Understanding the Anesthesia Machine

The **function of an anesthesia machine** is to deliver oxygen (O2) and anesthetic gases, remove carbon dioxide (CO2) from the breathing system and provide controlled ventilation. Understanding the functions of the anesthesia machine is essential to ensure proper use.

Most veterinary clinics use **compressed gas cylinders** for their oxygen source and other medical gases (ex., N2O). The two most common sizes of these cylinders are H and E. An E cylinder of oxygen holds about 700 liters and an H cylinder contains about 7,000 liters. Both have a pressure of 2, 200 pounds per square inch (psi) when they are full. The pressure of the oxygen cylinder is proportional to its volume; an E cylinder with a pressure of 1,100 psi holds about 350 liters. A full E cylinder of N2O contains about 1, 600 liters and a full H cylinder contains 16,000 liters. The pressure in a full H nitrous oxide cylinder at room temperature is about 750 psi. These cylinders are color coded: oxygen is green and nitrous oxide is blue.

Components immediately associated with the cylinder that ensure gases can be safely administered to the patient include the pressure gauge and the regulator. A **pressure gauge** indicates the pressure on the cylinder side of the regulator. The **pressure regulator** is used to decrease and maintain the gases at a safe operating level, usually about 50 psi. The regulator reduces the high storage pressure in a full cylinder of gas to a lower and more controlled pressure that is appropriate for the anesthesia machine. The regulator also maintains a constant flow to the flow meter even thought the pressure in the cylinder decreases as the contents are depleted.

The **flow meter** is a part of the low-pressure system of the anesthesia machine. The flow meter measures and indicates the rate of flow of gases and allows precise control of O2 or N2O delivery to the vaporizer/common gas outlet. Flow meters control the amount of gas being used in liters and, depending on the anesthesia machine, milliliters.

Pressure gauges, regulators, and flow meters are prone to failure. The flow meter should be turned off when not in use preventing the sudden build up of pressure in the glass tube and indicator that occurs when the flow meter is open. One of the most common causes of flow meter failure results from over tightening the valve.

The **O2 flush valve** bypasses the vaporizer and delivers oxygen gas only to the common gas outlet and then to the breathing circuit. Used to fill the breathing circuit with oxygen, it delivers a high but unmetered flow of oxygen. This flow, approximately 30 to 50 L/min, can quickly fill the breathing system. The flush valve should be avoided as a means of filling the system when a patient is connected to the breathing circuit, especially in pediatric circles, due to the danger of overpressurizing the patient's respiratory system. Turn up the flow on the flow meter to fill the system when a patient is connected to the breathing circuit.

From the flow meter, the gasses enter the vaporizer and the oxygen/medical gases mix with the anesthetic agent. The **vaporizer** is a device which changes a liquid anesthetic into its vapor and adds a specific amount of vapor to the gases being delivered to the patient.

The oxygen/medical gas/anesthetic agent mixture exits the machine by the **common gas outlet** on the way to the breathing system **--** a rebreathing or nonrebreathing system (see below).

The gas mixture enters the breathing system through the **fresh gas inlet** - the location at which gases from the common gas outlet of the anesthesia machine (or from the outlet of the vaporizer) enter the circle system. The inlet is usually located on the inspiratory side of a rebreathing system. This location minimizes the dilution of the fresh gas with expired gases, absorption of dust and the loss of fresh gas through the pop-off valve.

A **Y-piece**, constructed of plastic, unites the endotracheal tube connector to the inspiratory and expiratory breathing tubes. **Breathing tubes** are usually made of rubber or plastic and serve as flexible, low resistance conduits between the Y-piece and the one-way valves. One way, or unidirectional, valves are paired valves which direct gas flow away from the patient on expiration and toward the patient on inspiration, preventing the rebreathing of exhaled gases before they pass through the absorbent canister. Upon inspiration, the gas mixture is delivered through the inspiratory valve into the breathing tube and Y-piece, then to the patient. At this time the reservoir bag will deflate. When the patient exhales, the expired gases enter the Y-piece and flow through the breathing tube and expiratory valve. Circuit components are arranged to allow movement of the gas mixture in one direction.

The **CO2 absorber** assembly contains the canister for a chemical absorbent for carbon dioxide. CO2 is removed from the expired gases via the action of this absorbent, usually Baralyme granules. Chemical absorption of CO2 allows lower fresh gas flows, reduces wastage of anesthetics and oxygen, and lowers the cost of anesthesia. The granules will change from white to blue as they become exhausted and will return to white when not in use. Fresh granules are soft and easily crushed; exhausted granules are hard and brittle. The canister is an important area for malfunction in circle systems as the canister is removed regularly for changing the absorbent and failure to adequately create a seal when replacing the canister causes leaks.

Depending on the particular anesthesia machine, the gas mixture may enter the **reservoir bag** before of after it has passed though the absorber. Gas in an appropriately sized reservoir meets the patient's peak inspiratory flow demands and provides compliance in the system during exhalation. The bag also provides a mechanism for assisted or controlled ventilation and a visual means of roughly assessing respiratory rate and volume. In addition, if the pop-off valve is inadvertently left closed, the bag provides a compliant area of the system to prevent the immediate buildup of excessive pressure.

Another key component of the anesthesia machine is the **pop-off valve**, which vents waste anesthetic gases to the scavenger system, where it is removed from the workplace. The pop-off valve, also called an adjustable pressure-limiting valve, relief valve, or overflow valve vents gas to the scavenger system to prevent the build up of excessive pressure within the circle. The pop-off valve also allows a rapid elimination of anesthetic gases from the circle when 100% oxygen is indicated. The pop-off valve should be open when the patient is spontaneously breathing and closed for manual or mechanical ventilation.

A **manometer**, calibrated in cm of H2O, is integrated within the circuit and is used primarily to assess pressure during assisted or controlled ventilation.

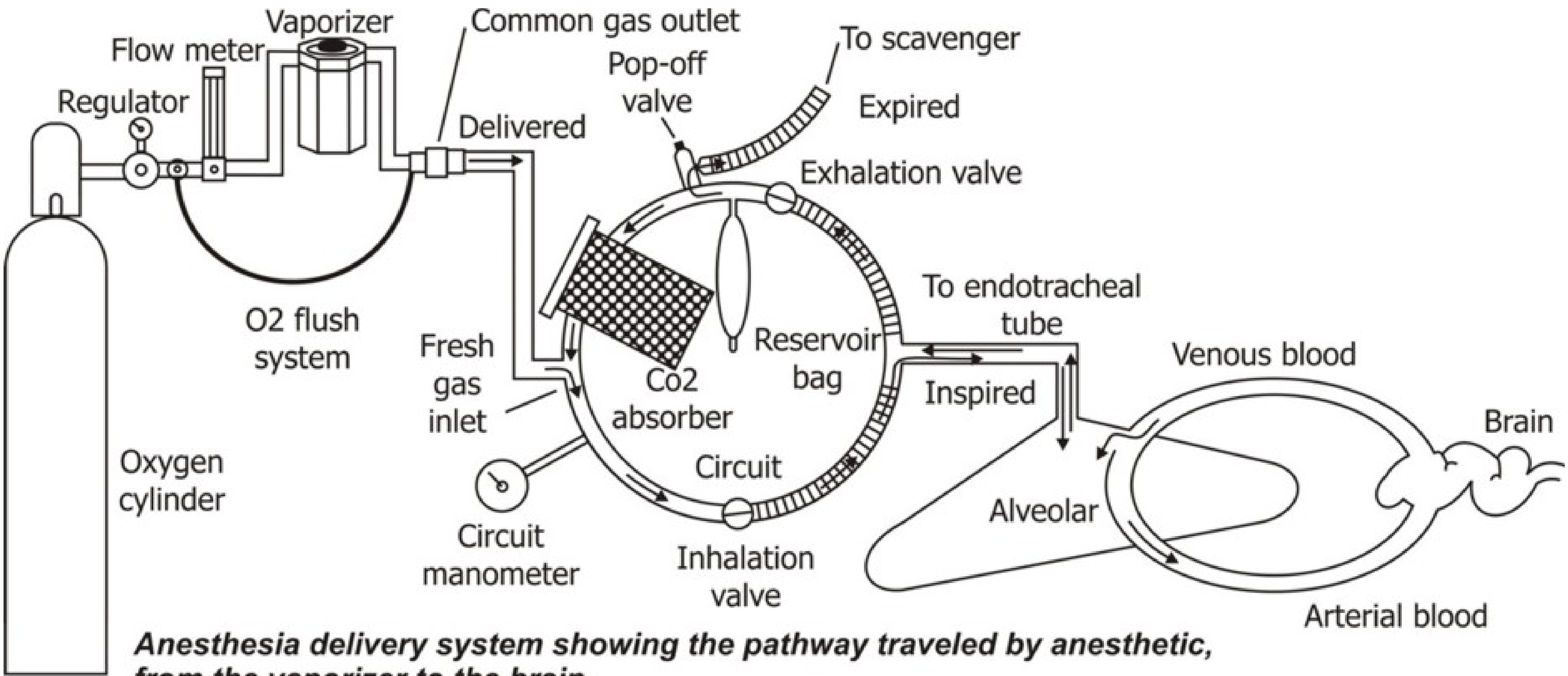
A **scavenging systems** collects waste gases from the anesthetic breathing system and eliminates them from the workplace.

All the components of the anesthesia machine and breathing system should be tested prior to use to ensure that they are functioning properly. Maintaining the anesthesia machine is extremely important to its longevity and proper function. Knowing the functions and components of the anesthesia machine and breathing system will help when troubleshooting problems.

Rebreathing vs. Nonrebreathing Systems

Rebreathing systems utilize a chemical absorbent for exhaled carbon dioxide. They are termed rebreathing systems because part or all of the exhaled gases, after extraction of carbon dioxide, flow back to the patient. In contrast to nonrebreathing systems, rebreathing systems conserve anesthetic, oxygen, heat, and moisture, but impart more resistance to ventilation. Rebreathing systems are relatively expensive to purchase, but comparatively economic to operate.

Nonrebreathing systems use no chemical absorbent for CO2, but depend primarily on high fresh gas flow rates to flush exhaled CO2 from the system. Such systems are Mapleson or nonrebreathing systems as a group. This terminology is technically incorrect because some rebreathing of exhaled gases occurs in most of these systems. The Mapleson systems are simple and easy to use, are lightweight and compact, can be positioned conveniently, have few moving parts, are relatively inexpensive, impart little resistance to respiration, do not require carbon dioxide absorbents, add minimal mechanical dead space, and allow the inspired concentration of anesthetic to be changed rapidly. The main disadvantage of the Mapleson systems is the requirement for higher flow rates of fresh gas, which decreases economy. High flow rates also promote hypothermia and drying of the respiratory tract.



Anesthesia delivery system showing the pathway traveled by anesthetic, from the vaporizer to the brain.

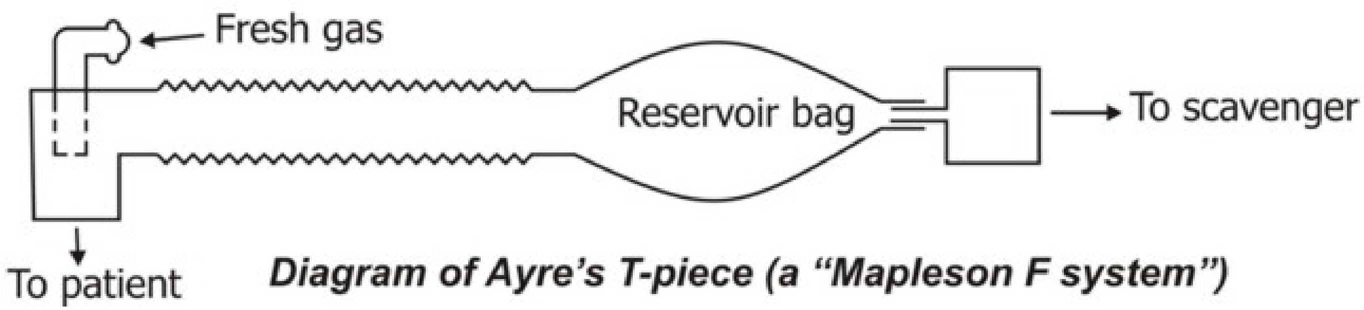


Diagram of Ayre's T-piece (a "Mapleson F system")