ENVIRONMENTAL HEALTH & SAFETY | RESEARCH SAFETY AND INDUSTRIAL HYGIENE

# 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 methoxyflourane. All work with anesthetic gases should be performed with either dedicated exhaust (e.g., fume hood, snorkel) or a scavenging system to minimize 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 (REL) and threshold limit values (TLV) 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/m3) | 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 |

1. REL: NIOSH recommended exposure limit measured as a TWA during the period of anesthetic administration, not to exceed one hour.
2. 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.
3. Ceiling limit, concentration not to be exceed 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, fume hoods) and personal protective equipment (PPE) such as gloves, long sleeves, long pants, closed-toe 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 their 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 (OLAR) 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 (charcoal canister) is used, a log must 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**
Hard-ducted biosafety cabinets (Class II, Type B2; these have a duct connecting them to the building exhaust), chemical fume hoods, and other local exhaust ventilation (snorkel, backdraft vents, etc.) 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.

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 or a Class II, Type B2 biosafety cabinet (BSC). If the building exhaust or vacuum system are going to be used to evacuate WAG, Facilities Management and EHS must be consulted to assess whether the ventilation system and/or vacuum are 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 in situations where there is limited space and/or portability is a concern. There are two types of charcoal canisters: single pass canisters, which have an inlet on one end and exhaust vent holes on the opposite canister end; and double pass canisters which have an inlet and an outlet port on the same side of the canister. Each manufacturer has different recommendations regarding the

proper positioning and weight increase of the canister, which indicates that the canister will no longer adsorb WAG. Charcoal canisters can be discarded in the trash inside a sealed plastic bag. Some charcoal 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 researchers should weigh 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 recommended.

**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 a file a Worker's Compensation Report of First Injury with Risk Management within 4 days of the incident.

**Exposure Monitoring**
EHS can perform 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. 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 4/10/24 from: https://ors.od.nih.gov/sr/dohs/Documents/wag-program.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

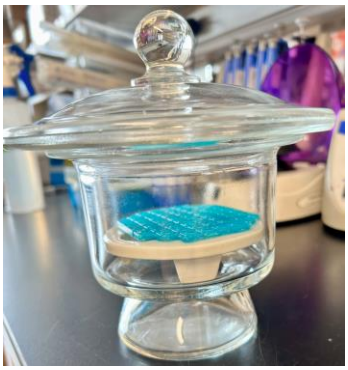
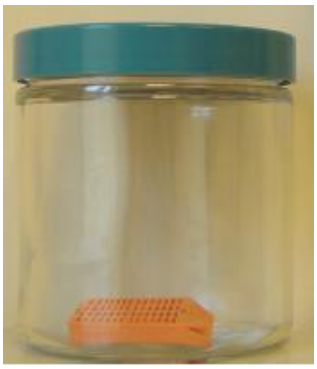
**Appendix A: Standard Operating Procedures for Animal Work with Isoflurane**
Isoflurane is an effective anesthetic and as well as anapproved method of euthanasia for rodents per the AVMA Guidelines on Euthanasia (2020). It can be delivered via a precision vaporizer or by using the drop method. When possible, a precision vaporizer is recommended as it provides the ability to precisely titrate the level of anesthesia during a procedure and decrease waste anesthetic gas exposure.

**Drop Method**: should be performed in a Class II, Type B2 BSC (hard ducted, does not recirculate) or chemical fume hood; or in conjunction with a snorkel, backdraft vent, or active scavenging system.

Animals should never come into contact with liquid isoflurane. This can be done using either:

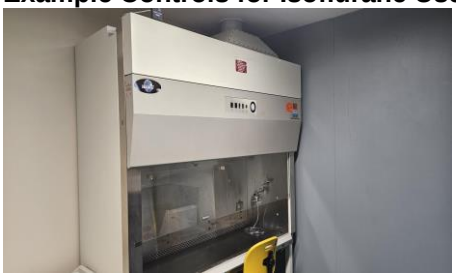
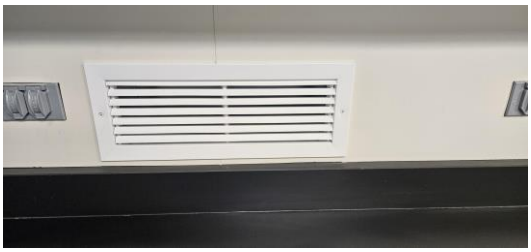
1. **Bell jar**: animal sits on a platform and absorbent material (cotton ball, paper towels, etc.) is soaked with isoflurane and placed below the platform. Options for bell jars: glass or plastic jar, modified lab materials (modified pipette box, desiccator, etc. – see picture below).

2. **Container within a container**: animal is placed in a large container that holds a second container with small holes. The second container has absorbent material soaked in isoflurane within it. Gas escapes out of the small holes but the animal does not come in contact with the liquid. Easily made from lab materials such as a tissue cassette within a plastic container (pictured below).


Perform subsequent openings of the container within the BSC or chemical fume hood, or other control(s).

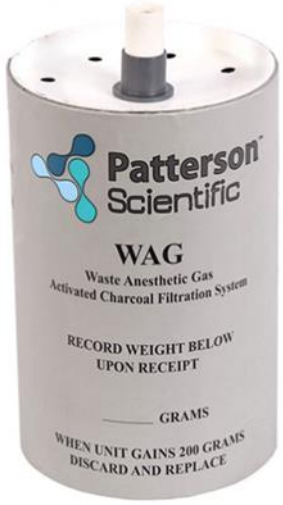
**Example Controls for Isoflurane Use** (from left to right): hard ducted BSC, backdraft vent, and snorkel

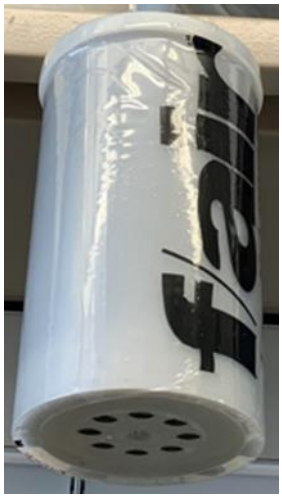



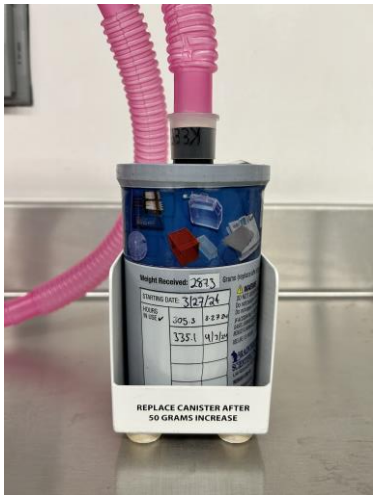

**Anesthesia Machine**: the exact procedure will depend on the equipment configuration, for example whether the vaporizer is used in conjunction with a nose cone/face mask, an induction chamber, a stereotaxic surgery device, or a non-rebreathing system. Use a scavenging system (passive or active) when using a vaporizer. Always follow the manufacturer instructions; general instructions include:

1. **Inspect equipment**: verify that equipment is calibrated and is in proper working condition (e.g., no leaks, hoses/valves connected and intact, etc.).
2. **Fill vaporizer** in a chemical fume hood, using a snorkel or backdraft vent, or in a Class II, Type B2 BSC, using an anti-spill bottle adaptor (pictured above, along with drop method examples).

**Example Charcoal Canisters** (from left to right): double pass canister (preferred and most effective), single pass canister, and a proper canister set-up vertically in a holder, with canister weights recorded.






3. **Connect scavenging equipment**.
- If using a nosecone, fit the nosecone as close as possible to animal. Additional IACUC approved materials may help improve nosecone fit (e.g., Press and Seal wrap).
- Active scavenging systems: check connections to ensure they are in place, and that devices are on (e.g., vacuum line).
- Passive scavenging systems (charcoal canister):
    - Multiple manufacturers produce charcoal canisters; always follow the manufacturer instructions on use. Single pass canisters have holes on the bottom that must not be blocked. Double pass canisters have a vent, typically on the top of the canister.
    - Weigh and record the canister weight before every use; compare the weight to the initial canister weight to verify it has not exceeded the recommended weight gain.
    - Place the canister upright in a holder so that the vents are not blocked.
    - If there is no possible upright configuration for the charcoal canister, it can be placed on its side as long the vents are not blocked **AND** the flow rate is low (low flow is 0.5 liters/minute, and no higher than 1 liter/minute).

4. **Turn equipment on and perform the procedure.** Follow the manufacturer's recommendations.

5. **Shut off the isoflurane once the procedure is complete,** 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.

6. **Flush the isoflurane** if using an induction chamber, before opening it and open the chamber within or using a control, and so that the opening is facing away from the operator to minimize exposure.

7. **Weigh and record the post-procedure charcoal canister weight** after the procedure is complete, if using passive scavenging. Each manufacturer has different recommendations regarding the weight increase of the canister which indicates that the canister will no longer adsorb.

**Example Products/Resources** (not an endorsement, included for example/reference only):
Anti-spill bottle adapter: Patterson Veterinary #07-804-0735, Fisher #501527996
Canister holder examples: Braintree Scientific #50-195-4516, AM Bickford #80000
Charcoal canister examples: VetEquip #931401, Patterson Scientific #78909457, AM Bickford #80120