

## APSF/ASA Guidance on Purposing Anesthesia Machines as ICU Ventilators

Anesthesia machines are equipped with ventilators that in many cases are capable of providing life-sustaining mechanical ventilation to patients with respiratory failure. They are used for this purpose every day in the operating room. FDA approved labeling does not provide for using anesthesia ventilators for long term ventilatory support. Nevertheless, anesthesia ventilators are an obvious first-line backup during the COVID-19 pandemic when there are not sufficient ICU ventilators to meet the patient care needs. Local resources and constraints will impact how this solution can best be implemented. Anesthesia machines not currently being used may be located in your own hospital operating rooms, NORA locations, at nearby ambulatory surgery centers, nearby office-based surgery practices, and through your anesthesia equipment distributors. Guidance is available from the manufacturers regarding, but the guidance may not convey all of the clinical considerations. Anesthesia professionals will be needed to put these machines into service and to manage them while in use. Safe and effective use requires an understanding of the capabilities of the machines available, the differences between anesthesia machines and ICU ventilators, and how to set anesthesia machine controls to mimic ICU-type ventilation strategies.

This document is intended to provide guidance on using anesthesia ventilators safely and effectively as ICU ventilators. Detailed information is provided below and a [quick reference guide](#) is available for downloading. The quick reference guide is intended to be a bedside tool and includes a suggested schedule for monitoring the effectiveness and safety of the anesthesia ventilator.

ASA is working with component societies to develop an inventory of local resources with the goal of moving machines to the locations where they are most needed.

*(NOTE: Local conditions will likely dictate modifications to the recommendations provided. This document is intended to provide reference information that empowers caregivers at the bedside to make the best decisions possible to provide safe and effective care.)*



[asahq.org/ventilators](https://asahq.org/ventilators)

# Key Points to Consider in Preparing to Use Anesthesia Ventilators as ICU Ventilators

## GENERAL TOPICS

- **IS THIS USE OF ANESTHESIA MACHINES AS ICU VENTILATORS APPROVED BY FDA AND MANUFACTURERS?**

The FDA has temporarily approved the use of anesthesia machines as ICU ventilators.

- <https://www.fda.gov/medical-devices/letters-health-care-providers/ventilator-supply-mitigation-strategies-letter-health-care-providers>
- FDA ENFORCEMENT POLICIES FOR VENTILATORS DURING COVID-19: <https://www.fda.gov/media/136318/download>

GE, Draeger and Mindray have released guidance documents on this off label use of their machines. These guidance documents have useful recommendations for the long term use of these machines as ICU ventilators.

- GE Healthcare: 24x7 phone support 800-345-2700
  - GENERAL: <https://www.gehealthcare.com/corporate/covid-19>
  - SPECIFIC: <https://www.gehealthcare.com/-/jssmedia/3c655c83bd6b427e9824994c12be0da5.pdf?la=en-us>
- DRAEGER Medical: 24x7 800-437-2437  
NOTE: Specific guidance may only be available directly from Draeger
  - [https://www.draeger.com/en-us\\_us/Home/novel-coronavirus-outbreak](https://www.draeger.com/en-us_us/Home/novel-coronavirus-outbreak)
- MINDRAY: 24x7 Technical Support 877-913-9663
  - Specific: <https://www.mindraynorthamerica.com/technical-support/>
  - General: <https://www.mindraynorthamerica.com/covid-19-response/>
- Getinge Group (Maquet):
  - [https://www.getinge.com/dam/hospital/documents/marketing-sales/customer-letters/english/mcv00103387\\_reva\\_covid-19\\_customer\\_letter\\_long\\_term\\_ventilation\\_with\\_flow-en-us.pdf](https://www.getinge.com/dam/hospital/documents/marketing-sales/customer-letters/english/mcv00103387_reva_covid-19_customer_letter_long_term_ventilation_with_flow-en-us.pdf)

- **WHO SHOULD MANAGE THE MACHINE?**

An anesthesia professional should be immediately available at all times (24/7/365) to manage the use of the anesthesia machine as an ICU ventilator. Intensivists, ICU nurses and respiratory therapists are not trained to manage anesthesia machines, and are likely to be overextended and stressed. Consultation with intensivists on the preferred ventilation strategy is of course desirable. Respiratory therapists are essential in the management of multiple critically ill patients and long-term ventilation. An anesthesia professional needs to be immediately available for consultation, and to “round” on these anesthesia machines at least every hour. Anesthesia machines are not protected against non-authorized users; policy and signs should warn non-authorized users about changing anesthesia machine settings.

- **WHERE SHOULD THE MACHINES BE USED? OR or ICU?**

Ongoing ICU level patient care is best done in an intensive care unit but the local resources will likely dictate where the anesthesia machines will be deployed.

- **ICU Rooms:** At a minimum, the room requires space to accommodate the machine and sources of high pressure air and oxygen. **Scavenging is not required or necessary if appropriate viral filters are placed on the circuits.**

Suction outlets are available in the ICU but cannot be attached to the WAGD connection on the machine due to connector incompatibility.

- **Operating Rooms:** These rooms should be available in the absence of elective surgery and are appealing as isolation rooms especially if negative pressure capability is present. The anesthesia machines will be readily available for use and connected to gas supplies as well as networked for recording data to the EMR. ORs may be the only option if the ICUs become filled but have patient care drawbacks. Alarms will not be audible outside of the operating room and will need to be set to maximum volume. A caregiver will need to be continuously present in the room with the doors closed and it may be challenging to reproduce all of the ICU care resources in that location.
- **PACU beds and other hospital rooms:** PACUs are typically open with increased noise levels and the potential to spread infectious agents. Other hospital rooms may be more desirable. Physical space and sources of high pressure air and oxygen are the only requirements for using the anesthesia machine as a ventilator. Wherever these machines are deployed, there will need to be an anesthesia professional immediately available and following a monitoring schedule to insure safe use.

- **IF WE HAVE A CHOICE, DOES IT MATTER WHICH ANESTHESIA MACHINE WE USE?**

There are differences in the mechanical ventilation capabilities of different anesthesia machines. In general, newer machines have more modes of ventilation, more flexible settings and specifications similar to ICU ventilators (Table). Anesthesia ventilators with **compliance compensation and tidal volume delivery unaffected by fresh gas flow** are preferred, as they provide more consistent tidal volume delivery and more accurate monitoring.

TABLE OF VENTILATOR SPECIFICATIONS BY ANESTHESIA MACHINE

Anesthesia machine model	Ventilator drive	Pmax	RR max	PEEP max	Vt / MV max	Spirometry/ Compliance/ Sensing
Draeger Apollo	E - Piston	70	100	20	1400 / 50	Y/Y/Y
Draeger Fabius or Tiro	E - Piston	70	60	15	1400 / 25	N/Y/Y
Draeger Perseus	E - Blower	80	100	35	1500 / 40	Y/Y/Y
GE Aisys	P - Bellows	100	100	30	1500 / 120	Y/Y/Y
GE Aisys C2	P - Bellows	100	100	30	1500 / 120	Y/Y/Y
GE Avance	P - Bellows	100	100	30	1500 / 120	Y/Y/Y
GE Avance C2	P - Bellows	100	100	30	1500 / 120	Y/Y/Y
GE Carestation 600 series	P - Bellows					Y/Y/Y
Getinge Flow-i	P - Reflector	80	100	50		Y/Y/Y
Mindray A7 Advantage	P - Bellows	100	100	30	1500 / 30	Y/Y/Y
Mindray A5 Advantage	P - Bellows	100	100	30	1500 / 30	Y/Y/Y
Mindray A4 Advantage	P - Bellows	100	100	30	1500 / 30	N/Y/Y

P-Pneumatic; E-Electrical

The most capable anesthesia machines should be utilized first. The minimum requirement should be the ability to mimic SIMV + PS using either volume and pressure targeted modes of ventilation mixed with pressure support. That said, the ventilation capabilities of most anesthesia machines, even those with limited ventilation modes and no PS capability, should be sufficient as a life saving intervention for the majority of patients. Respiratory monitoring is also important including pressure and flow monitoring with alarms. Real time spirometry (Flow-Volume and Pressure-Volume loops) is quite useful when caring for patients with respiratory failure, and for diagnosing leaks around the endotracheal tube and increased resistance through the airway HMEF. **Oxygen utilization** can be a factor when selecting anesthesia machine ventilators and managing the ventilation modes. In general, pneumatically powered ventilators consume more oxygen than electrically powered ones but modifications will be described for conserving oxygen with all ventilator designs.

- **DOCUMENTATION OF VENTILATION PARAMETERS**

In many hospitals, anesthesia machines are connected to a network to automate documentation of ventilation parameters to the patient record. Continuing that documentation is easy if the machines remain in the operating room. If moved to another location in the hospital, it may be possible to restore the network connection for automated documentation or intermittent manual documentation may be needed. If manual documentation is needed, a template should be used for documentation.

- **CAN THE ANESTHESIA MACHINE BE USED TO ADMINISTER INHALED ANESTHETICS FOR SEDATION?**

Using inhaled anesthetics for sedation is not recommended. The physiologic impact of inhaled anesthetics beyond sedation may complicate the patient's care, and the effects are not likely to be understood by other caregivers.

## **EQUIPMENT CONSIDERATIONS**

- **MACHINE SETUP**

Setting up the machine will require

- Connections to pressurized oxygen and air, either to hospital pipeline or large G or H cylinders. Backup oxygen and air cylinders.
- Removal or drainage of all vaporizers.
- Removal of nitrous oxide cylinder and pipeline hoses
- Adjustment of the scavenger system (if outside of an operating room, there may not be a compatible waste anesthetic gas disposal outlet - i.e., no way to hook-up the scavenger). If the scavenger is not connected to suction, then either 1) it should be disconnected from hoses coming from the breathing system and ventilator, or 2) the scavenger reservoir bag should be removed if it is a closed-scavenger system. Either of these interventions will prevent high pressures in the scavenger system which would cause gas to back up into the breathing system resulting in high airway pressures and unintended PEEP at the airway.
- Changing the drive gas if the anesthesia ventilator contains a bellows. 100% oxygen is the standard drive gas for a bellows-type ventilator, and it is consumed at approximately the minute ventilation (which is significantly more than the fresh gas oxygen consumption). If oxygen supplies are limited or being conserved, modifications can be made to use compressed air as the drive gas. Such

modifications can be done in less than one hour by a trained clinical engineer following the manufacturer's instructions.

- To convert a GE bellows ventilator from 100% O<sub>2</sub> to compressed Air:

*Technical Reference Manual Sections:*

- |                   |                               |
|-------------------|-------------------------------|
| • Aisys CS2       | Section 9.27 Change drive gas |
| • Avance CS2      | Section 9.27 Change drive gas |
| • Carestation 6xx | Section Change drive gas      |
| • Aespire View    | Section 9.28 Change drive gas |

*CAUTION: If you change the drive gas, you must also change the drive gas selection on the ventilator service setup screen. Refer to Section 4 of the ventilator Technical Reference manual. If the drive gas selection and the actual drive gas do not agree, volumes will not be correct.*

- A breathing circuit with reservoir bag and viral filters to protect the machine from internal contamination. A heat and humidity exchange filter (HMEF) should be placed at the endotracheal tube connection to the breathing circuit, and a second HMEF or filter should be placed on the expiratory hose where it connects to the anesthesia machine (see [FAQ on Anesthesia Machine Use, Protection, and Decontamination During the COVID-19 Pandemic](#)). Replacement filters and breathing circuits should be readily available.
  - A backup manual resuscitator (bag-valve-mask) with expiratory port filter that is available at all times for backup ventilation. In some anesthesia ventilator failure modes, the patient may also be ventilated manually using the anesthesia machine.
  - Respiratory gas monitor(s) for inspired oxygen and inspired/exhaled carbon dioxide, either internal or external to the machine
- **MANAGING THE SELF TEST**

Most modern anesthesia machines have self-test procedures to be performed before use that should be repeated every 24 hours to ensure proper function. The patient cannot be ventilated with the anesthesia machine during self-test, even in manual mode, so alternative means of ventilation are necessary during this time. Although it is not considered ideal, guidance from manufacturers during this crisis allows for a self test interval up to 72 hours. Power to the machine should be cycled between every patient and no longer than once every 25 days.
  - **DELIVERING A DESIRED INSPIRED OXYGEN CONCENTRATION**
    - Due to rebreathing in a circle system, the inspired oxygen concentration may be significantly lower than the fresh gas concentration. For this reason, **inspired oxygen concentration must be monitored**. Rebreathing increases progressively as fresh gas flow is reduced below minute ventilation.
    - On some anesthesia machines, the oxygen concentration of the fresh gas can be set directly, along with the total flow.
    - On other anesthesia machines, the flows of oxygen and air are set and the fresh gas oxygen concentration must be calculated. The following table is a general guide to ratios of oxygen and air flow and the resulting oxygen concentration that will be delivered to the circuit.

Desired FiO2	Oxygen to Air Ratio	Oxygen flow for 5 L/min total	Air flow for 5 L/min total
21%	0 to 1	0.0	5.0
25%	0.06 to 1	0.3	4.7
30%	0.13 to 1	0.6	4.4
35%	0.21 to 1	0.9	4.1
40%	0.31 to 1	1.2	3.8
50%	0.59 to 1	1.9	3.1
60%	0.99 to 1	2.5	2.5
80%	3 to 1	3.8	1.3
100%	1 to 0	5.0	0.0

- Regardless of how the fresh gas oxygen concentration is set, the resulting patient inspired oxygen concentration will depend upon the fresh gas flow and amount of rebreathing. Fresh gas oxygen concentration may require adjustment to maintain the desired inspired oxygen concentration.

- **TOTAL FRESH GAS FLOW SETTINGS**

The ability to change fresh gas flow and alter the amount of exhaled gas rebreathed is the key feature distinguishing an anesthesia ventilator from an ICU ventilator. In general, if the fresh gas flow exceeds minute ventilation, there is little to no rebreathing. As fresh gas flow is reduced, progressively more exhaled gas is rebreathed. The minimum safe fresh gas flow replaces oxygen consumption, plus any gases lost due to leaks and sampled gas. The following recommendation to minimize fresh gas flow is intended to utilize the unique design of an anesthesia ventilator to minimize oxygen utilization and maintain humidity in the inspired gas. Reducing fresh gas flow safely requires a supply of CO<sub>2</sub> absorbents and an anesthesia professional to manage the device.

- **OPTION 1 (Recommended if there is an adequate supply of CO<sub>2</sub> absorbent and an anesthesia professional attending the machine):**  
Reduce total fresh gas flow substantially below minute ventilation. 1-2 Liters per minute should be more than adequate for most patients and will conserve both oxygen and humidity. Monitoring will require that alarms be set for minimum inspired oxygen concentration and an inspired CO<sub>2</sub> of 5 torr. In addition, inspection should include looking for humidity in the breathing circuit and collapse of the reservoir bag due to leaks. It is prudent to increase FGF every four hours to exceed minute ventilation to help dry the internal components of the circuit. If managing excess condensate becomes a barrier to good care, increasing fresh gas flow can reduce the accumulation of water.  
Note: If the circuit is disconnected from the patient, put the ventilator into manual

mode first. This will preserve gas in the circuit. Otherwise high flows may be needed to restore the volume of the reservoir bag after disconnection.

- **OPTION 2 (Recommended if there is a shortage of CO2 absorbents and the supply of oxygen is not a concern):**

Increase total fresh gas flow to meet or exceed minute ventilation. CO2 absorbents will be utilized very little, if at all, since the goal is to reduce rebreathing. If inspired CO2 is present on the capnogram, increasing total fresh gas flow until the inspired CO2 is zero will eliminate rebreathing. The lack of humidity in the fresh gas may become a problem. At the very least, an HME or HMEF will be needed and an active humidifier should be considered. Using high fresh gas flow is not the preferred option due to the high utilization of oxygen, and difficulty delivering humidified gases. Monitoring is easier but will still require alarms for inspired CO2 and oxygen concentrations. CO2 absorbent should still be left in place, but at continuous high flows it will not need to be changed often if at all.

- **STRATEGIES FOR CONSERVING OXYGEN**

The availability of oxygen will vary from place to place. If an adequate supply of oxygen is a concern, strategies can be employed that will reduce oxygen utilization substantially when using an anesthesia ventilator. Without modification, some anesthesia machines can use 10-12 liters per minute or more of oxygen, compared to 7-10 liters per minute by an ICU ventilator, or 1-2 liters per minute using the strategies below.

- Reduce fresh gas flow to 1-2 L/minute.
- Use an electrically-powered anesthesia ventilator (currently, only made by Draeger): These ventilators do not consume any oxygen to develop pressure and flow; oxygen consumption equals the oxygen fresh gas flow rate.
- Convert the bellows ventilator (typically powered by compressed oxygen) to use compressed air as the drive gas.
  - GE has a documented procedure for converting any of their anesthesia ventilator models to compressed air. This can be done by a qualified clinical engineer in less than an hour. Anesthesia techs and anesthesia clinicians will not typically have the training or documentation to perform this conversion. Manufacturers' instructions are referenced above.

- **HUMIDIFICATION CONSIDERATIONS**

Compressed gases that enter the breathing circuit have 0% humidity. Not humidifying this gas can dry mucus and other airway secretions leading to mucus plugging, and can injure lung epithelium in the long-term. Thus, it is especially important to maintain airway humidity during long-term ventilation. While exact humidity levels and their effects are difficult to predict, the following considerations are helpful.

- At fresh gas flows below 2 L/min, inspired gas is passively humidified by the reaction of carbon dioxide absorption and exhaled humidity. Even without a heat and moisture exchange filter (HMEF) at the airway, humidity levels are adequate for the short term, and maybe for long-term ventilation. Addition of a HMEF at the airway should provide adequate humidification for long-term ventilation in this case.
- At fresh gas flows above 5 L/min, there is not enough humidity in the inspired gas unless a HMEF is used at the airway. Active humidification of inspired gas may be considered, but is discouraged by most manufacturers.

- If active humidification is used, you WILL experience problems with ventilation and monitoring that will need to be managed. At low fresh gas flows and with active humidification, significant amounts of water condense within the breathing system over time. Anesthesia machines are not designed to handle large amounts of condensed water within the breathing system. It can increase resistance to flow through the system, can interfere with sensors (such as flow sensors and respiratory gas analyzers), and can short-circuit electronics. Heated breathing systems prevent some of this condensation. Condensers and water traps can be added to some breathing systems. During extended use, the user must periodically drain water from the breathing circuit hoses, and sites of water collection within the breathing system. The patient may need to be ventilated by hand while this is done.

- **MONITORING VENTILATION**

While anesthesia professionals are trained to monitor ventilation during operative cases, there are additional considerations due to the use of extra filters in the breathing circuit, the accumulation of condensed water over time, and the potential for aerosolizing COVID-19 virus.

- Baseline monitored parameters (Pressure, Flow, Volume, Minute ventilation) should be recorded when therapy is initiated. If spirometry is available, the baseline reference loops should be saved for later comparison.
- One problem with airway filters is that the resistance through them increases when they become wet (especially electrostatic-type filters) or filled with airway secretions. Increased airway pressure is a late sign of this problem because pressure is sensed upstream of the airway HMEF. Impeded expiratory flow is an earlier indication that should be looked for by comparing expiratory flow tracings and flow-volume loops to baseline recordings. Impeded expiratory flow is indicated by a decrease in peak expiratory flow or a prolongation of expiratory flow that can be observed on a flow tracing or flow-volume loop. There may also be a slight delay or slurring of the expiratory capnogram.
- Condensed water buildup in breathing circuit hoses and dependent parts of the breathing system may cause oscillations in the pressure and flow waveforms, as gases bubble past the fluid obstructions. These oscillations may be sensed as patient inspiratory effort, causing the ventilator to initiate a patient-triggered breath. Consider this when the total respiratory rate exceeds set respiratory rate in a sedated or paralyzed patient.
- Leak around the endotracheal tube cuff is a hazard in the COVID-19 patient because of resulting aerosolization. With a leak around the endotracheal, the measured exhaled tidal volume will be significantly lower than the measured inhaled tidal volume, and the flow-volume loop will not close. At low fresh gas flows, the bellows will not totally reinflate on exhalation when there is a significant leak around the endotracheal tube cuff (on a Draeger machine with a piston or turbine ventilator, the reservoir bag will progressively deflate).



- **PROVIDING POTENT ANESTHETIC AGENTS**

Anesthesia machines have the capability of providing inhaled anesthetics for sedation during long-term care. While this might be an attractive option if intravenous sedatives are in short supply, it is not generally recommended when the machines are used as ICU ventilators. Certainly, this is not advised without proper waste anesthetic gas scavenging which will typically only be available in the OR. The potentially detrimental effects of long term sedation with inhaled anesthetics have not been studied. Provision of inhaled anesthesia would require constant presence of an anesthesia provider at the bedside to monitor the physiologic effects.

- **PROCESSING BETWEEN PATIENTS**

Hospital procedures for reprocessing ventilators between patients should be followed if breathing circuit filters have been used as directed. In this case, there should be no increased risk of passing COVID 19 virus to a subsequent patient via the anesthesia machine. The manufacturer's recommendation for decontaminating the anesthesia machine should be followed if there is evidence that the internal surfaces of the breathing system have been contaminated. Refer to manufacturer guidelines for specific procedures. Information can also be found on the APSF website:

<https://www.apsf.org/faq-on-anesthesia-machine-use-protection-and-decontamination-during-the-covid-19-pandemic/#cleaning>

**\*\*GUIDANCE IS PENDING FROM THE ASA COMMITTEE ON CRITICAL CARE AND THE SOCIETY FOR CRITICAL CARE MEDICINE (SCCM). THIS GUIDANCE WILL INCLUDE EDUCATIONAL MATERIAL TO GUIDE THE CLINICAL MANAGEMENT OF CRITICALLY ILL PATIENTS WITH COVID 19. LINKS TO THE GUIDANCE WILL BE ADDED AS SOON AS IT IS AVAILABLE.**

## **SETTING AN ANESTHESIA VENTILATOR FOR ICU VENTILATION**

### **MONITORING VENTILATION**