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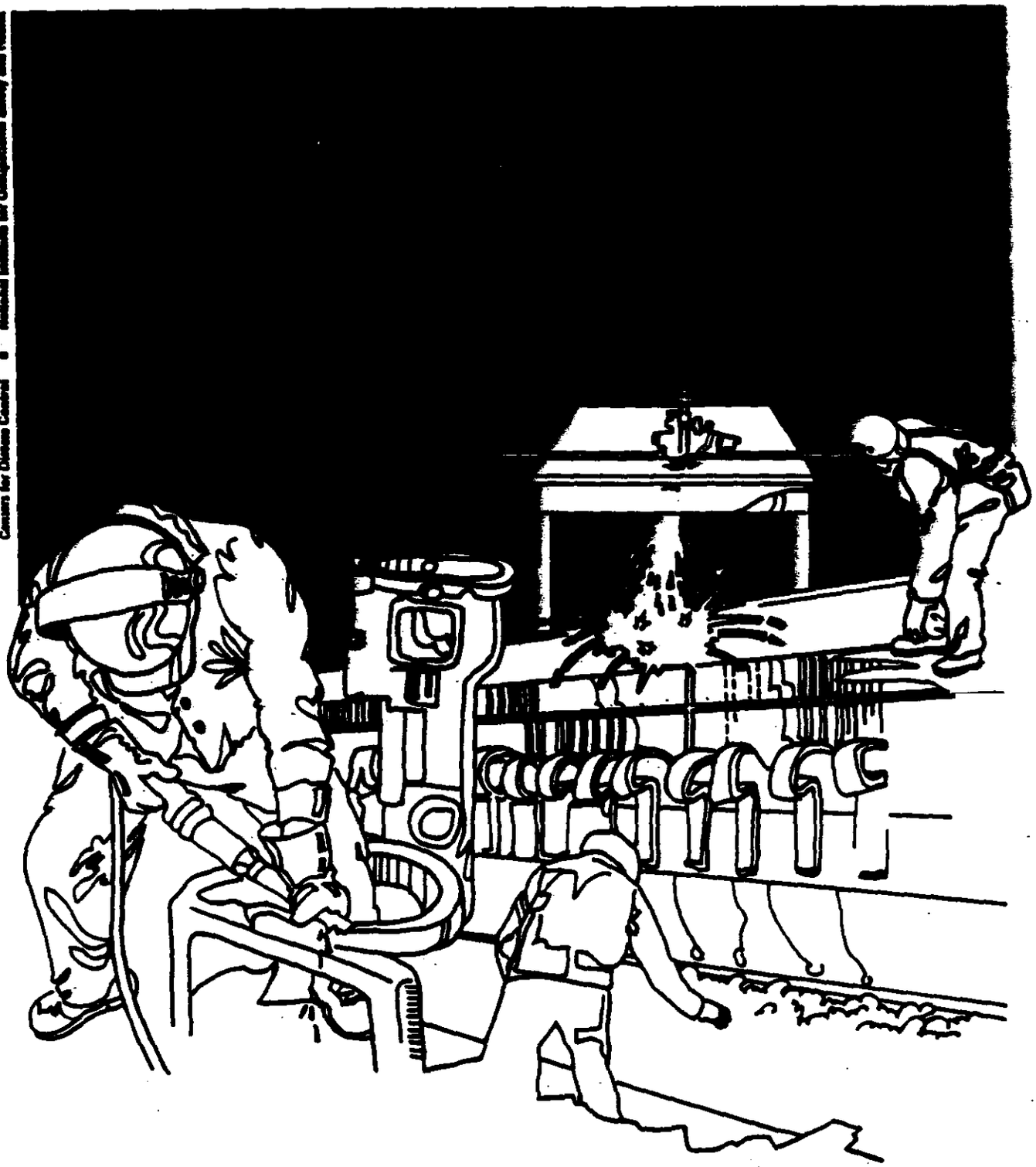

Health Hazard Evaluation Report

HETA 88-287-1942
SAINT MARY-CORWIN HOSPITAL
PUEBLO, COLORADO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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

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I. SUMMARY

On June 9, 1988, the National Institute for Occupational Safety and Health (NIOSH) was requested by management to evaluate exposures at Saint Mary-Corwin Hospital, Pueblo, Colorado. The requestor was concerned with exposures to waste anesthetic gases and vapors in the operating rooms, exposures to ethylene oxide during gas sterilizer use, and exposure to solvents in the hospital laboratory.

In August 1988, NIOSH investigators conducted an environmental survey at the hospital. During this survey, personal and area air samples were collected for nitrous oxide (N_2O), halogenated anesthetic agents, ethylene oxide (EtO), and xylene, acetone, and benzene.

Time-weighted average (TWA) concentrations of N_2O ranged from less than (<) the limit of detection (LOD) of 1 part per million (ppm) to 19 ppm in the nine personnel breathing zone samples collected. None of the samples exceeded the NIOSH recommended exposure limit (REL) of 25 ppm for N_2O as a TWA during the period of anesthetic administration. TWA concentrations of isoflurane ranged from < LOD of 0.01 milligrams (mg) per sample to 0.39 ppm in the nine personal samples collected. None of these samples exceeded the NIOSH REL of 0.5 ppm for halogenated anesthetics used in combination with nitrous oxide. No ethrane or halothane were detected above the limit of quantitation (LOQ) of 0.03 mg/sample.

TWA concentrations of 0.02 and 0.03 ppm EtO were found in two personal samples collected during gas sterilizer operation. These results are below the NIOSH REL's of < 0.1 ppm 8-hour TWA, and 5 ppm 10-minute ceiling, and the OSHA PEL of 1 ppm as an 8-hour TWA. Even though no 10 minute sampling was performed, the NIOSH 5 ppm 10-minute ceiling was not exceeded because if the 5 ppm level was exceeded in any 10 minute period the TWA concentrations would have been at least 0.16 ppm. The highest concentration in the breathing zone was 0.06 ppm.

Xylene was detected in two of three personal samples collected in the histology laboratory at TWA concentrations of 1.5 and 20 mg/M^3. These results are below the NIOSH REL and OSHA PEL of 435 mg/m^3 as an 8-hour TWA. Benzene and acetone were found to be below their LODs of 0.02 and 0.001 mg/sample, respectively.

Based on the data collected, no exposures above the environmental criteria were found during this survey. Recommendations are included in the full body of this report to help strengthen the hospital's existing programs for controlling employee exposures to waste anesthetic gases and vapors, ethylene oxide, and organic solvents.

Key Words: SIC 8062 (General Medical & Surgical Hospitals) nitrous oxide, isoflurane, ethrane, halothane, waste anesthetics, scavenging ethylene oxide, sterilization, xylene, laboratory safety

II. INTRODUCTION

On June 9, 1988, NIOSH received a request from Saint Mary-Corwin Hospital, Pueblo, Colorado, for a health hazard evaluation. The requestor was concerned with possible exposure to waste anesthetic gases and vapors in the hospital's main operating rooms, exposures to ethylene oxide from a gas sterilizer, and exposure to various solvents used in the laboratory. The only complaints were the odors of the solvents used in the laboratory.

On August 21, 1988, NIOSH investigators conducted an environmental survey at the hospital. During this survey, background information on the nature of the hospital operations was obtained, and personal breathing zone and area air sampling was conducted for nitrous oxide (N_2O), halogenated anesthetic agents, ethylene oxide (EtO), xylene, acetone, and benzene. The results of these surveys were provided to the requestor by phone in October 1988.

III. BACKGROUND

Saint Mary-Corwin Hospital, located in Pueblo, Colorado, provides a variety of health care services, including inpatient and outpatient surgical services. The Surgery Department is located on the hospital's first floor, and consists of eight operating rooms, a recovery room, and miscellaneous storage and supply rooms. Personnel normally involved in surgical procedures include a surgeon, an anesthesiologist, a scrub nurse, and a circulating nurse. Often, additional personnel may be involved, depending on the complexity of the procedure. The rooms contain vacuum connections for attachment to the scavenging system of the anesthetic carts. General ventilation is also supplied through vents located near the ceilings of each OR.

A gas sterilizer, which uses ethylene oxide, is located in the hospital's Surgical Stores Department. The sterilizer is recessed into a mechanical access room. This room is equipped with exhaust vents and kept under a negative pressure with respect to the main supply room area. The gas sterilizer also is equipped with local exhaust ventilation and has a large exhaust hood located directly above the sterilizer. At the completion of the gas sterilization cycle, the sterilizer door is cracked for fifteen minutes, during which time the personnel leave the immediate area. Following this interval, the sterilized equipment is transferred to the ventilated and exhausted aeration chamber. Two employees worked in the sterilizer area at the time of the survey.

A histology laboratory is also located on the first floor of the hospital. In this area, a variety of organic solvents are used to prepare tissue slides. Three employees were working in this area at the time of the survey.

IV. MATERIALS AND METHODS

NIOSH investigators conducted an environmental survey at the hospital on August 21, 1988. The operating room survey was designed to assess employee exposures to N_2O and halogenated anesthetic agents used during the course of the surgical procedures. All patients were intubated during this survey. Personal air samples were collected in the vicinity of the employees breathing zone. The samples for N_2O were collected using battery-powered portable sampling pumps operating at approximately 200 cubic centimeters of air per minute (cc/min). The exhaust port of each pump was attached via Tygon tubing to an inert Tedlar bag. Samples were collected for the duration of the surgical procedures, with bags being changed as necessary for the longer procedures. Bags were immediately analyzed at a location outside of the operating room area using an infrared analyzer (Foxboro Miran 103 Specific Vapor Analyzer) in accordance with NIOSH analytical method 6600.[1] Samples were collected in each of the OR's where N_2O use was anticipated. Additional information pertinent to sample collection is provided in Table 1.

To assess employee exposures to the halogenated anesthetics agents used during the surgical procedures, personal and area samples were collected at the locations previously described. Sampling pumps were operated at approximately 200 cc/min, and connected via Tygon tubing to charcoal tube collection media. Samples were later analyzed in accordance with NIOSH analytical method 1003, for ethrane, halothane, and isoflurane, using a gas chromatograph equipped with a flame ionization detector.[1] A listing of information pertinent to sample collection is provided in Table 2.

Where possible, leak detection for N_2O was conducted in the ORs. High pressure hose connections were checked at the wall and anesthetic cart. During anesthetic gas administration, low pressure connections were checked by measurements taken directly at the various anesthetic cart and scavenging system components. These measurements were made using a flexible sampling probe attached to the portable infrared analyzer. The location of these measurements are included in Table 3.

To assess employee exposures to ethylene oxide, personal samples were collected near the breathing zones of the two supply room technicians during the operational cycle of the gas sterilizer and the subsequent loading of the aerator. In addition, area samples were collected in the vicinity of the gas sterilizer, aerator, and in the mechanical access room, to identify areas where leakage from the system might occur. Samples were collected using battery-powered sampling pumps operating at 100 cc/min. The pumps were connected via Tygon tubing to a sorbent tube containing activated charcoal coated with hydrogen bromide. The samples were analyzed in accordance with NIOSH analytical method 1614 for ethylene oxide.[1] A complete listing of information pertinent to sample collection is provided in Table 4.

Samples were also collected in the laboratory area for xylene, acetone, and benzene in the manner previously described using charcoal tubes as the collection media. These samples were desorbed with carbon disulfide and analyzed by gas chromatography using a fused silica capillary column and a flame ionization detector according to NIOSH methods 1300 and 1501 with modifications.[1] A listing of information pertinent to the collection of these samples is provided in Table 5.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for 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 if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting 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 evaluation 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 becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits (PEL's)]. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits (REL's), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

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's) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures. A discussion of the toxicity and evaluation criteria for the substances examined during this survey is provided below.

A. Anesthetic Gases

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.[2,3] 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 the female was found.[4]

In a study published by NIOSH in 1976, "N_2O and halothane in respective concentrations as low as 50 parts per million (ppm) and 1.0 ppm caused measurable decrements in performance on psychological tests taken by healthy male graduate students.[5] 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.[6,7]

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 or halothane as suspected carcinogens.

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 nine percent of the unexposed. 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.[8] 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.[9] 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".[10]

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.

In a document recommending a standard for occupational exposure to waste anesthetic gas, NIOSH recommended a maximum exposure of 50 ppm N_2O on a time-weighted average basis during the anesthetic administration in dental offices.[6] This recommendation is based primarily on available technology in reducing waste anesthetic gas levels in these environments.

When N_2O is used as the sole 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. 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. When used in combination with N_2O, halogenated anesthetic agents should be controlled to 0.5 ppm, which, generally, can be arrived at by controlling N_2O to a TWA concentration of 25 ppm during the period of anesthetic administration.[6] There is presently no OSHA standard for nitrous oxide or the halogenated anesthetic agents. The ACGIH recommends a TLV of 75 ppm for ethrane, and 50 ppm for halothane. In addition, in it's "Notice of Intended Changes" for 1989-89, ACGIH proposes a TLV of 50 ppm for nitrous oxide.[11]

B. Ethylene Oxide (EtO)

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 Criteria Document.[12] More recently, cases of peripheral neuropathy among exposed workers have been reported.[13]

A recent study demonstrates that EtO induces cancer in experimental animals.[14] 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.[15,16]

In humans, epidemiologic investigations of cancer mortality among Swedish workers exposed to EtO suggest an increased risk of leukemia and other cancers.[17,18] Recent information also suggests that EtO is associated with chromosomal abnormalities in peripheral lymphocytes of exposed workers.[19]

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 extent possible.[20] An 8-hour TWA below 0.1 parts per million (ppm), and a ceiling limit not to exceed 5 ppm during any 10 minute period in a working day is recommended.[21] 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.[22] OSHA has also proposed an excursion limit of 5 ppm over a 15-minute exposure period (53FR1724, January 21, 1988). Due to its high cancer potency in experimental animals, the ACGIH recommends a TLV of 1.0 ppm as an 8-hour TWA.[11]

C. Organic Solvents

Several different organic solvents are routinely used in hospital laboratory settings. Several of these solvents are capable of causing irritation of the eyes, nose, and throat. Effects of direct skin contact with solvents range from dry skin or mild rash to a dry, scaly, fissured dermatitis. These chemicals can also affect the central nervous system (CNS) such that exposed workers may complain of headache, nausea, lightheadedness, dizziness, and uncoordination.

Simultaneous exposure to substances, such as solvents, which affect the body in a similar fashion may have an additive effect. To evaluate these additive effects, the exposure level of each substance is computed as a percentage of the evaluation criterion for that substance. If the sum of these percentages exceeds 100%, the worker is considered to be overexposed to that mixture of substances.

Recent research on the effects of multiple solvent mixtures has focused on behavioral and psychological effects which may indicate nervous system damage or deviations from normal CNS function.[23] For example, an epidemiologic study was conducted on Finnish car painters exposed to a mixture of toluene, xylene, butyl acetate, and white spirits for a mean duration of 15 years. Average combined exposures were less than 32% of ACGIH TLV's; however, researchers found more memory disturbances, decreased vigilance, and more absent-mindedness among car painters than among railroad engineers. Visual intelligence and verbal memory were the most affected. The authors concluded that car painters, although not ill in the clinical sense, showed clear signs of central and peripheral nervous system lesions more often than members of the comparison group.[24,25]

VI. RESULTS

A. Waste Anesthetic Gases

1. Nitrous Oxide

The results of the environmental samples collected for N_2O during the surgical procedures are presented in Table 1. During the procedures monitored, TWA concentrations of N_2O ranged from less

than (<) the limit of detection (LOD) of 1 part per million (ppm) to 19 ppm, with a average concentration of 7 ppm, in the nine personnel breathing zone samples collected. None of the samples exceeded the NIOSH recommended exposure limit (REL) of 25 ppm for N_2O as a TWA during the period of anesthetic administration.

2. Halogenated Anesthetics

Table 2 shows the results of the environmental samples collected for halogenated anesthetics used during the surgical procedures. During the surgical procedures monitored, TWA concentrations of isoflurane ranged from < LOD of 0.01 milligrams (mg) per sample to 0.39 ppm, with an average concentration of 0.13 ppm, in the nine personal breathing zone samples collected. None of these samples exceeded the NIOSH REL of 0.5 ppm for halogenated anesthetics used in combination with nitrous oxide. No ethrane or halothane were detected above the limit of quantitation (LOQ) of 0.03 mg/sample.

3. Leak Testing

Table 3 shows the results of the leak testing for N_2O which was conducted during the use of the carts. In operating room 4, leakage of approximately 200 ppm N_2O was found in close proximity to the popoff valve and absorber on the anesthetic cart, and near the exhaust from the CO_2 monitor for the cart. In operating room 6, leakage from all areas checked was less than 10 ppm. While there are no established criteria for N_2O leaks from these carts by this measurement method, any significant leakage can contribute to the overall exposures in the OR, and can especially influence the anesthesiologists exposure. Since personal breathing zone samples were not collected for the anesthesiologists during this survey, the exact magnitude by which this leakage may have influenced the personal exposure can not be determined.

B. Gas Sterilizer Area

The results of the air samples collected for ethylene oxide during the operation of the gas sterilizer are presented in Table 4. TWA concentrations of 0.02 and 0.03 ppm were found in the two personal breathing zone samples which were collected for the sterilizer technicians. These results were below the NIOSH REL of less than 0.1 ppm as an 8-hour TWA, and the OSHA PEL and ACGIH TLV of 1 ppm as an 8-hour TWA. Even though no 10 minute sampling was performed, the NIOSH 5 ppm 10-minute ceiling was not exceeded because if the 5 ppm level was exceeded in any 10 minute period the TWA concentrations would have to have been at least 0.16 ppm. The highest concentration in the breathing zone was 0.06 ppm. In addition to the personal samples, two area samples were collected to assess the EtO concentrations in the immediate vicinity of the sterilizer. A sample collected behind the sterilizer in the access room showed a TWA concentration of 0.28 ppm, while a concentration of 0.06 ppm was found in an area sample collected near the door of the sterilizer.

C. Laboratory Exposures

The results of the air samples collected for solvents in the hospitals histology laboratory are presented in Table 5. Xylene was detected in two of three personal samples collected in the histology laboratory at TWA concentrations of 1.5 and 20 mg/M^3, and in one of the two area samples at a TWA concentration of 69 mg/m^3. These results are below the NIOSH REL and OSHA PEL of 435 mg/m^3 as an 8-hour TWA. Benzene and acetone were found to be below their LODs of 0.02 and 0.001 mg/sample, respectively.

VII. DISCUSSION AND CONCLUSIONS

A. Waste Anesthetic Gases and Vapors

As evidenced by the results of the environmental survey, concentrations of waste anesthetic gases and vapors were maintained within the NIOSH recommended exposure limits in all of the procedures monitored. However, since the factors which can influence personnel exposure in this area can change over time, it is necessary to regularly examine all areas of exposure control to identify any shortcomings. To assist in the identification of problems, a brief discussion of some of the key areas necessary for controlling employee exposures is presented below.

1. Equipment Maintenance

Of primary importance in maintaining waste anesthetic concentrations within acceptable levels is the regular maintenance of anesthetic equipment in order to prevent leakage. Recent data indicates that leaks from the high and low pressure anesthetic delivery system resulting from poor maintenance of the anesthetic unit are a primary source of employee exposures in the OR.[26] Background N_2O levels of 5 ppm and greater generally have been associated with leaks in the high pressure gas delivery system, which includes the N_2O supply lines, the connections at and between the ceiling and anesthesia machine, and the connector-control valve from the flowmeter.[26] During anesthetic administration, low pressure leaks occurring between the flowmeters and breathing hoses (including the flowmeter, vaporizer, reservoir bag, popoff valve, endotrachial tube, automatic ventilator, and CO_2 absorber) can be a significant source of exposure.

2. Scavenging

Scavenging systems consist of a collecting device, means of disposal, and pressure balancing device if necessary. Depending on the particular type of anesthetic equipment in use, scavenging adapters should be located at the popoff valve for the circle absorber, nonbreathing valve, T-tube, and ventilator. In addition, scavenging may also be necessary at locations such as the exit port of the CO_2 meter, which may also be a source of waste anesthetic gases in the OR. As with all scavenging systems, it is important to ensure proper pressure balancing so that the gas system does not interfere with the proper operation of the anesthetic delivery system.

3. General Ventilation

While local exhaust ventilation (such as scavenging) is the preferred means of eliminating waste gasses at their point of generation, general room ventilation also plays an important role in maintaining acceptable waste gas levels in the OR. Reasons for maintaining good general ventilation exchange rates include the rapid removal of waste gasses generated as a result of anesthesia induction, poorly fitting face masks, improperly inflated endotrachial tubes, and low or high pressure leaks which may occasionally develop in the system. While increasing the number of air changes does not eliminate the source of the anesthetic gases, it does lead to the more effective removal of the waste gases and vapors, thereby reducing the magnitude of employee exposures. As a minimum, operating rooms should be provided with at least 20 air changes per hour.[27]

Although no exposures above the NIOSH REL were found in the recovery room during this survey, it is still important to ensure that adequate amounts of fresh air are being brought into this area. Since scavenging systems are not present in recovery rooms, general ventilation is solely relied on to remove the waste gases expired by the patient. As a minimum, recovery rooms should be provided with at least 6 air changes per hour.[27]

4. Work Practices

Proper work practices are also a key element in controlling waste anesthetic gas exposures. One study estimated that 94 to 99 percent of all waste gas exposure in OR's equipped with properly designed scavenging components may be the result of poor work practices of the anesthetist.[28] Improper work practices include the use of poorly fitting face masks, insufficient inflation of endotrachial tubes, and spillage of volatile anesthetic agents while filling vaporizers. Despite constant attention to good anesthetic techniques, it is not always possible for the anesthesiologist to be aware of possible leakage from these sources. Therefore, it is important that the general ventilation be adequate to remove any waste anesthetics that might result from this source.

5. Exposure Monitoring

To determine the effectiveness of the overall exposure control program within the hospital, it is necessary to periodically monitor employee exposures as well as monitor equipment for leakage. Sampling and analytical procedures, such as those provided in the NIOSH criteria document should be referenced for further guidance in the conduct of personal monitoring.[6]

B. Ethylene Oxide

The results of the environmental samples collected during the operation of the gas sterilizer showed that ethylene oxide levels were kept below the current evaluation criteria. However, since NIOSH considers ethylene oxide to be potentially carcinogenic, continued efforts should be taken to ensure that exposures are reduced to the lowest feasible level. Periodic testing of the local exhaust ventilation should be conducted to ensure that it continues to function effectively. Periodic environmental monitoring should also be conducted to help ensure that sterilizer equipment does not leak or malfunction. Manufacturer's recommendations for work procedures and equipment maintenance should be closely followed.

C. General Laboratory Safety and Health

During the survey, all of the exposures in the laboratory were found to be within the evaluation criteria. However, since laboratory workers are potentially exposed to a number of substances on a day to day basis, it is important that a comprehensive laboratory safety program be put into place in order to reduce the likelihood of overexposures to all types of substances. Such a program should include an overall written plan that includes standard safe laboratory practices to be carried out whenever working in the laboratory. In addition, specific written procedures should be developed for working with substances with high acute or chronic toxicities. The procedures developed for the use of chemicals such as these should include information on the appropriate engineering controls (e.g., fume hoods), personal protective equipment (e.g., respirator, gloves), and work practices to be used as needed.

To assist in determining the type of controls that are necessary, material safety data sheets and other supplementary information should be maintained for all chemicals used in the laboratory. This information should address in detail the routes of exposure, toxicity, compatibility, personal protective equipment, emergency first aid procedures, and spill, leak and disposal procedures for the substance. This information should be made readily available to the employees so that it can be referenced easily when necessary.

Whenever possible, exhaust hoods should be used when working with all substances used in the laboratory, especially those having moderate or high acute or chronic toxicities. The periodic testing of local exhaust ventilation hoods is also a necessary procedure to ensure the effective performance of laboratory hoods. Detailed information related to the testing of laboratory hoods can be found in the publication "Industrial Ventilation, A Manual of Recommended Practice", by the American Conference of Governmental Industrial Hygienists.[29]

A lack of proper housekeeping can greatly enhance the likelihood of accidents occurring. Ongoing efforts are necessary to ensure that work areas are kept free from obstruction and that chemicals not in use are stored properly. Adequate space should be allotted to each area to

ensure that overcrowding does not occur. Floors and equipment surfaces should be cleaned regularly to minimize dust accumulation in the area. All unlabeled chemicals, chemical waste, and chemical spills should be disposed of in accordance with established procedures, with which all employees should be familiar. The publication entitled "Prudent Practices for Disposal of Chemicals from Laboratories" by the Committee on Hazardous Substances in the Laboratory/National Research Council, provides detailed information related to proper chemical disposal.[30]

It is important to limit the amounts of chemicals stored in the laboratory and to be sure that each chemical in use has a definite storage place and is returned to that space when not in use. Storage of chemicals on counter tops makes the chemical containers more prone to inadvertent breakage or spillage and susceptible to fire. Selection of storage sites for the chemicals should take into consideration such factors as toxicity, flammability, compatibility, and other important properties of the chemical. Storage of flammable liquids should be in accordance with OSHA regulations and National Fire Protection Association (NFPA) standard No. 45, "Fire Protection for Laboratories Using Chemicals", and No. 30, "Flammable and Combustible Liquids Code".[31,32]

VIII. RECOMMENDATIONS

A. Waste Anesthetic Gases and Vapors

The previous section of the report touched on a number of areas that should be examined to continue to ensure that waste anesthetic gases are properly controlled in the OR's. More detailed recommendations regarding specific control procedures, work practices, and monitoring procedures are included in the NIOSH criteria for a recommended standard....occupational exposure to waste anesthetic gases and vapors.[6] To effectively control employee exposures in the operating room, a comprehensive program which addresses all of these areas is necessary. Due to the length of these recommendations they are not repeated in this section. In lieu of this, copies of this document have been provided separately to the hospital. Adherence to the recommendations specified in this document should help to maintain exposures within acceptable levels and protect the health of the employees in this area.

B. Ethylene Oxide

The hospital should also continue in its efforts to reduce ethylene oxide exposure to the lowest possible level. Adherence to the guidelines contained in the NIOSH Special Occupational Hazard Review with Control Recommendations: Use of Ethylene Oxide as a Sterilant in Medical Facilities, the NIOSH Current Intelligence Bulletin 35: Ethylene Oxide, and the provisions of the OSHA standard for ethylene oxide, should help to ensure that employee exposures are maintained at safe

levels.[20,22,33] Particular attention should be given to continued periodic exposure monitoring and leak detection to ensure the effectiveness of existing engineering controls. Additionally, the source of ethylene oxide exposure in the mechanical access room (presumable the drain area) should be identified. Although personnel would not normally be present in this area during sterilizer and aerator operation, it would still be advisable to control the EtO emissions at this point of generation in order to prevent migration of the gas into adjacent work areas.

C. Laboratory Safety and Health

The Occupational Safety and Health Administration has proposed a laboratory safety standard which would require laboratories to develop a "Chemical Hygiene Plan" which would encompass the areas previously discussed.[34] While this document is presently only a "proposal", the concepts and ideas presented in its text would be of value in strengthening the current laboratory safety program. Another reference, which might also prove useful, is the publication entitled Prudent Practices for Handling Hazardous Chemicals in Laboratories, by the Committee on Hazardous Substances in the Laboratory/National Research Council.[35] This document helps form the basis for, and is cited frequently in, the OSHA proposed lab standard.[34] A systematic implementation of the key concepts provided in these documents should help to reduce future risks of chemical exposure among laboratory personnel.

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IX. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to the following:

A. Saint Mary-Corwin Hospital, Pueblo, Colorado
B. U. S. Department of Labor, OSHA - Region VIII
C. NIOSH Regional Offices/Divisions

Table 1
Breathing Zone Air Concentrations of Nitrous Oxide
Saint Mary-Corwin Hospital, Pueblo, Colorado
August 24, 1988

SAMPLE No.	SAMPLE DESCRIPTION	SAMPLING PERIOD	TWA CONCENTRATION NITROUS OXIDE (PPM)
Bag 1	Circulating Nurse	6:55 - 8:20	< LOD
		Cumulative TWA	< LOD
Bag 1	Scrub Nurse	6:57 - 9:19	5
		Cumulative TWA	5
Bag 1	Circulating Nurse	6:58 - 8:10	25
Bag 2	" "	8:10 - 9:15	5
Bag 3	" "	9:15 - 10:30	< LOD
Bag 4	" "	10:30 - 12:00	6
		Cumulative TWA	9
Bag 1	Circulating Nurse	7:00 - 8:20	< LOD
Bag 2	" "	8:20 - 10:10	< LOD
Bag 3	" "	10:10 - 12:00	< LOD
		Cumulative TWA	< LOD
Bag 1	Scrub Nurse	7:03 - 10:15	2
Bag 2	" "	10:15 - 12:05	5
		Cumulative TWA	3
Bag 1	Scrub Nurse	7:04 - 8:25	3
Bag 2	" "	8:25 - 9:55	6
Bag 3	" "	9:55 - 11:55	6
Bag 4	" "	11:55 - 12:30	5
		Cumulative TWA	5
Bag 1	Scrub Nurse	7:05 - 8:10	20
Bag 2	" "	8:10 - 9:45	5
Bag 3	" "	9:45 - 12:00	4
		Cumulative TWA	8
Bag 1	Circulating Nurse	7:11 - 8:25	10
Bag 2	" "	8:25 - 10:10	30
Bag 3	" "	10:10 - 11:00	10
		Cumulative TWA	19
Bag 1	Recovery Nurse	8:25 - 10:10	13
Bag 2	" "	10:10 - 12:00	20
Bag 3	" "	12:00 - 12:40	5
		Cumulative TWA	15

Evaluation Criteria - NIOSH REL: 25 ppm TWA for the period of administration

< LOD - Less than the limit of detection estimated at 1 part per million (ppm)