumulation of fluid in the lungs. Acetic acid vapors and liquid can cause eye irritation. Concentrated solutions can cause severe burns and permanent eye damage. Acetic acid is also a strong irritant to the skin. Acetic acid is a normal body component and does not accumulate in the body. It is rapidly transformed and excreted, or used in the production of chemicals required for bodily functions.[6]

Both NIOSH and OSHA currently have 8-hr TWA evaluation criteria of 10 parts per million (ppm) for acetic acid. In addition, NIOSH recommends that exposures to acetic acid not exceed 15 ppm during any 15-minute exposure during the course of the day (short-term exposure limit).[4]

Ethylene Oxide

The acute toxic effects of EtO in humans and animals include acute skin, respiratory, and eye irritation; skin sensitization; nausea, vomiting, and diarrhea; and nervous system effects. Nonmalignant chronic effects in humans include anemia and respiratory irritation, with susceptibility to secondary respiratory infection. Further, occupational exposure to EtO may increase the frequency of mutations in human populations as noted in a 1977 NIOSH document.[7] More recently, cases of peripheral neuropathy among exposed workers have been reported.[8]

A study demonstrates that EtO induces cancer in experimental animals.[9] A dose-related increase in mononuclear cell leukemia was established in that study; exposures as low as 10 ppm increased the proportion of female rats with leukemia. Also, experiments indicate that EtO exposure to either male or female animals results in adverse effects on reproduction.[10,11]

In humans, epidemiologic investigations of cancer mortality among Swedish workers exposed to EtO suggest an increased risk of leukemia and other cancers.[12,13] Recent information also suggests that EtO is associated with chromosomal abnormalities in peripheral lymphocytes of exposed workers.[14]

Based on this information, NIOSH recommended in a 1981 Current Intelligence Bulletin that EtO be regarded in the workplace as a potential occupational carcinogen, and that exposure be reduced to the lowest extent possible.[15] An 8-hour TWA below 0.1 ppm, and a ceiling limit not to exceed 5 ppm during any 10 minute period in a working day is recommended.[16] The current OSHA standard for EtO is 1 ppm as an 8-hour TWA, with an action level of 0.5 ppm which triggers employee exposure monitoring and medical surveillance provisions.[17] OSHA also has a ceiling limit of 5 ppm for any 15-minute exposure period.[18] Due to its high cancer potency in experimental animals, the ACGIH recommends a TLV of 1.0 ppm as an 8-hour TWA.[4]

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract and sensitization of the skin. The first symptoms associated with formaldehyde exposure, at concentrations ranging from 0.1 to 5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory tract. There is variation among individuals, in terms of their tolerance and susceptibility to acute exposures of the compound.[19]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment industry.[20] NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL.[21] ACGIH has designated formaldehyde to be a suspected human carcinogen and therefore, recommends that worker exposure by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV.[5] ACGIH has set a ceiling limit of 0.3 ppm.

Note: NIOSH testimony to DOL on May 5, 1986, stated the following: "Since NIOSH is not aware of any data that describe a safe exposure concentration to a carcinogen NIOSH recommends that occupational exposure to formaldehyde be controlled to the lowest feasible concentration; 0.1 ppm in air by collection of an air sample for any 15-minute period as described in NIOSH analytical method 3500 which is the lowest reliably quantifiable concentration at the present time." NIOSH also lists a PEL for formaldehyde of 0.016 ppm for up to a 10-hour TWA exposure (again using NIOSH analytical method 3500) and indicating that this is the lowest reliably quantifiable concentration at the present time. Investigators should be aware that formaldehyde levels can currently be measured below 0.016 ppm. It may be appropriate to refrain from using numerical limits and instead state that concentrations should be the lowest feasible (in some situations, this may be limited by the ambient background concentration).

Glutaraldehyde

Glutaraldehyde is used primarily for disinfection or sterilization of medical, dental, and hospital equipment. It is irritating to the skin, mucous membranes, and upper respiratory tract. It has a pungent odor, an odor recognition threshold of 0.04 ppm and an irritation response level of 0.3 ppm.[4]

The current literature illustrates that glutaraldehyde is a relatively strong irritant to the nose and a severe irritant to the eye. It can produce staining and may be slightly irritating to the skin. It also may cause skin sensitization (allergic contact dermatitis) from occasional or incidental occupational exposures. Furthermore, it appears that the relatively strong irritant effect of pure glutaraldehyde on the eyes, nasal passages, upper respiratory tract and skin are slightly enhanced when the dialdehyde is activated. Finally, recent information suggests that glutaraldehyde may cause asthma.

NIOSH and ACGIH have established an evaluation criteria of (C) 0.2 ppm which is equal to (C) 0.82 milligrams per cubic meter (mg/m^3). The designation C refers to a ceiling concentration that should not be exceeded during any part of the exposure.[2] Currently there is no OSHA PEL for this substance.

Note: OSHA had revised their PELs in 1989 and had adopted a PEL for glutaraldehyde of 0.2 ppm (Ceiling). These PELs were vacated by the Court of Appeals in 1992.

Hydroquinone

Short-term exposure to hydroquinone can cause headache, dizziness, nausea, vomiting, increased respiration, breathing difficulty, discoloration of the skin, and irritation of the skin and eyes. Chronic exposure may result in depigmentation of the skin, brownish discoloration of the cornea, and blurred vision.

The current OSHA PEL is 2 mg/m^3 as an 8-hr TWA. NIOSH recommends 2 mg/m^3 as a 15-minute exposure. The ACGIH TLV is 2 mg/m^3 as an 8-hr TWA.

Volatile Organic Compounds (VOCs)

Volatile organic compounds describe a large class of chemicals which are organic (i.e., containing carbon) and have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. These compounds are emitted in varying concentrations from numerous indoor sources including, but not limited to, carpeting, fabrics, adhesives, solvents, paints, cleaners, waxes, cigarettes, and combustion sources.

Indoor environmental quality studies have measured wide ranges of VOC concentrations in indoor air as well as differences in the mixtures of chemicals which are present. Research also suggests that the irritant potency of these VOC mixtures can vary. While in some instances it may be useful to identify some of the individual chemicals which may be present, the concept of total volatile organic compounds (TVOC) has been used in an attempt to predict certain types of health effects.[22] The use of this TVOC indicator, however, has never been standardized.

Some researchers have compared levels of TVOCs with human responses (such as headache and irritative symptoms of the eyes, nose, and throat). However, neither NIOSH nor OSHA currently have specific exposure criteria for VOC mixtures in the nonindustrial environment. Research conducted in Europe suggests that complaints by building occupants may be more likely to occur when TVOC concentrations increase.[23] It should be emphasized that the highly variable nature of these complex VOC mixtures can greatly affect their irritancy potential. Considering the difficulty in interpreting TVOC measurements, caution should be used in attempting to associate health effects (beyond nonspecific sensory irritation) with specific TVOC levels.

Waste Anesthetic Gases

Nitrous Oxide and Halogenated Anesthetics: Isoflurane, Desflurane, Sevoflurane

Reports by Vaisman and Askrog and Harvald were among the first to identify an increased incidence of spontaneous abortion in women exposed to anesthetic gases and in wives of men exposed to anesthetic gases.[24,25] In 1974, the American Society of Anesthesiologists (ASA) published the results of a study indicating "that female members of the operating room-exposed group were subject to increased risks of spontaneous abortion, congenital abnormalities in their children, cancer, and hepatic and renal disease." This report also showed an increased risk of congenital abnormalities in offspring of male operating room personnel. No increase in cancer was found among the exposed males, but an increased incidence of hepatic disease similar to that in females was found.[26]

In a study published by NIOSH in 1976, "N_2O and halothane in concentrations as low as 50 ppm and 1.0 ppm, respectively, caused measurable decrements in performance on psychological tests taken by healthy male graduate students.[27]

Nitrous oxide alone caused similar effects. The functions apparently most sensitive to these low concentrations of anesthetics were visual perception, immediate memory, and a combination of perception, cognition, and motor responses required in a task of divided attention to simultaneous visual and auditory stimuli." Headache, fatigue, irritability, and disturbance of sleep were also reported.[28,29]

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

In a study of dentists, Cohen, et al. compared exposed persons who used inhalation anesthetic more than three hours per week with a control group who used no inhalation anesthetic. The exposed group reported a rate of liver disease of 5.9 percent, in comparison with a rate of 2.3 percent in the control group. Spontaneous abortions were reported in 16 percent of pregnancies of the wives of exposed dentists, in comparison with 9 percent of the unexposed.[30] This difference was statistically significant; however, it should be noted that the rate of spontaneous abortions for all pregnancies ranges from 10 to 20 percent.[31] This study did not identify the specific anesthetic being used by the dentists surveyed, that is, whether they used N_2O alone or in combination with a halogenated agent.[18] However, in a review of that study, NIOSH concluded that "the halogenated anesthetics alone do not explain the positive findings of the survey and N_2O exposure must be an important contributing factor, if not the principal factor."[32] This conclusion is based on a calculation which assumed that as many as one in ten of the dentists using an inhalation anesthetic employed a halogenated agent. If the actual fraction is less than one in ten, the conclusion has added strength.

The findings of several epidemiological studies were recently summarized by James T. Purdham of the Occupational and Environmental Health Unit, University of Toronto.[33] The consistent finding from these studies shows that women exposed to waste anesthetic gases have a higher than expected incidence of spontaneous abortions. Congenital abnormalities in the offspring of exposed women were less strongly associated, but were slightly higher than normal.[34]

When N_2O is used as an anesthetic agent in medical procedures, NIOSH recommends that occupational exposure be controlled so that no worker is exposed at TWA concentrations greater than 25 ppm during the period of administration.[16] NIOSH recommends that occupational exposure to halogenated anesthetic agents be controlled so that no worker is exposed at concentrations greater than 2 ppm of any halogenated anesthetic agent during the period of anesthetic administration.[18] When used in combination with N_2O, halogenated anesthetic agents should be controlled to 0.5 ppm, which, generally, can be achieved by controlling N_2O to a TWA of 25 ppm during the period of anesthetic administration. There is presently no OSHA standard for nitrous oxide or the halogenated anesthetic agents. The ACGIH recommends a TLV of 50 ppm for nitrous oxide, 75 ppm for ethrane, and 50 ppm for halothane, but does not have a TLV for isoflurane, desflurane, or sevoflurane.[4]

Xylene

Xylene is a colorless, flammable organic liquid with a molecular structure consisting of a benzene ring with two hydroxyl (OH) substitutions. Xylene is used in paints and other coatings, as a raw material in the synthesis of organic chemicals, dyes, and pharmaceuticals, and it is an ingredient of gasoline and many petroleum solvents.[35]

The vapor of xylene has irritant effects on the skin and mucous membranes, including the eyes and respiratory tract. This irritation may cause itching, redness, inflammation, and discomfort. Repeated or prolonged skin contact with liquid xylene may cause erythema, drying, and defatting which may lead to the formation of vesicles. At

high concentrations, repeated exposure to xylene may cause reversible damage to the eyes.[36]

Acute xylene inhalation exposure may cause headache, dizziness, incoordination, drowsiness, and unconsciousness.[37] Previous studies have shown that concentrations from 60 to 350 ppm may cause giddiness, anorexia, and vomiting.[36] At high concentrations, exposure to xylene has a narcotic effect on the CNS, and minor reversible effects on the liver and kidneys.[6,36]

Historical accounts of hematopoietic toxicity as a result of xylene exposure are likely due to the high concentration of benzene contamination in xylene prior to 1940.[37,38] These effects previously reported are no longer associated with contemporary xylene exposure.[37,38]

The current OSHA PEL, NIOSH REL, and ACGIH TLV for xylene are 100 ppm over an 8-hour TWA. In addition, NIOSH and ACGIH have published STELs for xylene of 150 ppm averaged over 15 minutes.

RESULTS

Area air samples collected in the dark rooms of the main hospital and in the Primary Care Clinic for acetic acid, hydroquinone, and glutaraldehyde are summarized in Tables 1, 2, and 3, respectively. All samples collected, both inside and immediately outside of the dark rooms, were well below all evaluation criteria.

Area air samples collected for ethylene oxide (EtO) during the first run of the EtO sterilizer are summarized in Table 4. All samples were below the limit of detection for the analytical method [3 micrograms per sample (µg/sample)] and thus, well below any evaluation criteria. These data confirm the readings taken with a portable photoionization detector on the same day: no EtO was detected.

Table 5 is a summary of area and personal samples collected for formaldehyde in the Pathology Laboratory and in the Autopsy Room. All samples were below the limit of detection for the analytical method (0.6 µg/sample) and thus, well below any evaluation criteria. Area air samples collected for xylene in the Pathology Laboratory are summarized in Table 6. The highest sample was 26 mg/m^3 collected on top of the Tissue Tek machine in the center of the Pathology Lab. This sample is approximately 6% of the NIOSH, OSHA and AGCIH 8-hr TWA.

Table 7 summarizes the personal breathing-zone air samples collected for the various halogenated waste anesthetic agents (isoflurane, desflurane, and sevoflurane) and nitrous oxide in the Operating Room suites. Concentrations for isoflurane ranged from 0.02 to 0.53 ppm; sevoflurane from 0.03 to 10.4 ppm; and desflurane concentrations (only one procedure sampled) were all at 0.4 ppm. Two of the samples for sevoflurane were above the NIOSH REL of 2 ppm for a procedure. Both samples were from pediatric dental rehabilitation procedures conducted in the OR: one from the dentist conducting the procedure and the other from a scrub nurse in a different procedure. Nitrous oxide concentrations ranged from 0 to 43 ppm over the various procedures. Only 1 of the 23 personal samples for nitrous oxide was above the NIOSH REL of 25 ppm for a procedure.

Four air samples were collected for volatile organic compounds (VOCs) using a thermal desorption tube method with GC-MS analysis. Air samples were collected outside, in the center rotunda of the Primary Care Clinic, in the center of the Pharmacy on top of a shelf, and on a shelf in the Sterilizer Room for endoscopes. The only compounds that were identified on any of these samples (excluding the outdoor sample) that were above the blank levels, were trace amounts of isopropanol and acetone. Both acetone and isopropanol have very high PELs and RELs (1000 ppm PEL for acetone, REL is 250 ppm; and 400 ppm PEL and REL for isopropyl alcohol), so

the trace amounts found in the air samples represent exposures at several orders of magnitude below these evaluation criteria.

Leak tests for nitrous oxide were conducted in each of the Operating Room suites using the Miran infrared analyzer. Leak checks were made at the two high pressure connection points at the ceiling, the slip connect between the ceiling and the cart, and on the cart. Other connections included at the tank on the cart and around the cart. No leaks were found in ORs #2, 3, 4, and 5. A very small leak was found at the slip connector in OR #1. Several leaks were noted in OR #6: a minor one at the threaded connection on the anesthetic cart, a major one at the slip connection midway between the cart and the ceiling, and a very small leak at the primary ceiling connection.

Personal samples for nitrous oxide in the Dental Operating suites are summarized in Table 8. The first two sets of samples were collected in OR #4 (referred to as Peds 2) without making any changes in the room. The Dentist's exposure to nitrous oxide was 225 and 150 ppm for the two procedures, while the Dental Assistant's exposure was 100 and 38 ppm over the same two procedures. The next day, a board was removed from the front of one of the exhaust ducts in the room and the supply louvers were re-directed to flush the anesthetic from the patient toward the exhaust duct (away from the Dentist and Dental Assistant) and the exposures were re-measured. The Dentist's exposure dropped to 8 ppm nitrous oxide over the entire procedure and the Dental Assistant's exposure was also 8 ppm.

DISCUSSION

Exposures to acetic acid, hydroquinone, and glutaraldehyde in the two dark rooms (Main Hospital and Primary Care Clinic) were very low. Pressure checks on the dark rooms in the Main Hospital revealed that one dark room (on the north) was under good negative pressure as per guidelines, but the southern dark room was under very slight positive pressure. The dark room in the Primary Care Clinic was under substantial positive pressure. In fact, the dark room was equipped with only a supply duct and no exhaust. The only way for air to exhaust from the room was through the open door.

Air samples for ethylene oxide (using both a direct-reading photoionization detector and OSHA Method 50) revealed no leaks around the sterilizer during the first trial run of both sterilizer units.

All samples for xylene and formaldehyde in the Pathology Laboratory were quite low indicating no problems. The xylene recycling unit was not operating the day of sampling, so it is unknown what effect this unit may have on xylene concentrations. Tissue samples were being stored in the Autopsy Room and even in some of the Morgue vaults. Air flow in these areas was sufficient to control any formaldehyde vapors.

Only 3 of the 50 samples collected in the Operating Room suites were above the NIOSH REL: 2 for sevoflurane and 1 for nitrous oxide. In general, the sevoflurane air samples were higher than either of the other two halogenated anesthetics (isoflurane and desflurane). This is probably because the vapor pressure of sevoflurane is higher, and sevoflurane seemed to be the agent of choice in the majority of cases that we observed over the 3 days of monitoring. There are no OSHA or ACGIH evaluation criteria for sevoflurane and it was not an agent in use at the time the NIOSH REL for Waste Anesthetic Gases was established (1977), nor was desflurane. The two sevoflurane samples that were above 2 ppm, occurred during pediatric dental rehabilitation work in the OR; the highest was to the Dentist when he was attending to an infant. Infants are recognized to be difficult patients to handle when controlling waste anesthetic emissions. The one high nitrous oxide exposure was to the Circulating Nurse during a procedure when the Anesthetist had difficultly securing the mask on the patient. Once the mask problem was resolved, the nurse's

exposure dropped from 58 ppm to 12 ppm but the average was still 43 ppm for the entire procedure.

Leak checks for nitrous oxide in the Operating Rooms indicated only one problem area in one suite, #6. The largest leak was due to a makeshift slip connector while the original slip connector was on order. The new connector was scheduled to arrive the week after we sampled.

The VOC samples were collected to determine if there were any higher than expected concentrations of organics in the new hospital. Construction of the building had been completed for many months prior to occupancy, so the low levels of VOCs reflect that sufficient time had passed from completion of the hospital to occupancy so that VOC outgasing from new materials had occurred. The only chemicals above background were isopropanol and acetone, which are commonly used throughout the hospital. The air concentrations of isopropanol and acetone were well below any evaluation criteria.

Nitrous oxide concentrations in the Dental Operating suites were initially high (150-225 ppm for the Dentist). Two changes were made in OR #4 (Peds 2) that had a significant effect on lowering the nitrous oxide concentrations. First, there was a board blocking one of the exhaust vents which was moved. Second, the louvers in the supply grill were adjusted so that they swept air across the patient, away from the Dentist and Dental Assistant, towards the exhaust vent. Exposure after this was done dropped to 8 ppm of nitrous oxide for both the Dentist and the Dental Assistant. There were 4 Operating Suites on the outside portion of the Dental Area which were all designed similar to OR #4. In the center of the Dental Area were two more suites whose design made nitrous oxide control more difficult. The supply vents were located at the ceiling level, but the exhaust vents were not directly across from the supply vent as was in OR #4. Rather, they were at right angles to the supply vent. We were not able to monitor during nitrous use in these suites, but with the current design, higher concentrations of nitrous oxide would be expected.

CONCLUSIONS

Exposures to gluaraldehyde, acetic acid, and hydroquinone in the two dark rooms; ethylene oxide in Central Supply; formaldehyde in Pathology and the Autopsy Room; xylene in Pathology, and volatile organic compounds (VOCs) in the Main Hospital and in the Primary Care Clinic were all well below any evaluation criteria. Only 3 of 50 samples for waste anesthetics in the Operating Room Suites were above the NIOSH REL for either nitrous oxide or halogenated anesthetics. The three elevated samples were all associated with pediatric dental cases in the OR where sevoflurane was used. The initially high nitrous oxide concentrations measured in the Dental Operatories were able to be reduced to acceptable concentrations by some minor ventilation and room adjustments. Chemical exposures in the new hospital, in general, were minimal.

RECOMMENDATIONS

1. Exhaust in the south dark room in the Main Hospital should be increased to insure that a negative pressure exists in the dark room. An exhaust vent needs to be added to the dark room in the Primary Care Clinic to establish a negative pressure in this area. The air exchange rate in this room should be 10-15 air changes per hour (ACH). The drain from the processor should be covered and the chemical reservoirs should also be covered. Once the proper ventilation parameters are established, the door to the dark room needs to be kept closed. The employees are used to keeping it open, since this is currently the only way for air to be exhausted from the room.

2. A better system for storage of tissue samples should be established, rather than on counter tops and in morgue vaults.

3. Only slip fittings that were originally specified for use on the high pressure nitrous oxide hoses in the Operating Rooms should be used. Care must be taken when working with children in the OR to avoid overexposure to the waste anesthetic gases. Personnel working with pediatric cases should be informed of the exposure potential and instructed to use additional care when working with children.

4. All louvers in the Operating Suites in the Dental Area should be adjusted to sweep nitrous oxide from the patient to the exhaust vents as was done in OR #4. The center suites with the right angles between the supply and exhaust vents, should not be used for nitrous oxide procedures unless design changes can be made to insure proper collection of nitrous oxide.

5. While in Pathology, a strong sewer odor was noticed from a drain in the hallway (adjacent to an eyewash station) outside the Pathology Laboratory. This area was marked A1-G14D. The odor indicated that the drain trap was probably dry allowing sewer odors to emit from the drain. Routine maintenance procedures should include occasional filling of traps to insure they do not become dry.

6. Peracetic acid odors were noted in the Steris Room at the time of the survey. Work was underway at that time to increase the ventilation in the room to remove the irritating vapors. The increased ventilation should effectively control the peracetic acid vapors, however, this should be verified with monitoring if possible.

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Table 1. Summary of Area Air Sampling Results for Acetic Acid. New Alaska Native Medical Center, Darkroom Samples. July 1-2, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Acetic Acid (milligrams per cubic meter, mg/m^3)
AA-05	Hospital, inside southern darkroom	0.2	24	(0.5)*
AA-06	Hospital, outside entrance to southern darkroom	0.2	24	(0.5)
AA-07	Primary Care Clinic, inside darkroom	0.2	60	(0.22)
AA-08	Primary Care Clinic, outside entrance to darkroom	0.2	60	(0.2)
NIOSH/OSHA/ACGIH 8-hr TWA				**25**

*Parenthesis indicates sample results is above the Limit of Detection (0.01 mg/sample) and below the Limit of Quantitation (0.05 mg/sample)

Table 2. Summary of Area Air Sampling Results for Hydroquinone. New Alaska Native Medical Center, Darkroom Samples. July 1-2, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Hydroquinone (milligrams per cubic meter, mg/m^3)
HG-10	Hospital, inside southern darkroom	2.0	240	<0.004*
HG-11	Hospital, outside entrance to southern darkroom	2.0	240	<0.004
HG-15	Primary Care Clinic, inside darkroom	2.0	600	<0.002
HG-16	Primary Care Clinic, outside entrance to darkroom	2.0	600	<0.002
OSHA/ACGIH 8-hr TWA				**2**

*All samples were below the analytical Limit of Detection (1 microgram/milliliter)

Table 3. Summary of Area Air Sampling Results for Glutaraldehyde. New Alaska Native Medical Center, Darkroom Samples. July 1-2, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Glutaraldehyde (milligrams per cubic meter, mg/m^3)
GT-90	Hospital, inside southern darkroom	0.5	60	<0.0005*
GT-91	Hospital, outside entrance to southern darkroom	0.5	60	<0.0005
GT-92	Primary Care Clinic, inside darkroom	0.5	150	<0.0002
GT-93	Primary Care Clinic, outside entrance to darkroom	0.5	150	<0.0002
OSHA 8-hr TWA				**0.4**

*All samples were below the analytical Limit of Detection (0.03 microgram/sample)

Table 4. Summary of Area Air Sampling Results for Ethylene Oxide. New Alaska Native Medical Center. June 30, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Ethylene Oxide (parts per million, ppm)
ETO-110	Central Supply Sterilizer Room, on top of flammable storage cabinet	0.1	32	<0.05*
ETO-111	Central Supply Sterilizer Room, on right edge of sterilizer	0.1	32	<0.05
ETO-112	Central Supply Sterilizer Room, behind sterilizer on top of drain pump box	0.1	32	<0.05
OSHA/ACGIH (NIOSH 10-hr)8-hr TWA				**1(0.1)**

*All samples were below the analytical Limit of Detection (3 microgram/sample)

Table 5. Summary of Air Sampling Results for Formaldehyde. New Alaska Native Medical Center. July 3, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Formaldehyde (parts per million, ppm)
FM-70	Pathology, top of tissue processing booth	0.1	19	<0.02*
FM-71	Autopsy Room, top of booth	0.1	26	<0.02
FM-72	Autopsy Room, on work bench at head of autopsy table	0.1	26	<0.02
FM-73	Pathology, personal, on Head Pathologist during tissue sectioning	0.1	8.6	<0.06
FM-74	Pathology, on top of sectioning table during tissue sectioning	0.1	8.7	<0.06
FM-75	Pathology, on top of Tissue Tek-VIP to left of sectioning table	0.1	8.4	<0.06
OSHA 8-hr TWA OSHA (NIOSH) Ceiling				**0.75** **2 (0.1)**

*Samples were all below the analytical Limit of Detection (0.6 microgram/sample)

Table 6. Summary of Area Air Sampling Results for Xylene. New Alaska Native Medical Center. July 3, 1997. HETA 97-0062.

Sample No.	Description/Location	Flow Rate (liters per minute)	Sample Volume (liters)	Xylene [all isomers] (milligrams per cubic meter, mg/m^3)
XT-52	Pathology, above sectioning table	0.2	38	2.2
XT-53	Pathology, top of Tissue Tek, center of room	0.2	37	25.7
XT-55	Pathology, top of xylene recycling unit	0.2	20	1.15
NIOSH/OSHA/ACGIH 8-hr TWA				**435**

Table 7. Summary of Personal Air Sampling Results for Waste Anesthetic Gases. New Alaska Native Medical Center, Operating Room Suites, July 1-2, 1997. HETA 97-0062.

Case Description/ Location	Waste Anesthetic Agents	Job Code*	Time of Sample (min)	Halogenated Agent Concentration (ppm)	Nitrous Oxide Concentration (ppm)
OR #1,7/1/97, 3-8% Sevo, Mask with N_2O @ 4 Lpm	Sevoflurane Nitrous Oxide	AN	45	0.03#	17
		CN	69	1.1	43
		SN	45	<0.03	-
OR #5, 7/1/97	Isoflurane Nitrous Oxide	AN	182	0.03	4
		CN	182	0.02	2
		SN	182	0.02	4
OR#4, 7/2/97, 6% Desflurane, 1 Lpm (50/50, O_2/N_2O), breast biopsy and radical removal	Desflurane Nitrous Oxide	AN	212	0.04	3
		CN	152	0.04	3
		SN	188	0.04	2
OR#2, 7/2/97, 1-2% Isoflurane, 2 Lpm (50/50, O_2/N_2O), dental rehab	Isoflurane Nitrous Oxide	DMD	77	0.53	13
		DA	74	0.3	15
OR#2, 7/1/97, 4% Sevo, 2 Liters (50/50, O_2/N_2O), pediatric dental rehab	Sevoflurane Nitrous Oxide	AN	119	1.3	1
		CN	89	0.6	-
		SN	23	3.4	9
		RRN	73	0.4	0

Table 7. Continued

Case Description/ Location	Waste Anesthetic Agents	Job Code*	Time of Sample (min)	Halogenated Agent Concentration (ppm)	Nitrous Oxide Concentration (ppm)
OR#3, 7/2/97, Isoflurane	Isoflurane Nitrous Oxide	AN	51	(0.05)@	3
		CN	52	<0.025@	3
		SN	55	<0.024@	6
OR#2, 7/2/97, 6-7%Isoflurane	Isoflurane Nitrous Oxide	AN	80	<0.13@	3
		CN	80	<0.13@	3
		SN	70	<0.14@	3
OR #2, 7/1/97, 2.5-4% Sevo, 2 Liters (50%/50%, O_2/N_2O), infant dental rehab	Sevoflurane Nitrous Oxide	AN	128	1.7	11
		CN	131	0.4	7
		SN	88	0.9	-
		DA	94	0.7	19
		DMD	122	10.2	-
		RRN	59	0.34	8

#Left early for lunch
*AN = Anesthetic: CN = Circulating Nurse; SN = Scrub Nurse; DMD = Dentist; DA = Dental Assistant; RRN = Recovery Room Nurse
@( )Indicates sample analysis is between Limit of Detection (0.001 mg/sample) and Limit of Quantitation (0.0033 mg/sample)
<Indicates analysis was below the Limit of Detection

Table 8. Nitrous Oxide Concentrations in the Dental Suite OR#4 (Peds #2). New Alaska Native Medical Center. July 2-3, 1997. HETA 97-0062.

Description/Location	Sample Duration (minute)			Nitrous Oxide Conc. (ppm)		
	1st*	2nd*	3rd*	1st*	2nd*	3rd*
Dentist	45	45	51	225	150	8
Dental Assistant	45	45	51	100	38	8
Two feet below Supply grill	45	45	51	-	-	5
Exhaust, Dentist side	45	45	51	-	-	5
Exhaust, Assistant side	45	45	51	-	-	5
NIOSH REL				25		

*1st and 2nd: No changes made in the room
3rd: Board was removed from in front of exhaust vent and supply louvers were adjusted to sweep air from patient to exhaust vent.

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