Purpose:

- delivery of O2
- delivery of safe anesthetic concentrations
- removal of CO₂
- provide a method for assisting ventilation

ANESTHETIC EQUIPMENT:

Three basic components:

Compressed gas source

- compressed gas cylinders or tanks - oxygen; sometimes nitrous oxide
- tank pressure gauges - attached to cylinder
- pressure-reducing valve (regulators) - reduces pressure of gas moving from a high pressure tank to an anesthetic machine; constant flow of pressure at 50 psi.

Anesthetic machine

- flow meter - precisely controls the flow of gas entering the patient's breathing system.
- vaporizer (precision) - converts a liquid anesthetic (halothane, isoflurane, or sevoflurane) to a vapor state and delivers a controlled concentration of the inhalation anesthetic into the patient's breathing system via carrier gases (O₂ and N₂O).

Breathing circuit

- unidirectional valves (inhalation and exhalation) - minimizes apparatus dead space; fresh gas flows one way to the patient and is exhaled one way away from patient, back to breathing circuit passing through the CO₂ absorber.
- hoses and reservoir bag - filled with gas that enters circuit or of the patient exhalates; emptied when the patient inhales: stores gas, indicates proper endotracheal tube placement, observe patient respirations, and deliver O₂ by "bagging" patient.
- pop-off valve - "pressure relief," allows excess gas to exit the system to a scavenging system.
- carbon dioxide absorber (soda-lime or barium hydroxide-lime granules) - removes carbon dioxide from expired gases.
- oxygen flush valve - O₂ bypasses the flowmeter and vaporizer, delivering pure O₂ to the breathing circuit at a rate of 35 to 75 L/min.
- pressure manometer - measures the pressure of gases within the breathing system. Indicates pressure when "bagging" the patient (not to exceed 15-20 cm H₂O in small animals).
- negative pressure relief valve - open and admit room air into circuit if there is a negative pressure build up (vacuum) detected (i.e., O₂ flow too low, active scavenging system).

CHECKLIST FOR SET-UP:

NOTE: Verify proper function before each anesthesia; daily and before each use.

- Assemble all supplies needed
- Inflate endotracheal cuffs to check for leaks and to see amount of air it can hold
- Check the laryngoscope light
- Have available the preanesthetic and anesthetic agents to be used (labeled)
- Inspect anesthesia machine: fill vaporizers, tighten filler caps, turn off vaporizers; make sure CO₂ absorbent is not out-dated; change if necessary.
Central O2 and N20 supplies should be checked for quantity and pressure. Turn on gas cylinders slowly with the flowmeter “off” to assure a minimum pressure of 500psi. The cylinder should be checked for slow leaks (drop in pressure over a 10 min. period).

- Check breathing circuit for leaks.
- Connect pop-off valve to scavenger system.
- Attach reservoir bag to machine or connect non-rebreather.
- Visually inspect machine for defects and improper connections
- Check the function of the one-way valves on a circle system. Wearing a mask, you can exhale through the y-piece to check the movement of the expiratory valve. With the pop-off valve closed and the y-piece open, compression of the reservoir bag will confirm the inspiratory valve.
- You can also refer to Anesthetic Apparatus Checkout Recommendations published by the Food and Drug Administration. There are also specific guidelines that were published for veterinary anesthesia machines.

**CHECKING THE CIRCLE or BAIN CIRCUIT and ANESTHESIA MACHINES FOR LEAKS:**

- **Circle System**
  - Close pop-off valve and occlude the y-piece. Fill system with O2 at a rate of 5 L/min. until the system pressure reaches 30 cm H2O. Check the manometer for any decrease in pressure over 1 minute. There should not be a drop in pressure over a 10 second period and a drop of no more than 250 ml/min.
  - You can also squeeze the reservoir bag to a pressure of 40 cm H2O to check that the system is tight.
  - Open the pop-off valve slowly and the pressure should decline to zero.
  - The open pop-off valve should provide pressure relief when the flush valve is activated.

- **Bain System**
  - Occlude patient port, the relief valve, and distend reservoir bag. The bag should remain distended.
  - A Bain coaxial system should also be checked for leaks. Occlude the inner tube at the patient end of the system and set the flow rate at 1-2 L/min. The O2 flow indicator should fall in the flow tube.
  - You can check most pediatric systems as mentioned in the first line.

**FINDING EQUIPMENT LEAKS**

- **High Pressure Leaks:** high pressure system - nitrous or oxygen tank supplies to the flowmeters. Leaks can be found:
  - at the "quick connects" (crimp joints, screw joint seals, spring seals, and O-rings).
  - at yoke connectors and regulators

- **Low Pressure Leaks:** low pressure system - flowmeters to the patient. Leaks can be found:
  - At the connection between flowmeters and vaporizer
  - At the unidirectional valves
  - At the soda lime canister
  - At the connection around the endotracheal tube
  - At the holes in reservoir bag or delivery hoses
  - Holes in pop-off valve

- **Check for leaks** by using a 10% detergent solution at the joints and will see bubbles if there is a leak.

**Operation of the Anesthetic Machine** - Decide which breathing system to use

- will gases be “rebreathed”?
- oxygen or nitrous oxide flow rates
- pop-off valve (open or closed)
- equipment (breathing tubes, rebreathing bags, or Bain system)

**THREE COMMON ANESTHETIC SYSTEMS:**

NOTE: Rebreathing systems are a circle system with a precision vaporizer out-of-circuit.

**Total rebreathing (closed)**

- “pop-off” valve is closed,
- all gases exhaled by the patient remain in system,
- flow rates are maintained to keep constant volume in rebreathing bag.
  - **Maintenance O2 Flow rate:** 15 ml/kg/min; use of N2O not advised at this rate
Partial rebreathing (semi-closed)

- some gases exhaled remain in system and some are scavenged,
- fresh gas flows of three time's patient's metabolic oxygen needs.

Maintenance O2 Flow rate: 25-50 ml/kg/min; with minimal rebreathing use 150-200 ml/kg/min

Non-rebreathing (open)

- little or no exhaled gases are returned to patient.
- scavenged instead (ex. Bain coaxial system).

Maintenance O2 Flow rate: 130-200 ml/kg/min (Bain system)

* HOW TO DECIDE *

- **Patient size:** Non-rebreathing (<7 kg)
- **Convenience:** Bain systems are lightweight
- **Cost:** Total rebreathing are more economical than non-rebreathing
- **Control:** How fast the anesthetist can change anesthetic depth
- **Conservation of patient’s heat/moisture:** Fresh gas is cool/dry vs. exhaled is warm/moist
- **Production of waste gas:** Total rebreathing = less waste gas

INDUCTION FLOW RATES:
Chamber Induction

- 5 L/min

Face Mask Induction

- 300 ml/kg/min (1-3 L/min <10 kg or 3-5 L/min >10 kg)

Intravenous Induction

- 200 ml/kg/min

CLEANING & DISINFECTING ANESTHETIC EQUIPMENT

- Hoses, Y-piece, reservoir bags, endotracheal tubes and non-rebreathing systems - can be washed in mild soapy solution, and then air dried.
- External components can be sprayed each day with cleanser.
- CO2 canister, pop-off valve, and air tanks - wiped down each week with a disinfectant.
- Laryngoscope can be cleaned w/alcohol or benzalkonium
- Flutter valves can be unscrewed to wipe out moisture build-up

TROUBLESHOOTING PROBLEMS ENCOUNTERED

**What if the reservoir bag is empty?** - Flow rate is too low, flowmeter is off, system leak (hole in breathing bag, gasket on canister is improperly placed, leak in endotracheal tube, waste-gas scavenging system using active suction is improperly regulated, and water drain near CO2 canister is open).

**What if the reservoir bag is too distended?** - There is pressure build-up; pop-off valve is closed off, flow rate is too high in a closed system, and waste gas system improperly regulated.

**What if the patient is too “light”**? - Check vaporizer, increased CO2 build-up, expired CO2 absorber, sticky unidirectional valve.

**When does the vaporizer need to be serviced?** - Recalibration, and water build-up on the wick.
CO2 absorbent granules are exhausted and should be changed if any of the following occurs:

- Half of the granules change color (pink to white or white to blue or lavender). This color change reaction occurs upon exhaustion and may revert to the original color after several hours, so watch the canister closely.
- The texture of the granules changes from crumbly and soft to hard and brittle.
- Rebreathing of CO2 occurs (requires monitoring patients' inspired CO2 levels using capnography).

**Procedure for changing absorbent:**

- There are anesthesia machines with a double canister and others are single.
- Canisters are either clamped or screwed to the circuit and need to be removed in order to change the expired soda lime.
- Wear gloves and a mask, as the indictor granules are caustic.
- There should be a fill-line on the canister as to how much soda lime needs to be replaced.
- As you fill the canister, gently tap to pack the granules closer together. Also helps shake some of the dust off. Do not tamp or pack tightly as this increases resistance to gas flow through the canister.
- Once filled, fasten the canister back to the anesthetic machine. Models vary; some screw on and others clamp. Make sure the gaskets are clean before fastening the canister.
- Leak test the system once again to ensure the canister has been attached properly. Sometimes the gaskets on the canister don't seal tight.