**THE CARE AND USE OF ANESTHESIA VENTILATORS**  
Katy W. Waddell, RVT, VTS (ECC, Anesthesia)  
Texas A&M University, College Station, TX.

*Key points*
- Ventilator classifications
- Trouble shooting
- Calculating minute volume

Ventilators, while not in widespread use in private clinics, are becoming more accessible to the practitioner. There are a number of benefits a ventilator can provide. Aside from maintaining a patient during some surgical procedures which necessitate mechanical ventilation, such as those involving opening the chest cavity, mechanical ventilators are very valuable in many other procedures in which the patient may not be able to ventilate well on its own. It is important to know the basic components and workings of the two most common kinds of mechanical ventilators, the ascending bellows type, and the descending bellows type, and know how to maintain and trouble shoot these systems. Correct knowledge of this equipment can quiet any fears one may have in regards to harming a patient.

A ventilator is essentially an extension of the anesthesia machine, the breathing bag having been replaced by the bellows. The bellows are encased in a housing in which a driving gas, usually O₂, is pumped into the housing and forces the bellows to be compressed like an accordion, thereby pushing gas into a patient at a predetermined tidal volume. In a descending bellows ventilator, the bellows hang inside their housing, and are forced upwards by the driving gas during the inspiratory cycle. Leaks in this system may go unnoticed longer due to this mechanism. A leak would be determined by bellows that do not LOWER to the original tidal volume starting point. In an ascending bellows ventilator the bellows are forced downwards inside the bellows housing during the inspiratory cycle. Leaks are easily noticed by bellows that do not refill after each breath; the bellows does not return to the TOP of the bellows chamber. Another ventilator which is less common is the non-rebreathing ventilator for use with Bain systems. Ventilators generally are classified as volume cycled or time cycled. Additionally, most ventilators, whether volume or time cycled, are also pressure limited, which means that the ventilator will not allow inspiratory pressures to exceed a preset limit. Most ventilators are volume cycled, that is to say, the time required for one complete inspiratory and expiratory cycle is dependent upon the machine delivering the tidal volume which the operator has set for the machine, in addition to the time required for a preset “resting” period between inspiratory and expiratory periods. In regards to inspiratory/expiratory ratios (I: E ratio), if the ratio is variable, it should never be less than 1:3. In the time cycled ventilator, as the term implies, the ventilator cycles at preset time intervals for the inspiratory, expiratory, and “resting” periods, and the tidal volume needs to be made to fit in that preset inspiratory time.

Connecting the ventilator to the anesthesia machine can seem complicated at first. Once the proper set up is understood, connecting the ventilator can become second nature. Ventilator connection, regardless of bellows type, is as follows:

1. Squeeze the rebreathing bag until no gas remains.
   a. This is done so no waste gas is released into the environment.
2. Connect the breathing system hose from the ventilator to the rebreathing bag port.
3. Close the pop-off valve completely.
4) Make sure the pressure transducer (if equipped) is in place.
   a. On some models, this is placed between the machine and the breathing circuit at the inspiratory valve. On other models, it is built into the ventilator system.

When using the Bain system ventilator, connecting the breathing circuit and machine can be the hardest task to remember but the easiest to do. Connecting the ventilator is as simple as removing the bag portion of the Bain system and connecting the breathing circuit directly into the breathing system hose.

Since the ventilator is an “extension” of the anesthesia machine, the same trouble spots may occur in the ventilator which exists in the normal anesthesia machine. All gaskets, hoses, and junctions should be checked for soundness, and should be suspected if the bellows do not inflate and deflate as expected. The bellows may be difficult to test for leaks since they are enclosed within the bellows housing. By the same token, however, the bellows are usually protected from damage and accidental punctures. Other trouble spots which typically arise with ventilators have to do with operator error. The most likely, although infrequent, problem a technician may encounter is attempting to set the inspiratory time and respiratory rate so high that the machine is not able to operate as it is designed. In short, the ventilator is designed to give controlled breaths at reasonable intervals. It is not designed to pant.

Once connected and leak checked, the ventilator is ready for operation. If you are using an ascending bellows, it helps to initially increase the oxygen flow to fill the bellows. Start the ventilator at the lowest tidal volume (5 mls/lb body weight) and increase the tidal volume and inspiratory time (if required) slowly until you reach 15 cm of H₂O in small animals, or 20 cm of H₂O in large animals, while you watch the patient’s chest excursions. Respiratory rates are generally started at 8-10 breaths per minute for small animals and 8 breaths per minute in large animals. Remember that increased inspiratory pressure can have a negative effect on cardiac output in many animals, especially equines and bovines. When using a ventilator it is ideal to also use a capnograph to measure end-tidal CO₂. Using this monitoring device can assist in the prevention of hypoventilation (decreased ventilation with increased carbon dioxide), and hyperventilation (increased ventilation with decreased carbon dioxide). The ideal end-tidal CO₂ range is 35 – 45 mm of Hg.

Basic metabolic oxygen needs - awake dogs consume 4-7 ml/kg/minute. Dogs under anesthesia utilize 3-14 ml/kg/minute. These needs are influenced by: body weight – surface area (smaller patients have a higher metabolic rate), body temperature – remember that the metabolic rate decreases with decreased body temperature

Tidal volume is the volume of gas delivered at exhalation and should be at least 10ml/kg of body weight (range 10-20 ml/kg). This guideline is for those patients with presumed normal airway resistance and should not be used for patients with pulmonary bullae. Minute volume is the volume of gas delivered at exhalation per minute. (Tidal volume x breaths per minute).