



Anesthetic Gases Safe Work Practices

Environmental Health and Safety (EHS) has developed these safe work practices to protect individuals at the University of Colorado Denver | Anschutz Medical Campus with potential exposure to anesthetic gases. Inhaled anesthetics may include nitrous oxide and halogenated agents, such as halothane, isoflurane, sevoflurane, desflurane, enflurane, and methoxyflurane. All work with anesthetic gases must be performed with either dedicated exhaust (e.g., fume hood, local exhaust ventilation) or a scavenging system to prevent exposure to anesthetic gases or waste anesthetic gases (WAG) resulting from leakage from equipment, from the patient or animal breathing circuit during delivery of anesthesia, or as exhaled by the patient or research animal (e.g., during recovery).

Health effects that have been associated with exposure to high concentrations of anesthetic gases, even for short durations, include headaches, irritability, fatigue, nausea, drowsiness, difficulties with judgment and coordination and liver and kidney disease. Long term exposure to low concentrations has been linked to miscarriages, genetic damage, and cancer.

The Occupational Safety and Health Administration (OSHA) has not adopted a permissible exposure limit (PEL) for anesthetic gases; however, citations may be issued under the General Duty Clause of the OSH Act if protective measures are not employed that are reasonable and in keeping with industry recognized controls and exposure limits. The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) both have recommended exposure limits for anesthetic gases. Table 1 summarizes the recommended exposure limits. It is of note that as of November 2022, NIOSH dropped its REL of 2 ppm for isoflurane and the ACGIH adopted a TLV of 50 ppm for isoflurane.

TABLE 1. Anesthetic Gas Exposure Limits

Anesthetic Gas	OSHA PEL	*NIOSH REL ¹	ACGIH TLV ²
Nitrous Oxide	None	TWA 25 ppm (46 mg/m ³)	50 ppm
Isoflurane	None	None	50 ppm
Halothane	None	Ceiling ³ 2 ppm (16.2 mg/m ³)	50 ppm
Desflurane	None	None	None
Sevoflurane	None	None	None
Enflurane	None	Ceiling 2 ppm (15.1 mg/m ³)	75 ppm
Methoxyflurane	None	Ceiling 2 ppm (13.5 mg/m ³)	None

- REL: NIOSH recommended exposure limit measured as a TWA during the period of anesthetic administration, not to exceed one hour.
- TLV: threshold limit value TWA. These values can refer to an 8-hour workday and a 40-hour work week averaged exposure or a short term exposure limit.
- Ceiling limit, concentration not to be exceeded within 60 minute period (max/hour).

Anesthetic gases are typically administered via an anesthesia vaporizer machine or the drop method (anesthesia-soaked gauze or cotton ball in sealed container). Depending on the method of administration and location of the procedures, a combination of controls may be necessary to ensure personnel exposures are maintained at or below the recommended exposure levels in Table 1. Examples of controls include administrative practices, engineering controls (e.g., gas scavenging units, local or general ventilation), and personal protective equipment (PPE) such as gloves, long sleeves, long pants, closed shoes, eye protection, etc.

Administrative Controls

Administrative controls are aimed at changing the way work is performed to ensure that all individuals who perform a given task are performing that task safely. With respect to anesthetic gases administrative controls include:

- **Training:** all individuals who work with anesthetics should be trained by his/her supervisor as part of the on-the-job training process, and documented on the on-the-job training form. Training should include the safe use of the anesthetic gas delivery equipment and controls. Additionally, Veterinary Technicians with the Office of Laboratory Animal Research offer hands on training on anesthesia machines; this training is required for anyone reserving an anesthesia machine in the animal facility.
- **Equipment maintenance:** routine maintenance procedures for anesthetic equipment are typically explained in the manufacturer's user manual; most equipment requires annual certification and calibration. Each piece of equipment involved in the delivery of anesthesia (anesthesia machine, ventilator, vaporizer, scavenging equipment) should be evaluated according to the manufacturer's instructions to ensure proper function. EHS recommends establishing checkout and maintenance procedures for anesthetic equipment and keeping a log of maintenance procedures; in particular, if a passive scavenging unit (F/Air canister) is used, a log should be maintained with the pre- and post-procedure weight of the canister.
- **Standard Operating Procedure:** each lab should develop its own standard operating procedure (SOP) for training purposes. See Appendix A of this document regarding the general procedure for tasks involving anesthetic gas.

Engineering Controls

Biosafety cabinets or chemical fume hoods are the preferred engineering controls when utilizing the drop method of anesthesia delivery. Additionally, in some cases, scavenging systems may be exhausted to a hood through an active collection system; care should be taken to ensure that any equipment being used does not disrupt the proper function of the hood.

Scavenging systems are another form of engineering control; scavenging systems collect gases and vapors that vent or leak from the breathing circuit and related equipment. There are two types of scavenging systems: active or passive; minimum room ventilation must be maintained regardless of the type of scavenging system.

1. **Active scavenging:** WAG is channeled from the anesthetic circuit or equipment to a fume hood, a hard ducted biosafety cabinet, vacuum system, or mechanically exhausted through a building's exhaust ductwork (i.e., evacuated outside the building without recirculation). If the building exhaust is going to be used to evacuate WAG, Facilities Management and EHS must be consulted to assess whether the ventilation system is adequate for removal of WAG.
2. **Passive scavenging:** a system where tubing from breathing circuit or waste gas system vents through non-mechanically assisted means into an adsorber (e.g., carbon filter) such as an F/Air canister. Although active scavenging systems are preferred, passive scavenging may be used and more appropriate in situations where there is limited space and/or portability is a concern. Each manufacturer may have slightly different recommendations, but in general a 50 gram

increase in the weight of the canister indicates that the canister will no longer effectively adsorb WAG. F/Air canisters can be discarded in the trash inside a sealed plastic bag. Some F/Air canisters may indicate a time limit for use in addition to and/or alternative to a weight increase; EHS has found that relying on the time of use may significantly underestimate accumulation in the canister (in one case, the canister had already gained 62 grams in only 5 hours of use), and as such recommends weighing the canister after each procedure.

Personal Protective Equipment

When working with anesthetic gases, wear gloves and long sleeves to avoid skin contact especially while pouring liquid anesthetic agents. Eye protection should also be worn to protect from splashes. If proper controls are used, in most cases, respiratory protection is not necessary. However, in some instances (specialized equipment, vulnerable worker such as pregnant women, etc.) respiratory protection, such as a half- or full-face respirator, may be necessary.

Medical Surveillance

Medical surveillance is conducted by the EHS Occupational Health program for personnel working routinely with anesthetic gases. Information regarding anesthetic gas use is captured via the initial and annual medical surveillance questionnaire. Disclosure of specific concerns or conditions (such as pregnancy) may result in additional medical surveillance activities as additional precautions or guidance may be warranted. Employees should report health problems that they believe may be related to anesthetic gas exposure to their supervisor and Occupational Health. Additionally, employees and supervisors should report any acute high level exposure to anesthetic gases (such as from an unplanned release or significant equipment leakage) to EHS and file a Worker's Compensation Report of First Injury with Risk Management within 4 days of the incident.

Exposure Monitoring

EHS can perform personal air monitoring to determine the anesthetic gas concentrations in the air. Personal monitoring is conducted at the employee's breathing zone to determine WAG exposure for the employee. Monitoring is performed using a passive dosimeter which collects gas on the media and is analyzed by a third party laboratory. For more information or to submit a request for personal monitoring please contact EHS at 303-724-0345.

Spill and Release Information

Most incidental small spills of liquid anesthetic agents with high volatility (e.g., halothane, isoflurane, enflurane, desflurane, and sevoflurane) will dissipate readily at normal room conditions. Spill kits should be maintained in areas where chemicals are stored, dispensed, or used. If large spills occur, exit and close off the area and contact EHS for response. Report information regarding individuals present during the release, the amount and location of the spill and their immediate contact information. Uncontrolled releases of gases and vapors must also be reported. A workers compensation report for personnel exposed to acute high dose should be filed within 4 working days.

References

NIH. National Institutes of Health Office of Research Services Division of Occupational Health and Safety: Waste Anesthetic Gas (WAG) Surveillance Program. Retrieved 5/8/17 from: [https://www.ors.od.nih.gov/sr/dohs/Documents/Waste%20Anesthetic%20Gas%20\(WAG\)%20Surveillance%20Program.pdf](https://www.ors.od.nih.gov/sr/dohs/Documents/Waste%20Anesthetic%20Gas%20(WAG)%20Surveillance%20Program.pdf)

NIOSH. CDC Waste Anesthetic Gases: Occupational Hazards in Hospitals, September 2007 [Pub No. 2007-151]. Retrieved 5/8/17 from: <http://www.cdc.gov/niosh/docs/2007-151/pdfs/2007-151.pdf>

OSHA. Anesthetic Gases: Guidelines for Workplace Exposures. Retrieved 5/8/17 from: <https://www.osha.gov/dts/osta/anestheticgases/>

University of California Santa Cruz. Safety Procedures for Isoflurane Use. Retrieved 5/8/17 from: <http://ehs.ucsc.edu/lab-safety-manual/specialty-chemicals/Isoflurane.html>

Appendix A: Standard Operating Procedures

Drop Method: because there is a high potential for WAG via this method, it must be performed in either a biosafety cabinet or chemical fume hood. Place the container for induction (e.g., bell jar) in a biosafety cabinet or chemical fume hood before applying the liquid anesthetic to a gauze or cotton ball. Perform any subsequent openings of the container within the biosafety cabinet/chemical fume hood.

Anesthesia Machine: the exact procedure will depend on the equipment configuration, for example whether the vaporizer is used in conjunction with a nose cone/face mask, an induction chamber, a stereotaxic surgery device, or a non-rebreathing system. Additionally, if the equipment is being used in the animal facility, additional procedural requirements may apply. In general, a vaporizer should be used in with a scavenging system (passive or active), unless the procedure is performed within a fume hood.

1. Verify that equipment is calibrated and is in proper working condition (e.g., no leaks, hoses/valves connected and intact, etc.).
2. Fill vaporizer using an anti-spill bottle adaptor, in a chemical fume hood, or with local exhaust ventilation.
3. Ensure that the scavenging equipment is properly connected.
 - Active scavenging systems typically consist of a gas collecting device (e.g., a scavenging pop-off or overflow valve), transfer tubing, an interface, additional transfer tubing, and a gas disposal system. Check each of these connections.
 - Passive scavenging systems (F/Air canister) have a finite life span, which is typically monitored by weight; as the filter adsorbs halogenated anesthetic gases the mass of the filter increases. It is important to note that carbon canisters will not work for nitrous oxide. For most devices, a 50 gram increase in the weight of the canister means that it must be discarded and replaced. During the procedure, the canister must be placed on its side or in a holder so that the vents are not blocked and also at a level below that of the vaporizer.
4. If using passive scavenging, check the equipment log for the pre-procedure F/Air canister weight.
5. Turn equipment on and perform the procedure, following all of the manufacturer's recommendations.
6. When the procedure is complete, turn off the isoflurane, leaving oxygen flowing; complete this step BEFORE turning off the flow or disconnecting the animal from the circuit. If feasible, let the animal breathe oxygen for a few minutes or until recovered, to scavenge anesthetic gas being eliminated from the lungs.
7. If using an induction chamber, flush the isoflurane from the chamber before opening it, and open the chamber so that the opening is facing away from the operator to minimize exposure.
8. After the procedure is complete, if using passive scavenging, weigh and record the post-procedure F/Air canister weight.