

**TECHNICAL BULLETIN**

**GUIDELINES FOR THE RECOGNITION,  
EVALUATION, AND CONTROL OF  
OCCUPATIONAL EXPOSURE TO WASTE  
ANESTHETIC GASES**

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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August 2004

**GUIDELINES FOR THE RECOGNITION, EVALUATION, AND CONTROL  
OF OCCUPATIONAL EXPOSURE TO WASTE ANESTHETIC GASES**

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\*This bulletin supersedes TB MED 510, 29 April 1994.

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## CHAPTER 1

### INTRODUCTION

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#### 1-1. Purpose

a. This bulletin provides guidance to Department of the Army (DA) industrial hygiene, preventive medicine, facility management, safety management, maintenance, medical, dental, and veterinary personnel for recognizing, evaluating, and controlling occupational exposures to waste anesthetic gases (WAG) and vapors.

(1) This guidance applies to all DA locations and activities where inhalation and other volatile intravenous, topical anesthetic and analgesic agents are administered, stored, delivered, prepared, and removed; and where their delivery devices and machines, if necessary, are repaired or maintained. These areas include, but are not limited to—

- (a) Hospital operating suites.
- (b) Recovery areas.
- (c) Labor and delivery suites.
- (d) Emergency rooms.
- (e) Dental operatories.
- (f) Veterinary surgical prep/dental, surgery and recovery areas.
- (g) Laboratories and pharmacies where special volatile analgesic agent preparations are performed and also where laboratory animal euthanasia is performed.
- (h) Research and teaching facilities.
- (i) Repair and maintenance shops for closed machines and gas scavengers.

(2) Personnel should adhere to this guidance as closely as combat zone operations allow.

b. For purposes of this bulletin, WAG refers to gases and vapors used to provide clinical anesthesia that escape into the work site air. WAG includes—

- (1) Nitrous oxide (N<sub>2</sub>O).
- (2) Halogenated agents, such as—

(a) Halothane (commercial name Fluothane®). (®Fluothane is a registered trademark of Wyeth-Ayerst Laboratories, Inc., St. Davids, Pennsylvania.)

(b) Methoxyflurane (commercial name Penthrane®). (®Penthrane is a registered trademark of Abbott Laboratories, Abbott Park, Illinois.)

(c) Enflurane (commercial name Ethrane®). (®Ethrane is a registered trademark of Abbott Laboratories, Abbott Park, Illinois.)

(d) Isoflurane (commercial name Forane®). (®Forane is a registered trademark of Abbott Laboratories, Abbott Park, Illinois.)

(e) Desflurane (commercial name Suprane®). Desflurane may include trace amounts of chloroform. (®Suprane is a registered trademark of the Baxter Healthcare Corporation, Deerfield, Illinois.)

(f) Sevoflurane (Ultane®). (®Ultane is a registered trademark of Abbott Laboratories, Abbott Park, Illinois.)

- (3) Volatile analgesic adjuvants to inhalation anesthesia.

Use of trademarked names does not imply endorsement by the U.S. Army but is intended only to assist in identification of a specific product.
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**1-2. References**

Appendix A contains a list of references used in this bulletin as well as a list of other publications.

**1-3. Abbreviations and terms**

The glossary contains a list of abbreviations and an explanation of technical terms used in this bulletin.

## CHAPTER 2

## CONTROLLING EXPOSURE

**2-1. Occupational exposure limits**

a. Although no Federal standard for WAG exists, the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend control of occupational exposure to WAG.

(1) Appendix B provides information on the sources and factors that contribute to WAG exposure.

(2) The recommendations below apply to all personnel who are exposed to inhalation and volatile anesthetic and analgesic agents that escape into locations associated with the administration of anesthetics or recovery from anesthesia. The recommended levels of exposure are designed to protect personnel from adverse effects based on available scientific information.

b. Table 2-1 contains the recommended occupational exposure limits in parts per million (ppm) for airborne concentrations of N<sub>2</sub>O and the halogenated agents identified in chapter 1 of this bulletin. Recommended exposure limits (RELs) have been provided by both ACGIH and NIOSH. As of the writing of this bulletin, OSHA has not developed limits; however, OSHA reserves the right to cite facilities for high WAG exposures under the General Duty Clause.

**Table 2-1. Recommended exposure limits (RELs) for specific waste anesthetic gases (as of 2003)**

Anesthetic Gas	ACGIH TLV®-TWA (ppm) <sup>a</sup>	OSHA PEL (ppm) <sup>b</sup>	NIOSH REL (ppm) <sup>c</sup>
Nitrous Oxide (N <sub>2</sub> O)	50	None	25 <sup>d</sup>
Halothane	50	None	Ceiling 2 <sup>e</sup>
Methoxyflurane	Not Established	None	Ceiling 2 <sup>e</sup>
Enflurane	75	None	Ceiling 2 <sup>e</sup>
Isoflurane	Not Established	None	Not Established <sup>f</sup>
Desflurane	Not Established	None	Not Established <sup>f</sup>
Sevoflurane	Not Established	None	Not Established <sup>f</sup>

Notes:

a – Threshold limit value (TLV) time-weighted average (TWA). (®TLV is a registered trademark of ACGIH, Cincinnati, Ohio.) The TWA concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed nearly all workers may be repeatedly exposed, day after day, without adverse effect.

b – Permissible exposure limit (PEL). (OSHA has not assigned any values for any agents. This column has been included for potential future usage.)

c – REL (measured as a TWA during the period of anesthetic administration). (According to OSHA, “the American Dental Association points out that Dr. D. Bruce, who conducted the 1974 study upon which the REL was based, said in letters to the editor published in *Anesthesia Analgesia* (1983) and *Anesthesiology* (1991) that he no longer believes his conclusions to be valid and that the ‘NIOSH standards should be revised.’”<sup>1</sup>)

d – Measured as a TWA over the period of anesthetic administration.

e – Ceiling limit concentration of no greater than 2 ppm over a sampling period of 60 minutes.

f – NIOSH has not established RELs for these newer anesthetics. It is recommended that the 2 ppm ceiling limit be used for any halogenated anesthetic agent.

<sup>1</sup>Occupational Safety and Health Administration. Anesthetic gases: guidelines for workplace exposures. OSHA Directorate for Technical Support and the Office of Science and Technical Assessment. Washington, DC: U.S. Department of Labor; May 18, 2000, 1. <http://www.osha.gov/dts/osta/anestheticgases/index.html>

c. Based upon the general consensus of various subject matter experts within the U.S. Army Medical Command, all facilities should adhere to the exposure limits recommended by NIOSH in Table 2-1. The RELs developed by NIOSH are more stringent than the TLVs provided by the ACGIH.

d. Based on NIOSH research, when a combination of N<sub>2</sub>O and halogenated agents are used, control of N<sub>2</sub>O to 25 ppm during the administration period will result in concentrations of the halogenated agents of about 0.5 ppm.<sup>2</sup>

e. The use of new flouride-based anesthesia at maximum concentrations and delivery (such as sevoflurane) should prompt the anesthetist to ensure there are no additional sources of flouride from leaking refrigerants in operatory and recovery areas. Consideration should be given to patients who have a work history with coated stick arc welding, aluminum reduction, semiconductor manufacturing, glass etching, and other occupations where residual plasma flouride levels may contribute to the synergistic effects of halogenated anesthetic agents.<sup>3</sup>

## **2-2. Maintaining recommended waste anesthetic gas levels**

a. The early 20th century marked the development of removal systems to eliminate WAG from operating rooms (ORs). These systems were initially designed to protect personnel from the safety concerns identified with WAG, such as flammability and explosion hazards. The use of halogenated anesthetic agents further decreased the safety risks. The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) has prohibited the use of flammable anesthetic agents in anesthetizing locations. Today's concerns regarding exposure to WAG extend beyond safety risks to the associated potential health effects and performance degradation.

b. It is difficult to maintain levels of WAG below the NIOSH RELs in Table 2-1 without a combination of engineering and administrative controls, such as—

- (1) Gas scavenging.
- (2) General dilution ventilation.
- (3) Proper maintenance of equipment.
- (4) Application of work practices by anesthetists to minimize the release of anesthetic agents into the room.
- (5) Applications of surgical procedures that can reduce the potential for WAG exposures.

c. If acceptable conditions cannot be met with properly maintained anesthetic units or proper ventilation systems, medical clinics, dental clinics and veterinary services must consider alternate work practices and different clinical methods, such as using nonvolatile intravenous, topical, and injectable anesthetics for surgical procedures.

## **2-3. Gas and vapor scavenging systems**

a. Scavenging systems are designed to collect gases and vapors that are vented from the breathing circuit; the adjustable pressure-limiting (APL), pop-off, or spill-off valve; and the ventilator pressure relief valve (PRV). (See figure 2-1.) The gases are then directed to a safe area (directly exhausted outside of the facility) or a dedicated WAG disposal system. WAGs are released from rebreathing, non-rebreathing, and partially rebreathing systems.

b. At present, gas scavenging is the most practicable engineering control for removing WAGs. Levels of WAG can be minimal when gas scavenging is combined with other recommended control procedures. When compared to dilution ventilation, gas scavenging requires very low air exhaust rates. Use of gas

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<sup>2</sup> National Institute for Occupational Safety and Health. Guidelines for protecting the safety and health of health care workers. NIOSH Publication 88-119. Washington, DC: U.S. Department of Health and Human Services; September, 1988, section 5.1.12. <http://www.cdc.gov/niosh/pdfs/88-119-f.pdf>

<sup>3</sup> U.S. Department of the Army. Anesthesia and perioperative care of the combat casualty. Textbook of Military Medicine. Washington, DC: Headquarters, Department of the Army (Office of The Surgeon General); 1995.



*Figure 2-1. Typical adjustable pressure-limiting valve.*

scavenging can result in a considerable savings in energy costs and can protect employee health and safety. Although no Federal regulations currently exist for the exhaust of WAGs to outside air, consult with air quality control boards to determine if local and State regulations apply.

c. All gas scavenging systems are composed of five components—

(1) The *gas collection assembly*, typically a collection manifold, which traps excess WAG at the site of emission.

(2) *Transfer tubing*, which connects the gas collection assembly to the interface.

(3) The *interface*, which provides pressure relief to protect patients against excessive scavenging system pressure and, depending on the system, reservoir capacity, either in a bag or canister.

(4) *Gas disposal assembly tubing*, which connects the interface to the gas disposal assembly.

(5) The *gas disposal assembly*, which vents the gas away safely. This is accomplished with either a nonrecirculating ventilation system, a central vacuum system, a dedicated waste gas exhaust system, a passive duct system, or an absorber. (See figure 2-2.)

d. There are two types of gas scavenging systems, active and passive.

(1) An active system has either a source for negative pressure or a vacuum directly attached to the interface. The gas is moved along by negative pressure generated in the gas disposal assembly.

(2) A passive system is one in which the tubing of the gas disposal assembly is allowed to vent openly into an area or into an absorber. If vented openly into an area, the WAG should then be removed with a nonrecirculating ventilation exhaust system. The WAG movement in a passive system relies on positive pressure created by a patient breathing circuit to move the WAG through the scavenging system until it reaches the point of the gas disposal assembly.

e. After reviewing the available literature and surveying existing systems, consider the following when designing a WAG system:

(1) Compatibility of scavenging systems with anesthetic equipment. Review the requirements for gas scavenging with personnel responsible for anesthetic administration and equipment maintenance.

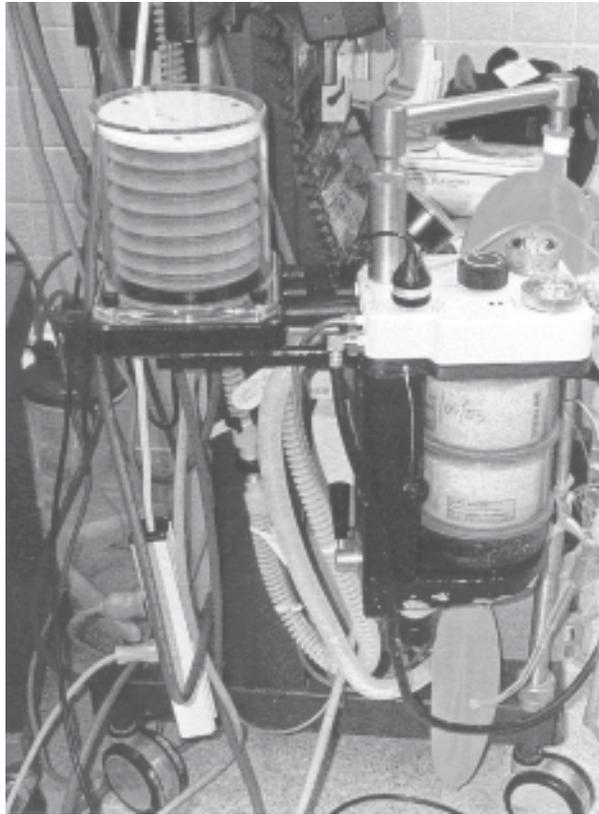
(2) Use of a central vacuum for exhaust ventilation when the system is—

(a) Of adequate size to handle the expected load.

(b) Exhausted to outdoors, away from supply air intakes.

f. Confirm system reliability after installation by actual environmental monitoring. Any specifications should include performance requirements.

g. Because deployable medical systems (DEPMEDS) use a recirculating heating and air-conditioning system that allows only a small percentage of fresh air exchange, personnel must take extra precautions for WAG. For instance—



*Figure 2-2. Side view of operating room waste anesthetic gas system.*

(1) The DEPMEDS recirculating system precludes the exhaust of WAG. Whenever possible, fill vaporizers outside of DEPMEDS modules.

(2) When scavenging WAG from DEPMEDS modules, ensure that scavenging hose exhausts are as far away as possible from the environmental control unit fresh air intake.

h. Assistance in gas scavenging system design and criteria is available from several sources including—

(1) The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). Obtain information from the Commander, USACHPPM, ATTN: MCHB-TS-OFS, Aberdeen Proving Ground, MD 21010-5403, <http://chppm-www.apgea.army.mil>.

(2) Anesthetic equipment manufacturers.

(3) Consulting architectural and engineering firms.

(4) A variety of reference journals and Government publications. The NIOSH publications referenced in appendix A offer a comprehensive review of design requirements for gas scavenging systems.

#### **2-4. General dilution ventilation**

a. General dilution ventilation is necessary to reduce the residual amounts of fugitive anesthetic gases and vapors and WAGs not removed by the gas scavenging system. Adequate dilution ventilation is especially critical where effective gas scavenging is not available. Gas and vapor scavenging systems shall be disposed of so that re-exposure to patients and staff does not occur.

b. Table 2-2 presents general design criteria for the most commonly encountered anesthetizing locations. These and additional design criteria and locations can be found in Military Handbook (MIL-HDBK) 1191. Any upgrade or redesign of the ventilation system will be per MIL-HDBK-1191.

**Table 2-2. Interior mechanical design criteria for specific areas**

Area	Air Pressure Relationship to Adjacent Areas <sup>a</sup>	Minimum Air Changes of Outdoor Air Per Hour	Minimum Total Air Changes Per Hour	Temp. Winter (Min) °F	Temp. Summer (Max) °F	Relative Humidity (RH) Range (% RH)	All Air Exhausted Directly to Outside
<b>MEDICAL</b>							
General and Specialized Operating Rooms (Recirculating Air System) <sup>b</sup>	++	5	25	68	75	50-60	Optional
General and Specialized Operating Rooms (All Outdoor Air System)	++	15	15	68	75	50-60	Yes
Cytoscopic Surgery <sup>b</sup>	++	5	25	68	75	50-60	Yes
Labor and Delivery, Delivery Room (Recirculating Air System) <sup>b, c</sup>	++	5	25	68	75	50-60	Optional
Labor and Delivery, Delivery Room (All Outdoor Air System) <sup>c</sup>	++	15	15	68	75	50-60	Yes
Recovery Room, Surgical Suite <sup>d</sup>	+	2	6	75	75	50-60	Optional
X-Ray Imaging Areas	0	2	6	78	70	30-60	Optional
<b>DENTAL</b>							
General Dental Treatment Room <sup>e</sup>	0	2	6	68	75	30-60	Optional
Comprehensive Dental Treatment Room <sup>e, f</sup>	++	3	12	68	75	30-60	Optional
Dental Treatment Room, Oral Surgery <sup>e</sup>	++	3	12	68	78	30-60	Optional
<b>VETERINARY</b>							
Veterinary Surgery Room (incl. Dental)	+	5	15	64	79	50-60	Yes
Veterinary Recovery Area	+	2	6	64	79	30-60	Yes
Veterinary Surgical Prep	+	2	6	64	79	30-60	Yes

**NOTES:**

a – Air pressure relationships:

0 – Room supply air volume is equal to the exhaust/return room air volume.

+ Room supply air volume is 10 percent greater than the exhaust/return air volume.

++ Room supply air volume is 20 percent greater than the exhaust/return air volume.

b – During periods of non-use, the air volume may be reduced to 6 air changes per hour, while maintaining the required air balance.

c – Provide adjustable (to user) thermostat and humidistat within the room.

d – Provide adjustable (to user) humidistat within the room.

e – During periods of non-use, ventilation rate may be reduced to 5 total air changes while maintaining positive pressurization. One return air register, sized for a minimum 20 percent of the total return air from the dental operatory, should be located at low level, though not less than 6 inches above the finished floor.

f – Comprehensive includes (but is not limited to) Endodontics, Periodontics, and Pediatrics.

## 2-5. Maintenance of anesthetic equipment

a. Anesthetic equipment should be maintained according to the manufacturer's specifications to minimize leakage of anesthetic gases. This is primarily done by the Medical (or Healthcare Equipment) Maintenance Branch at most military treatment facilities (MTFs). The equipment user typically conducts daily inspections.

b. Leaks may occur in the high- and/or low-pressure systems of the anesthesia machine.

(1) Common leakage areas or items in the high-pressure system of the anesthesia machine include: wall outlets connections (where a manifold is provided), compressed gas regulator and cylinder valves, worn gaskets, worn yoke plugs, quick connect fittings, and worn hoses. Leakage may also occur within the anesthesia machine.

(2) Common leakage areas or items in the low-pressure system of the anesthesia machine include the gas analysis sensor; flow meter tubes (rotometers); site glasses; vaporizers; breathing circuits and masks; inspiratory/expiratory hoses and tracheal tubes in animals and children; connection points for monitoring devices (temperature probe, humidifier, or positive end-expiratory valve); nose and laryngeal masks; drainage port valve of the carbon dioxide absorber; worn hoses; breathing bags; and the breathing bag inflator gasket. Improper installation or misalignment of a vaporizer on its manifold may also lead to gas leakage. The exhaust from a side-stream sampling respiratory gas analyzer and capnograph should also be connected to the gas scavenging system because the analyzed sample may contain WAG.

c. During daily inspections, include the following actions in your preoperational checks:

(1) Perform leak test procedures on pressurized breathing circuits, prior to the initiation of anesthesia. Leaks should be identified and corrected before the system is used.

(2) Inspect face masks, tubing, breathing bags, and other components for cracks and other signs of deterioration after each cleaning and before each use.

(3) Verify that all gaskets and valves are sealed properly.

(4) Verify that disposable tubing and bags fit tightly.

## 2-6. Recommended work practices to reduce occupational exposure to waste anesthetic gases

a. Personnel administering the anesthetic agent retain responsibility for reducing WAG levels in the anesthetizing location. The implementation of proper work practices significantly reduces exposure.

b. In addition to performing the actions in paragraph 2-5, complying with the following guidelines will reduce levels of WAG in the anesthetic environment without adverse effect on patient safety or anesthetic administration.

(1) Connect the waste gas scavenging system to the anesthetic machine and verify that all connections and fittings are tight and functioning properly prior to beginning administration.

(See figure 2-3.)

(2) Fill vaporizers in a well-ventilated area. The OR is most practical; however, the optimal practice is to fill the vaporizers when the OR is not in use. (See figure 2-4.)

(a) If long cases require the vaporizers be refilled within the OR while administering an anesthetic, hold a vacuum hose near the filling port to help suction off some or all of the vapors.

(b) Filler interlock kits can help reduce escaping vapors or spillage by providing a closed system to transfer the agent from the bottle to the vaporizer.

(c) If spillage occurs while filling the vaporizer, provide ample ventilation. (In most cases the halogenated anesthetic agent will vaporize immediately.)

(3) Switch the vaporizer off when not in use and whenever disconnecting the breathing circuit.

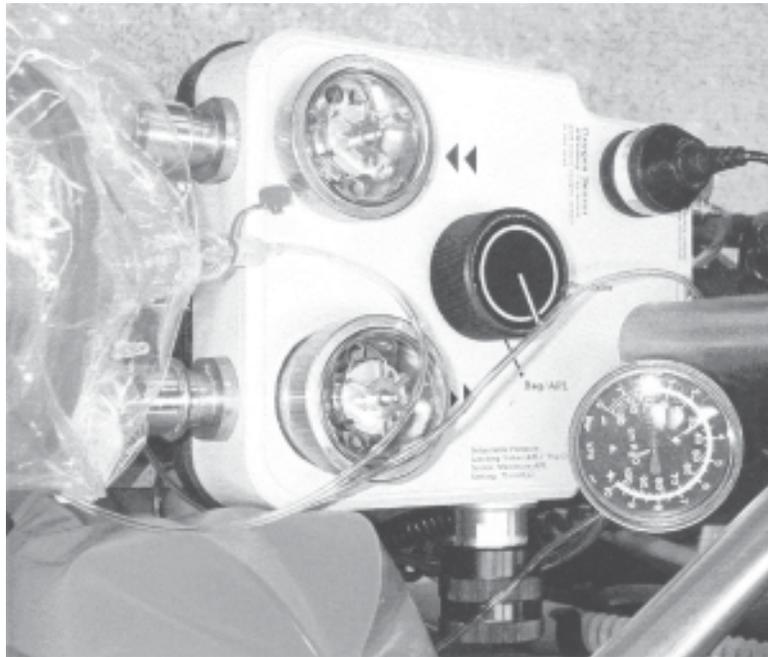
(4) Perform a low pressure leak test daily prior to the first case. All leaks noted must be corrected.

(5) Select a face mask that will provide a tight fit with minimal pressure. Several different sizes and shapes of face masks are available.

(6) If it is necessary to empty the breathing bag, empty it into the scavenging system and turn off

the flow of N<sub>2</sub>O or anesthetic agent prior to disconnecting the patient circuit.

(7) If liquid anesthesia is to be used in any procedure, ensure a spill kit is available.



*Figure 2-3. Top view of waste anesthetic gas scavenging system*



*Figure 2-4. Sevoflurane and desflurane vaporizers.*

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## CHAPTER 3

### EVALUATING EXPOSURE

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#### 3-1. Exposure evaluations

The implementation of controls will not guarantee that personnel are adequately protected from excessive exposure to WAG. Thus, the evaluation of the effectiveness of these controls is essential.

#### 3-2. Surveying the anesthetizing location

a. Prior to determining exposure levels, the industrial hygienist or authorized preventive medicine representative, in coordination with a qualified medical maintenance technician, should conduct semiannual surveys of each anesthetizing location.

b. As a minimum, the survey includes—

(1) Measuring room air exchange rates and comparing results with those in table 2-2.

NOTE: Newer heating, ventilating and air-conditioning (HVAC) systems are typically provided with direct digital control (DDC) systems that can monitor airflow rates, air temperature, humidity levels, and other properties continuously. In facilities where these systems exist, measurements still should be taken by the surveyor with conventional air measuring devices (i.e., balometers and anemometers) at least annually to validate the readings provided by the DDC system. Consult with facility management representatives to determine if DDC systems are present in the HVAC system.

(2) Using a portable MIRAN<sup>®</sup> infrared analyzer or equivalent test instruments and following the manufacturer's specifications to conduct—

(a) Low pressure leak testing on the patient's breathing circuit.

(b) Leak testing on the scavenging tubes.

(c) High pressure leak testing on the anesthesia machine. (®MIRAN is a registered trademark of the Foxboro Company, Norwalk, Connecticut.)

c. In areas where the room ventilation may be suspect as compared to values in table 2-2 or other referenced criteria, ensure that the facility management department is made aware of the survey results. Refer to paragraph 3-3 of this bulletin for additional survey frequencies. Air exchange rates should be revalidated immediately in affected areas after any repairs or modifications are made to the HVAC system.

#### 3-3. Measuring occupational exposure (time-weighted average) of personnel to waste anesthetic gases

a. Evaluate the anesthetizing location semiannually to determine personnel exposure levels. If personnel samples are expected to show exposures in excess of the standards presented in table 2-1 (based on previous sampling) or if the ventilation is not in compliance with table 2-2, perform quarterly surveys until repairs/modifications are made to bring the areas into compliance with the accepted standards.

b. Per OSHA recommendation, only the agent(s) most frequently used need(s) to be monitored, since proper engineering controls, work practices, and control procedures should reduce all agents proportionately. All sampling should be conducted at the same time that validation of the ventilation system is completed. There are three types of air sampling: personal, area, and source.

(1) Personal samples allow the best estimate of a worker's exposure level. Personal samples provide the concentration of airborne contaminant in a worker's breathing zone (BZ) over a timed period. BZ samples measure WAG levels 6 to 10 inches from the mouth and nose area. Per OSHA, this is the preferred method for determining a worker's TWA exposure.

(2) Area samples measure WAG levels within the anesthetizing location and can also identify cross-contamination in other sections of the facility.

(3) Source samples are used to find leaks in the anesthesia delivery and scavenging system and to identify ineffective scavenging system capture.

c. The following methods are recommended for sampling:

(1) Portable infrared gas analyzers (for example, MIRAN®) are direct-reading instruments that can be used to sample and analyze for N<sub>2</sub>O. They can be used to detect leaks (source sampling), and may be used with electronic data loggers to provide time-integrated personal or general area sampling. Time-integrated personal or general area samples can also be collected using a bag and air sampling pump, and the sample can be analyzed using an infrared gas analyzer. Consult the following documents for further information:

(a) NIOSH sampling and analytical method 6600 at the following website: <http://www.cdc.gov/niosh/nmam/nmammenu.html>.

(b) U.S. Department of Health and Human Services (DHHS) NIOSH Publication 96-107.

(2) Adsorption tubes, used in conjunction with air sampling pumps, can be used to collect general area and personal samples of halogenated anesthetics. See the following websites for sampling and analytical methods:

(a) SKC Incorporated: <http://www.skcinc.com>.

(b) OSHA: <http://www.osha.gov/SLTC/wasteanestheticgases/index.html>.

(c) USACHPPM: <http://chppm-www.apgea.army.mil/tg.htm> (USACHPPM Technical Guide (TG) 141, Industrial Hygiene Sampling Guide).

(d) 3M Company: <http://www.3m.com\occsafety>.

(3) Landauer® or other passive monitors can be used to collect personal samples of N<sub>2</sub>O. (®Landauer is a registered trademark of Landauer, Inc., Glenwood, Illinois.) Organic vapor passive monitors can be used to collect personal samples of halogenated anesthetic agents. See the websites, above, for sampling and analytical methods, as well as manufacturer literature for passive dosimeters (for example, 3M, etc.).

d. Collect samples representing a variety of inhalation anesthetic procedures, and clearly identify these procedures during the survey.

## CHAPTER 4

### MEDICAL SURVEILLANCE

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#### 4-1. Basis for medical surveillance

A medical surveillance program is established for personnel with potential for exposure to WAG per Draft DA Pamphlet (DA Pam) 40-XX. Appendix C of this bulletin provides information on the potential health effects from exposure to WAG. Questions pertaining to medical surveillance may be directed to the USACHPPM, Directorate of Occupational and Environmental Medicine, MCHB-TS-M, 5158 Blackhawk Road, APG, MD 21010-5403, <http://chppm-www.apgea.army.mil/doem>.

a. The occupational health (OH) physician determines the need, frequency, and scope of medical surveillance for personnel potentially exposed to WAG. In formulating the decision, the OH physician considers information from the industrial hygienist, the supervisor, and the employee. This information includes, but is not limited to, exposure data, work practices, toxicology data, medical and occupational histories and prior examination results.

b. Surveillance requirements for students and transient personnel are difficult to delineate. These individuals should be evaluated for the need to be included in medical surveillance based on their frequency, duration, and level of exposure at the work site.

#### 4-2. Baseline evaluations

The occupational medicine and nursing staff conducts baseline evaluations on all personnel normally assigned to perform duties that result in the potential occupational exposure to WAG. The evaluation includes—

a. Administration of a preplacement medical questionnaire that includes a detailed work history (including past exposures to WAGs) and a medical history with emphasis on hepatic (liver), renal (kidney), neurological (nervous system), cardiovascular (heart and circulation), and reproductive functions.

b. An appropriate medical evaluation (i.e., in-depth history and physical examination where appropriate) and, where relevant, suitable laboratory tests, such as liver function tests, following pertinent positive response(s) to the questionnaire.

#### 4-3. Acute exposure

The OH physician should document any acute exposure (i.e., a sudden, high-dose exposure due to a WAG scavenger system leak) and identify any individuals who may warrant follow-up surveillance. Any subsequent health effects should trigger a medical history and a physical examination (where appropriate).

#### 4-4. Periodic evaluations

a. Routine annual follow-up is primarily educational. A system should be created for employees to report health problems that they believe may be associated with anesthetic exposure. Employees should be informed of this reporting system and of the method by which reports can be submitted.

b. The occupational medicine and nursing staff should, at a minimum, administer a questionnaire at least annually when exposure levels are at or above the corresponding action level of one-half the TWA exposure limits listed in paragraph 2-1 of this bulletin. Physical examination and laboratory testing should be considered based on the questionnaire responses for conditions suspected of being related to occupational exposure.

c. Medical surveillance action levels should be lowered when N<sub>2</sub>O and halogenated agents are used in combination. Performance decrements can occur and should be evaluated through examination of the occupational history and questioning regarding symptoms of exposure upon the central nervous system and altered performance.

**4-5. Termination evaluations**

The occupational medicine and nursing staff provides medical evaluations to all personnel included in the medical surveillance program when they terminate employment (Army Regulation (AR) 40-5). A termination evaluation should encompass all components of the baseline evaluation as well as any other components that the OH physician deems appropriate.

**4-6. Medical recordkeeping**

Medical and exposure records developed for employees who may be exposed to hazardous chemicals such as N<sub>2</sub>O and halogenated anesthetic agents must be retained, made available, and transferred according to title 29, Code of Federal Regulations (CFR), 1910.1020 (29 CFR 1910.1020). The occurrence of injury or illness related to occupational exposure must be recorded according to OSHA recordkeeping regulations (29 CFR 1904) and DA Pam 385-40.

## CHAPTER 5

### ADMINISTRATIVE REQUIREMENTS

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#### 5-1. Administrative recordkeeping

a. Maintenance. The medical commander ensures the military or civilian medical record is maintained and kept confidential according to AR 40-66.

b. Atmospheric monitoring records. Documentation of atmospheric sampling, even for negligible results, is important to maintain a full exposure history and to meet legal requirements.

(1) The industrial hygiene program manager maintains the monitoring records according to 29 CFR 1910 and AR 340-21.

(2) The medical commander—

(a) Includes the results of atmospheric sampling affecting personnel in the military or civilian medical records using DA Form 4700 (Medical Record-Supplemental Medical Data) or other appropriate forms.

(b) Retains these records according to AR 25-400-2.

(3) Any record of exposure or potential exposure above the action levels prescribed in paragraph 2-1 must include—

(a) The date, number, duration, location, and results of each sample taken. Consider also recording a description of the anesthetic process or procedure taking place, if applicable, while the sample is being collected, according to paragraph 3-3 of this bulletin. This would better allow the identification and targeting of any “problem procedures” in need of correction.

(b) A written description of the sampling and analytical methods used, or a reference to a publication in the open literature describing these methods.

c. Access. The medical commander—

(1) Removes all personal identifiers from the atmospheric sampling results (after incorporating data into the medical record if appropriate) and forwards recommendations to the supervisor for posting in the work area.

(2) Provides affected personnel, former personnel, or their designated representatives access to the atmospheric sampling records.

#### 5-2. Information and reporting requirements

a. The employee’s supervisor, in coordination with the industrial hygienist and the employee, provides the following information to the health care worker(s) responsible for providing occupational health services:

(1) A written description of the affected employee’s duties as they relate to the potential exposure.

(2) The employee’s potential exposure (measured or estimated).

b. If an employee is removed from work because of signs and symptoms commonly associated with exposure to WAG, the medical commander ensures that the occurrence is—

(1) Reported through the Reportable Medical Events System (RMES) as an occupationally related illness per AR 40-400. The RMES can be accessed at the Army Medical Surveillance Activity (AMSA) website: [http://amsa.army.mil/AMSA/amsa\\_home.htm](http://amsa.army.mil/AMSA/amsa_home.htm).

(2) Documented in the military or civilian medical record.

(3) Reported and documented per AR 385-40.

#### 5-3. Employee information and training

a. Employee health education program.

(1) The commander establishes a health education program to inform personnel potentially exposed to WAG within 30 days of employment and at least annually of—

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(a) The information contained in this bulletin with particular emphasis on health effects of exposure to WAG (see appendix C) and the purpose, limitations, and implementation of work practices to reduce occupational exposure to WAG.

(b) The specific nature of operations that could result in exposure above the occupational exposure limit and the necessary steps to prevent such exposures. Methods of instruction may include medical screening interviews, formal classes, work area meetings, and audiovisual presentations as appropriate.

(2) According to hazard communication directives—

(a) Supervisors will educate employees about the specific hazards of WAG in the workplace.

(b) The commander will provide technical assistance, monitor selected training sessions, and approve, in writing, the program of instruction and lesson plans.

b. Access to health education materials. The medical commander ensures that a copy of all materials used in the health education program or training, to include a copy of this bulletin, are readily available to all employees with the potential for exposure.

c. Respirator protection. Where individuals are exposed or reasonably expected to be exposed to WAG levels above the levels mentioned in chapter 2 of this bulletin, respirator protection is an acceptable interim engineering control measure. The use of respirators does not excuse the facility from meeting the standards prescribed in chapter 2 of this bulletin. Refer to technical bulletin, medical (TB MED) 502/DLAM 1000.2 for additional guidance (<http://chppm-www.apgea.army.mil/tbm.htm>).

d. Documentation of employee training. Document training, in writing, to include the signature of both the trainee and the approving authority. Document training for all DA personnel on Department of Defense (DD) Form 1556 (Request, Authorization, Agreement, Certification of Training and Reimbursement) or other appropriate forms, and incorporate it as a permanent part of the official personnel folder.

### **5-4. Reproductive hazards policies**

The medical commander must ensure a reproductive hazards policy is in place at the facility and should address worker exposure and reproductive health effects in male and female employees. The supervisor must ensure all military and civilian employees working with WAG are provided training in the known and potential adverse health effects, including reproductive effects, of WAGs, as is required for chemicals covered by the Hazard Communication Standard (29 CFR 1910.1200). The occupational medicine and nursing staff will provide technical assistance to the supervisor and offer counseling for personnel of reproductive age who work with WAGs according to Draft DA Pam 40-XX.

**APPENDIX A****REFERENCES**

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**A-1. Army Publications**

Except as noted below, Army regulations and DA pamphlets are available online from the Army Publishing Directorate (formerly the U.S. Army Publishing Agency (USAPA)) website: <http://www.army.mil/usapa/epubs>. Codes of Federal Regulations are available online from <http://www.access.gpo.gov/nara/cfr/index.html>. Publications from NIOSH are available online from <http://www.cdc.gov/niosh/publistb.html>.

AR 25-400-2

The Army Records Information Management System (ARIMS)

AR 40-5

Preventive Medicine

AR 40-66

Medical Record Administration and Health Care Documentation

AR 40-400

Patient Administration

AR 340-21

The Army Privacy Program

AR 385-40

Accident Reporting and Records

DA Pam 385-40

Army Accident Investigation and Reporting

Draft DA Pam 40-XX

Preventive Medicine

TB MED 502/DLAM 1000.2

Respiratory Protection Program

<http://chppm-www.apgea.army.mil/tbm.htm>

Unnumbered Publication

U.S. Department of the Army. Anesthesia and perioperative care of the combat casualty, Textbook of Military Medicine. Washington, DC: Headquarters, Department of the Army (Office of The Surgeon General); 1995.

USACHPPM TG 141

Industrial Hygiene Sampling Guide

<http://chppm-www.apgea.army.mil/tg.htm>

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### **A-2. Other Publications**

ANSI/ASHRAE 62-2001  
Ventilation for Acceptable Indoor Air Quality  
<http://www.ashrae.com/>

DHHS (NIOSH) Publication 75-137  
Development and Evaluation of Methods for the Elimination of Waste Anesthetic Gases and Vapors in Hospitals

DHHS (NIOSH) Publication 77-171  
Control of Occupational Exposure to Nitrous Oxide in the Dental Operatory

DHHS (NIOSH) Publication 77-140  
Criteria for a Recommended Standard: Occupational Exposure to Waste Anesthetic Gases and Vapors

DHHS (NIOSH) Publication 88-119  
Guidelines for Protecting the Safety and Health of Health Care Workers

DHHS (NIOSH) Publication 94-100  
Controlling Exposures to Nitrous Oxide During Anesthetic Administration

DHHS (NIOSH) Publication 94-113  
NIOSH Manual of Analytical Methods, 4<sup>th</sup> Edition

DHHS (NIOSH) Publication 96-107  
Hazard Controls (HC)-3 Control of Nitrous Oxide in Dental Operatories

MIL-HDBK-1191  
DoD Medical Military Facilities Design and Construction Criteria, 9 July 2002  
<http://hfpa.otsg.amedd.army.mil/refs/1191/index.asp>

NIOSH Analytical Method 6600  
Nitrous Oxide (Portable IR)  
<http://www.cdc.gov/niosh/nmam/nmammenu.html>

NFPA 99  
Standard for Health Care Facilities  
<http://www.nfpa.org/codesonline>

29 CFR 1904  
Recording and Reporting Occupational Injuries and Illnesses

29 CFR 1910  
Occupational Safety and Health Standards

29 CFR 1910.1020  
Access to Employee Exposure and Medical Records

29 CFR 1910.1200  
Hazard Communication

Unnumbered Publication

American Conference of Governmental Industrial Hygienists. Documentation of threshold limit values. Cincinnati, OH: ACGIH; 2003.

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Cohen, E. N.; Belville, J. W.; Brown, B. W. Anesthesia, pregnancy, and miscarriage: a study of operating room nurses and anesthesiologists. *Anesthesiology*. 34: 343-347; 1971.

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### Unnumbered Publication

Occupational Safety and Health Administration. Anesthetic gases: guidelines for workplace exposures. OSHA Directorate for Technical Support and the Office of Science and Technical Assessment. Washington, DC: U.S. Department of Labor; 2000.  
<http://www.osha.gov/dts/osta/anestheticgases/index.html>

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**A-3. Forms**

DA Form 4700  
 Medical Record-Supplemental Medical Data  
<http://www.army.mil/usapa/eforms>

DD Form 1556  
 Request, Authorization, Agreement, Certification of Training and Reimbursement  
<http://web1.whs.osd.mil/icdhome/DDEFORMS.HTM>

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## APPENDIX B

### SOURCES OF WASTE ANESTHETIC GAS EXPOSURE

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#### **B-1. Exposure location**

Exposures to WAG occur in ORs, labor and delivery rooms, recovery rooms, cystoscopy rooms, dental clinics, emergency rooms, outpatient clinics, veterinary clinics, and other miscellaneous locations.

#### **B-2. Factors contributing to WAG exposure**

Factors that contribute to the overall exposure of WAG are—

- a. Leakage from anesthetic equipment.
  - (1) The leaks may be related to poor work practices of the anesthesiologist and nurse anesthetists.
  - (2) Generally more leakage occurs when using a face mask than an endotracheal tube.
  - (3) Higher concentrations normally occur during procedures where the mask or tube is frequently moved or reinserted (that is, oral surgery).
- b. Maintenance of anesthetic equipment.
  - (1) Special attention must be given to equipment tubing, gaskets, bags, valves, and fittings.
  - (2) Frequently, the wheels on various OR equipment are rolled over flexible tubing (for example, gas scavenging exhaust system and high pressure circuit), which may result in cracks, holes, and tears.

#### **B-3. Typical sources of WAG**

- a. Gas may escape during hookup and pre-operational checks of the system.
- b. Excess gas may seep over the lips of the patient.
- c. Tenting of the patient during surgery may trap gases and vapor around the patient's BZ.
- d. Gas cylinders have the potential to leak, both those cylinders in use and those in storage.
- e. The anesthetic system tubing and bags may have holes and breaks.
- f. Gaskets, gauges, and valves may leak allowing WAG into the area.
- g. Fittings on gas lines may be incompatible, that is, the fittings may be the wrong size.
- h. The gas scavenging system may be misused or not used at all. If a system is not used for an extended period of time, degradation may occur around seals and fittings.
- i. Postoperative patients and the OR staff may exhale breath that contains WAG.

#### **B-4. Machine maintenance**

The manufacturer's instruction manual can be a good resource in the evaluation of an anesthetic gas machine. The local medical maintenance staff, a valuable asset, should be consulted during the evaluation of these units.

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## APPENDIX C

## HEALTH EFFECTS FROM EXPOSURE TO WASTE ANESTHETIC GASES

**C-1. General**

a. The term WAG refers to gases and vapors that escape into work site air during the course of administration of clinical anesthesia. WAG may be composed of N<sub>2</sub>O, halothane, enflurane, methoxyflurane, isoflurane, and other inhalation anesthetics in varying concentrations.

b. While the flammability of earlier agents led to safety concerns over their use, current concerns relate to health effects of occupational exposure to the newer agents. Two anesthetics, chloroform and trichloroethylene, are suspected carcinogens and are no longer used. The major health concerns for presently used anesthetics include possible reproductive, mutagenic and cytogenic, carcinogenic, nervous system, liver, kidney, and hematopoietic effects.

c. The potential of both desflurane and sevoflurane to be considered “hazardous” has not been thoroughly evaluated.<sup>4</sup> The levels of risk for sevoflurane have not been established.

**C-2. Reproductive system effects**

The association between occupational exposure to WAG in medical and dental personnel and adverse reproductive outcomes has been investigated repeatedly. Studies have focused on the pregnancies of female medical, dental, and veterinary professionals. The rates of spontaneous abortion and congenital abnormalities of workers exposed to WAG have been compared to workers in unexposed settings.

a. A 1992 study published by the New England Journal of Medicine reported that female dental assistants exposed to unscavenged N<sub>2</sub>O for 5 or more hours a week had a significant increased risk of reduced fertility compared with nonexposed assistants. The exposed assistants had a 59 percent decrease in probability of conception for any given menstrual cycle compared with the nonexposed assistants. For dental assistants in areas where N<sub>2</sub>O scavenging systems were employed, the probability of conception was not significantly different from that of nonexposed assistants.<sup>5,6</sup>

b. A 1995 study published in the American Journal of Epidemiology probed the relationship between occupational exposure to N<sub>2</sub>O and spontaneous abortion in female dental assistants. According to the study, women who worked with unscavenged N<sub>2</sub>O at least 3 hours per week had an increased risk of spontaneous abortion (relative risk = 2.6, 95 percent confidence interval (CI) = 1.3-5.0) adjusted for age, smoking, and the number of dental amalgams prepared per week. These results were not typical among assistants in areas where scavenging systems were used. The authors of the study determined, “Scavenging equipment can make large differences in exposure levels at moderate cost and appears to be important in protecting the reproductive health of women who work with nitrous oxide.”<sup>4,7</sup>

c. The effects of other WAGs (besides N<sub>2</sub>O) have also been linked to adverse pregnancy outcomes. As early as the late 1960s, studies in the former Soviet Union, Denmark, and the United States linked other anesthetic agents, such as halothane, to pregnancy complications.<sup>4</sup> A study completed by Cohen in

<sup>4</sup> Occupational Safety and Health Administration. Anesthetic gases: guidelines for workplace exposures. OSHA Directorate for Technical Support and the Office of Science and Technical Assessment. Washington, DC: U.S. Department of Labor; May 18, 2000, 4. <http://www.osha.gov/dts/osta/anestheticgases/index.html>

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<sup>6</sup> Rowland, A.S.; Baird, D.D.; Weinberg, C.R.; Shore, D.L.; Shy, C.M.; Wilcox, A.J. Reduced fertility among women employed as dental assistants exposed to high levels of nitrous oxide. *New Engl J Med.* 327:993-997; 1992.

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1980 revealed female dental assistants exposed to unscavenged anesthetic gases for greater than 8 hours a week reported a significant increase in the rate of spontaneous abortions (19.1 per 100 pregnancies) compared with the rate in a nonexposed group (8.1 per 100).<sup>4,8</sup>

d. Most studies reported an increased risk of miscarriage in women occupationally exposed during pregnancy when compared with controls.<sup>7, 9, 10, 11, 12</sup> In most instances, the relative risk was found to be less than 2, and the absolute frequency does not appear to be much greater than in the general population. A few studies found an increased rate of spontaneous abortions among women whose husbands had occupational exposures to WAG, but most of these studies resulted in negative findings.<sup>11</sup>

e. According to most studies, there appears to be no associated risk of congenital anomalies with occupational WAG exposure during pregnancy.<sup>4, 7-11</sup> No consistent number or pattern of anomalies has been seen between women in exposed groups and women in control groups.

### C-3. Mutagenic and cytogenic effects

Cellular studies on anesthetic agents have been inconclusive. Some studies have shown abnormal cell formation and chromosomal aberrations. Other studies have shown negative mutagenicity for N<sub>2</sub>O, halothane, methoxyflurane, enflurane, and isoflurane in Ames and sister chromatid exchange assays. One study showed induced mutations by the Ames assay using the urine of anesthesiologists, but the significance of this is unclear because the specific chemicals in the urine were not identified.<sup>9</sup>

### C-4. Carcinogenic effects

A possible association between cancer and anesthetic gases has been suggested from both experimental and occupational data. Relevance of reported animal studies to occupational risk, however, is debatable because of the high dose of anesthetic employed.<sup>7</sup>

a. Three epidemiological studies report a small increase in the incidence of cancer in women, but not men, occupationally exposed to anesthetic gases. Tumor types and locations were inconsistent among the three studies. Higher frequencies of cancers, especially leukemia and lymphoma, were seen among female OR personnel; no effects of WAG were seen in men.<sup>13, 14, 15</sup>

b. One study found a 2.4-fold increase in cancer of the cervix with heavy occupational exposure to inhalation anesthetics in female dentists.<sup>14</sup> Unlike most other cancers seen in the WAG study cohorts, cancer of the cervix is known to be caused by human papilloma virus infection. This may be a confounder in this study.

c. Four studies that investigated deaths from cancer among personnel exposed to WAG did not find any evidence of adverse health outcomes associated with exposure to WAG.<sup>14, 16, 17</sup>

<sup>8</sup> Cohen, E.N.; Brown, B.W.; Wu, M.L.; Whitcher, C.E.; Brodsky, J.B.; Gift, H.C.; Greenfield, W.; Jones, T.W.; Driscoll, E.J. Occupational disease in dentistry and chronic exposure to trace anesthetic gases. *J Am Dent Assoc.* 101: 21-31; 1980.

<sup>9</sup> Cohen, E. N.; Brown, B. W., et al. A survey of anesthetic health hazards among dentists. *J Am Dent Assoc.* 90: 1291-1296; 1975.

<sup>10</sup> Cohen, E. N.; Belville, J. W.; Brown, B. W. Anesthesia, pregnancy, and miscarriage: a study of operating room nurses and anesthesiologists. *Anesthesiology.* 34: 343-347; 1971.

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<sup>15</sup> Bruce, D. L., et al. Causes of death among anesthesiologists: a 20 year survey. *Anesthesiology.* 29: 565; 1968.

<sup>16</sup> Bruce, D. L., et al. A prospective survey of anesthesiologist's mortality. *Anesthesiology.* 29: 41; 1974.

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d. Recent studies have indicated when WAGs (to include N<sub>2</sub>O, isoflurane, halothane, enflurane, and methoxyflurane) have been administered by inhalation, test results for carcinogenicity have been negative. Sevoflurane and desflurane have not been tested for carcinogenicity based on the results of these other halogenated agents, and have been subsequently approved for use by the Federal Drug Administration.<sup>18</sup>

### C-5. Nervous system effects

Animal and human experiments indicate that exposure to anesthetic gases affects the central nervous system. The effects are seen acutely.<sup>19</sup>

a. One study determined that the threshold at which N<sub>2</sub>O started to affect performance occurred between 8,000 and 12,000 ppm. The effects of low-level exposures to WAG on health and performance are unclear.

b. A study among dental personnel has reported increased incidence of numbness, tingling, and muscle weakness. The NIOSH-recommended exposure limit of 25 ppm for N<sub>2</sub>O was based on one study, which reported audiovisual decrements at 50 ppm. Several subsequent studies have failed to confirm this report and have led ACGIH to set their TLV at 50 ppm.

### C-6. Liver effects

Liver damage has been reported in animal experiments after high-dose exposure to halogenated agents. Some human epidemiological studies have reported an increased frequency of liver disease among anesthesia workers and dental personnel exposed to WAG. These were based on numbers of exposed individuals reporting current liver disease by questionnaire. Data include liver disease of various or unspecified types.<sup>16, 20, 21, 22</sup> Most studies measuring liver function tests have been negative.<sup>21</sup>

### C-7. Kidney effects

Animal experiments have reported kidney damage after exposure to halothane.<sup>9</sup> A few human epidemiological studies using retrospective questionnaires administered to exposed individuals have reported an increased frequency of kidney disease among the exposed.<sup>16, 19-21</sup> The increase is less for male dentists (1.2 fold) as compared with female chair assistants (1.2-1.7 fold). Furthermore, the relatively small increase in renal disease in the male dentists reflects a specific increase in renal lithiasis, and the larger increase seen in females was due to infections of the urinary tract. No satisfactory explanation for these sex differences is available.<sup>7</sup>

### C-8. Bone marrow effects

Animal studies and clinical observation have shown that prolonged, high-dose level exposures and treatments with N<sub>2</sub>O can induce leukopenia. However, a study measuring hematological functions did not show a difference between personnel exposed or not exposed to WAG.<sup>21</sup>

<sup>18</sup> Berry, A.; McGregor, D.; Baden, J.; Bannister, C.; Domino, K.; Ehrenwerth, J.; Eisenkraft, J.; Mazze, R.; Spence, A. Waste anesthetic gases: information for management in anesthetizing areas and the postanesthesia care unit (PACU). Park Ridge, IL: American Society of Anesthesiologists; 1999. <http://www.asahq.org/publicationsServices.htm>

<sup>19</sup> American Conference of Governmental Industrial Hygienists. Documentation of threshold limit values. Cincinnati, OH: ACGIH; 2003.

<sup>20</sup> Lauwerys, R.; Siddons, M.; Mission, C. B. Anesthetic health hazards among Belgian nurses and physicians. *Int Arch Occup Environ Health.* 48: 195-203; 1981.

<sup>21</sup> Guirguis, S. S.; Pelmeur, P. L.; Roy, M. L., et al. Health effects associated with exposure to anesthetic gases in Ontario hospital personnel. *Br J Ind Med.* 47: 490-497; 1990.

<sup>22</sup> De Zotti, R.; Negro, C.; Gobbato, F. Results of hepatic and hemopoietic controls in hospital personnel exposed to waste anesthetic gases. *Int Arch Occup Environ Health.* 52: 33-41; 1983.

**C-9. General signs/symptoms of nitrous oxide and halogenated agent potential overexposure**  
 OSHA provided the following information on N<sub>2</sub>O.<sup>23</sup> The UCLA Office of Environment, Health, and Safety provided the following information on select halogenated agents halothane, enflurane, and isoflurane.<sup>24</sup>

*Table C-1. Symptoms of overexposure to waste anesthetic gases*

<b>Anesthetic Gas</b>	<b>Acute Exposure Symptoms</b>	<b>Chronic Exposure Symptoms</b>
<i>Nitrous Oxide</i>	Dizziness, difficult breathing, headache, nausea, fatigue, and irritability. Loss of consciousness may occur at levels of 400,000 to 800,000 ppm.	Tingling, numbness, difficulty in concentrating, interference with gait, reproductive effects.
<i>Halothane</i>	Headache, nausea, vomiting, skin irritation, dizziness, narcosis, decreased respiration, low pulse and blood pressure.	Fatigue, cardiac arrhythmias, liver dysfunction, loss of appetite.
<i>Enflurane</i>	Nausea, vomiting, irritation (eye, skin, nose, and throat), headache, dizziness, drowsiness.	Hypotension, cardiac arrhythmias, respiratory depression, liver/kidney dysfunction.
<i>Isoflurane</i>	Nausea, vomiting, irritation (eye, skin, nose, and throat), headache, dizziness, drowsiness.	Hypotension, tachycardia, respiratory depression, elevated blood glucose levels.

<sup>23</sup> Occupational Safety and Health Administration. Nitrous Oxide Factsheet. Washington, DC: U.S. Department of Labor; 2002. <http://www.osha.gov/SLTC/healthguidelines/nitrousoxide/recognition.html>

<sup>24</sup> University of California at Los Angeles Office of Environment, Health, and Safety. Environmental Health and Safety Fact Sheets. Los Angeles, CA: UCLA; 2002. <http://www.biosafety.ucla.edu>

## GLOSSARY

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### Section I. ABBREVIATIONS

ACGIH

American Conference of Governmental Industrial Hygienists

AMSA

American Medical Surveillance Activity

ANSI

American National Standards Institute

APL

adjustable pressure limiting

AR

Army Regulation

ASHRAE

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

BZ

breathing zone

CDC

Centers for Disease Control and Prevention

CFR

Code of Federal Regulations

CI

confidence interval

DA

Department of the Army

DA Pam

Department of the Army Pamphlet

DD

Department of Defense

DDC

direct digital control

DEPMEDS

deployable medical systems

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DHHS

U.S. Department of Health and Human Services

HVAC

heating, ventilating, and air-conditioning

JCAHO

Joint Commission of Accreditation of Healthcare Organizations

MIL-HDBK

Military Handbook

MTF

military treatment facility

N<sub>2</sub>O

nitrous oxide

NFPA

National Fire Protection Association

NIOSH

National Institute for Occupational Safety and Health

OH

occupational health

OR

operating room

OSHA

Occupational Safety and Health Administration

PEL

permissible exposure limit

ppm

parts per million

PRV

pressure relief valve

REL

recommended exposure limit

RH

relative humidity

RMES  
Reportable Medical Events System

TB MED  
technical bulletin, medical

TG  
technical guide

TLV®  
threshold limit value

TWA  
time-weighted average

UCLA  
University of California at Los Angeles

USACHPPM  
U.S. Army Center for Health Promotion and Preventive Medicine

WAG  
waste anesthetic gas

## **Section II. TERMS**

**Anesthetizing location**  
Any location including, but not limited to, hospital operating, recovery, labor and delivery, and emergency rooms; specialty, dental operatories; and research and teaching facilities where inhalation anesthetic agents are administered.

**Deployable medical systems**  
Combat support hospitals that can be used in, but are not limited to, battlefield operations. These structures often provide temporary accommodations during military construction projects at MTFs.

**Exposed personnel**  
All personnel occupationally exposed to WAG, to include anesthesiologists, anesthetists, other OR staff, oral surgeons, dental assistants, and other medical, dental, veterinary, and research personnel.

**Fugitive anesthetic gas/vapor**  
Includes the anesthetic or analgesic gas or vapor that leaks from its container, delivery machine, or gas scavenging/exhaust system due to failures or to deviations in engineering designs, back-pressure and aspiration, connections (e.g., hanger yoke), overpressures, operating procedures, setups, operation, and repair/maintenance of used containers, delivery devices, and gas scavenging equipment. Leakage may originate from both high and low pressure systems of the analgesia or anesthesia machines. Common leak sources include gas cylinder connections and regulators, flow meters, wall outlet connections (manifold systems), quick connect fittings, O-rings, gaskets, yoke plugs, worn and punctured hoses, worn and defective breathing bags, carbon dioxide absorber drain port, slip joints, gas analysis sensor and its sampling sites, accessory connections, and vaporizer misalignment on its manifold.

## **TB MED 510**

### High-pressure system

All of the piping and sections of the anesthesia machine that receive gas at either cylinder or pipeline pressure. The system consists of the wall supply or gas cylinder up to the flow control valves. (See low-pressure system.)

### Low-pressure system

The section of the anesthesia machine where the pressure is slightly above atmospheric. The system consists of the piping and sections after the flow control valves, including the flow meter tubes, vaporizers, common gas outlet, and the patient breathing circuit. (See high-pressure system.)

### Medical commander

The unit surgeon, command chief surgeon, U.S. Army Medical Department Activity/U.S. Army Medical Center commanders, and the Director of Health Services, or his or her representative responsible for provision of medical support at the unit, command, or installation concerned.

### Military treatment facility

Includes all permanent U.S. Army medical facilities (to include hospitals, ambulatory care, and outpatient clinics) and U.S. Army dental facilities where human patient care is provided.

### Occupational medicine and nursing staff

Includes the chief of preventive medicine services, the OH physician, the OH nurse, and ancillary health professionals who perform such activities as—

- a. Providing the first level of OH services under the auspices of the local Preventive Medicine Service.
- b. Determining response to the work environment.
- c. Correlating employee complaints with potential hazard areas.
- d. Undertaking special biochemical tests to determine if normal bodily functions have been impaired.
- e. Providing the employee medical guidance on general health problems in relation to the physical requirement of the job, through physical examinations.
- f. Selecting workers for job assignments where preexisting conditions will not be aggravated and where the worker's presence will not endanger the health and safety of others.

### Scavenging

The collection of WAG in the anesthetizing location and removal of gases from the workplace.

### Waste anesthetic gas/vapor

Includes the anesthetic or analgesic gas or vapor that escapes or is lost (even when the delivery machine and scavenging and exhaust system are working properly) due to general poor work practice procedures, spills, overcharging the vaporizer, breathing and re-breathing, face fitting of mask or inspiration or tracheal tube, exhalations in the recovery room, evaporation from skin surfaces, pop-offs from pressure valves, failure to turn off flow control valves, allowing system to flush gas into the room, replacing compressed gas tanks, and other pathways where the patient does not absorb the intended amount administered. Waste anesthetic gases and vapors also include all fugitive anesthetic gases and vapors. (See fugitive anesthetic gas/vapor.)

By Order of the Secretary of the Army:

PETER J. SCHOOMAKER  
General, United States Army  
Chief of Staff

Official:

  
JOEL B. HUDSON  
Administrative Assistant to the  
Secretary of the Army

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