

What is ventilation? respiration?

Ventilation is the process of moving air in and out of the lungs. Respiration is the process during which the exchange of oxygen (O₂) and carbon dioxide (CO₂) occurs in the alveoli of the lungs. The alveoli are small air sacs at the end of the bronchial tree in the lungs, and it is through the walls of these air sacs that O₂ diffuses into the blood and CO₂ diffuses out of the blood. Ventilation is a constant process of maintaining the proper balance between the two.

What is a ventilator?

A ventilator, also known as a respirator, is the equipment used to mechanically assist breathing by delivering air to the lungs. Many people may be familiar with ventilators in the hospital setting, such as the ICU, where large complex acute care ventilators are used. The ventilators used in the home are small, lightweight and portable; they can be mounted on wheelchairs or carts or put on a bedside stand. Most of these operate on household electric current – some have internal batteries – and can be operated with external batteries. It is advisable to have a backup battery or even a generator readily available in case of power outages or emergencies.

How does mechanical ventilation work?

The diaphragm is the primary muscle for inspiration, along with the intercostal muscles between the ribs. Other muscles of the chest, neck and shoulders play smaller roles. When these breathing muscles are weakened or paralyzed, breathing becomes difficult or impossible. A mechanical ventilator can take over the act of breathing completely or make breathing easier by assisting weakened respiratory muscles.

The muscles of the abdomen are important for breathing out and for an effective cough. Weak expiratory muscles result in impaired cough and inability to clear secretions that can lead to respiratory infections and pneumonias. In certain neuromuscular diseases, the bulbar muscles – those responsible for swallowing, speech and coughing – can become progressively impaired. Cough can be assisted by the use of manual techniques such as lung volume recruitment and breath-stacking and/or mechanical devices such as the CoughAssist®.

How did mechanical ventilation develop?

The iron lung or “tank” was the first effective form of mechanical ventilation, and one of the earliest iron lungs, often used to resuscitate drowning victims, dates from 1838. A century later, in the 1930s, improvements in the iron lung made widespread use of mechanical ventilation possible, particularly during the polio epidemics.

Positive pressure ventilators developed as a more effective breathing option to the larger, bulkier negative pressure devices. Since the 1980s, computer technology has enabled manufacturers to produce even smaller, lightweight ventilators that are easier to transport and operate, and are better suited for people living at home.

What is negative pressure ventilation?

When the pressure around the chest is negative – lower than atmospheric pressure – the chest expands to allow air to enter the nose and mouth. Iron lungs enclose the whole body, except for the head, and create pressure changes between the chest and the encasing shell of the unit.

Other forms of negative pressure ventilation, also known as body ventilators, include the chest shell or cuirass, Nu-Mo suit and Pulmo-wrap. The Porta-Lung™ is a smaller and more mobile version of the iron lung that is still used by a small number of people.

A technologically advanced form of negative pressure ventilation called biphasic cuirass ventilation (BCV) controls both the inspiratory and expiratory phases of breathing. Higher frequencies and tidal volumes allow for higher minute ventilation.

The following equipment specifications are for negative pressure ventilators currently on the markets. There is no “standard” form for specifications. American and European manufacturers differ in the technical information that they provide about their products. Alarms must be a certain volume. Minimum and maximum alarm volume is regulated.

What is negative pressure ventilation? *(continued)*

KEY:

① = available only in USA ② = available only outside USA ③ = available worldwide

Hayek RTX (Biphasic cuirass ventilation)

United Hayek Medical, www.unitedhayek.com ③

Pediatric use > 5 kg,

Also used as cough assistant

Modes:	Continuous negative; mandatory control; respiratory synchronized
Rate:	6-1200 cycles per minute
Maximum inspiratory pressure:	-50 cm H ₂ O
Maximum expiratory pressure:	+50 cm H ₂ O
I:E ratio:	1:6 - 6:1
AC voltage:	110-230, 50-60 Hz
External battery:	12 VDC
Dimensions:	370 mm W x 260 mm D x 180 mm H
Weight:	9 kg

Italian Iron Lung, Model CA 1001

Officine Coppa S.r.l., www.coppabiella.it ②

Pegaso V

Dima Italia S.r.l., www.dimaitalia.com ②

Rate:	5-50 CPM
Negative pressure:	Variable from -5 to -99 cm H ₂ O
Positive/negative pressure E:	Variable from +99 to -25 cm H ₂ O
AC voltage:	115V/230V, 50-50 Hz, 400 VA
Dimensions:	30 cm H x 32 cm W x 25 cm D
Weight:	17 lbs.
Alarms:	High/low respiratory pressure, power failure, mechanical failure

Porta-Lung™

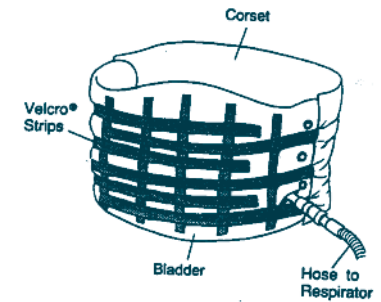
Porta-Lung, Inc., www.portalung.com

(No longer manufactured; still in use)

Breathing rate:	4-60 BPM
Pressure:	-60 to +20 cm H ₂ O
Sizes:	X-small, small, medium and large
AC voltage:	120 VAC
External battery:	12 VDC
Weight:	72 lbs-138 lbs
Alarms:	Low pressure

What is a pneumobelt?

The pneumobelt, also known as an exsufflation belt, consists of an air bag or bladder inside a cloth corset that is worn around the abdomen and lower chest. The pneumobelt is connected by tubing to a positive pressure ventilator that alternatively inflates and deflates the bladder.



As the belt inflates, the abdominal contents are compressed and the abdomen rises, forcing air out of the lungs. When the belt deflates, the diaphragm is lowered and inhalation occurs passively. Because the pneumobelt works with gravity, it is most effective in the sitting and standing positions and should not be used at night in the supine position. The pneumobelt is powered by a volume or combination/multi-mode ventilator. It is available as needed from Philips Respironics. Contact the area representative.

Consumer comments. “The pneumobelt is not noisy at all; there is just a whooshing sound as it exhales. However, the ventilator used to power the pneumobelt can be noisy. I use the turbine-driven LTV®950 which has a high-pitched whistle and a loud inhaling sound. It can be annoying to some people.

“Care is easy. Circuits are disposable, and I change them about once a month, more often during flu season. The belt requires no cleaning. The only ‘maintenance’ is to be careful to change settings to lower volumes when transitioning from using mouth intermittent positive pressure (which I also use) to the pneumobelt. It is possible to over-inflate the belt and blow a hole in it. The rubber bladder can be replaced, but it’s costly.

“The pneumobelt is not very comfortable. The settings can be set to provide a smooth, natural inhale and exhale so that it is not jerky but provides a natural breathing rate for speaking. Because one is breathing normal air through the mouth and nose, a humidifier is not needed with the pneumobelt.

“A commercial version of the pneumobelt is available from Philips Respironics, but custom belts can be made by a prosthetic/orthotic company. The nylon straps on the original casing are narrow and cut into the sides of the body.

A cotton T-shirt under the belt helps. I also use a thin foam pad to prevent pressure sores on my ribs and hipbones – the new Dr. Scholl’s gel pads for shoes work well. Similar pads can be obtained from a physical therapy department. I’m experimenting with a new custom pneumobelt using the elastic belting found in low-back support belts with gel pads on wider straps.

“There are no alarms on the pneumobelt, but there are many alarms on the ventilator. I turn the low-pressure alarms off as much as possible because

What is a pneumobelt? *(continued)*

they are annoying and not necessary for me. The alarm in case the belt becomes disconnected is sufficient to summon help.

“The pneumobelt provides hands-free ventilation without any intrusive apparatus around the face. However, the pneumobelt cannot be used in the reclining or supine position so I can’t recline in my wheelchair.” –TS, Arizona

What is positive pressure ventilation?

Positive pressure – higher than atmospheric pressure – pushes air into the lungs. It can be administered either noninvasively via a wide variety of interfaces (nasal, facial and oral masks, nasal pillows, or mouthpieces), with tubing attaching the interface to the ventilator or invasively via tracheostomy.

Examples of equipment that deliver positive pressure ventilation are bilevel positive airway pressure ventilators, pressure support ventilators and volume ventilators, and combination/multi-mode ventilators.

The high flow of air from positive pressure may cause dryness in the nasal passages and upper airway, and humidifiers may help relieve symptoms of nasal stuffiness, dry mouth and thick nasal secretions. An integrated humidifier is a feature of some ventilators.

What is CPAP?

CPAP (continuous positive airway pressure) provides a continuous flow of air at a constant pressure for both inhalation and exhalation to keep the airway open during sleep. It is the standard of treatment for obstructive sleep apnea, during which the muscles of the throat collapse and block the airway. Auto-titrating CPAP units or APAPs deliver varying pressures based on the detection of sleep-disordered breathing events; the pressure can change breath-by-breath. A nasal or facial mask, connected by tubing to the CPAP unit, is worn during the night.

What is a bilevel positive airway pressure ventilator?

Bilevel ventilators were developed by modifying CPAP so that both inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP) could be delivered. The IPAP/EPAP settings can be adjusted separately.

People with neuromuscular disorders and weak diaphragmatic muscles may have difficulty breathing in and may need IPAP set higher than EPAP, e.g. IPAP of 14, EPAP of 3. The difference between IPAP and EPAP is called the span, and in these cases, should be at least 10.

Bilevel ventilators are made by several manufacturers. BiPAP® was the name patented and registered by Respironics, Inc., and many bilevels have been incorrectly referred to as BiPAPs.

Bilevels are used primarily during the night with a noninvasive facial, nasal or oral mask, or nasal pillows. Some people use their bilevels continuously, but in the USA, the FDA has not approved them for 24-hour use in the home. They are also not approved for use by people who have tracheostomies. Some physicians prescribe them for infants and children, particularly in developing countries because the bilevel ventilatorss are more affordable and available than volume, pressure, or combination/multi-mode ventilators.

The bilevel modes are:

- “S” for spontaneous breathing patterns that the unit senses and then switches between prescribed pressures.
- “T” for timed breaths that are delivered at a preset rate.
- “S/T” for spontaneous/timed. The unit switches to a timed mode (also known as a backup rate) when breaths are not spontaneously initiated by the individual. People with neuromuscular disorders should use a bilevel ventilator with a backup rate so that breaths are initiated for them.

The advantages of bilevel ventilators are: small size, light weight and portability, lower cost, and compensation for leaks from masks. Disadvantages include lack of internal batteries, no or few alarms, inadequate pressures for some people, higher electricity operating costs, and discomfort from EPAP. Many of the combination/multi-mode ventilators can provide bilevel ventilation.

The following equipment specifications are for bilevel ventilators currently on the markets. There is no “standard” form for specifications. American and European manufacturers differ in the technical information that they provide about their products. Alarms must be a certain volume. Minimum and maximum alarm volume is regulated.

Bilevel Positive Airway Pressure Ventilators	Mode	IPAP	EPAP/CPAP	Breath Rate	Trigger/Tidal Volume	AC Voltage	Battery	Dimensions	Weight	Noise	Alarms	Humidifier = H Oxygen = O
BiLevel ST 22 Weinmann GmbH & Co. KG www.weinmann.de ② <i>Available only outside USA</i>	CPAP, spontaneous, timed, spontaneous/timed	6-22 hPa	4-20 hPa	6-45 BPM	6	115-230 V, 50/60 Hz	No internal External: Ventipower	230 mm W x 120 mm H x 280 mm D	3.7 kg	<26 dB	Leak/mask disconnect, apnea, high pressure, high temperature, device failure, malfunction, low external batteries, power failure	H Venticlick O Venti-O2
BiPAP A30 Philips Respironics http://healthcare.philips.com/main/homehealth/respiratory_care/bipapa30 ②	CPAP, spontaneous, timed, spontaneous/timed, pressure control	4-30 cm H2O	4-25 cm H2O	0-40 BPM (4-40 BPM in T mode)	200-1500 ml	100-240 V, 50/60 Hz	12-24 VDC	21.6 cm W x 19 cm L x 11.5 cm H	2.1 kg (with power supply)	<30 dB	Apnea, circuit disconnect, high respiratory rate, low minute ventilation, low tidal volume	H - integrated
BiPAP A40 Philips Respironics http://healthcare.philips.com/main/homehealth/respiratory_care/bipapa40 ②	CPAP, spontaneous, timed, spontaneous/timed, pressure control, AVAPS-AE	4-40 cm H2O	4-25 cm H2O	0-40 BPM (4-40 BPM in T mode)	200-1500 ml, flow trigger, auto-trak	100-240 V, 50/60 Hz	12 VDC detachable external up to 5 hrs; 24 VDC power supply	21.6 cm W x 19 cm L x 11.5 cm H	2.1 kg (with power supply)	<30 dB	Apnea, low minute ventilation, low tidal volume (with AVAPS/AVAPS-AE only), high respiratory rate, leak, mask disconnect	H
BiPAP AVAPS (Average Volume-Assured Pressure Support) Philips Respironics http://bipapavaps.respironics.com ③ Pediatric use	CPAP, spontaneous, timed, spontaneous/timed, pressure control, average volume-assured ventilator pressure support	4-25 cm H2O	4-25 cm H2O CPAP: 4-20 cm H2O	0-30 BPM	200-1500 ml	110-240 V, 50/60 Hz	No internal External: 12 V	7" L x 5.5" W x 4" H; 18 cm x 14 cm x 10	3 lbs, 1.36 kg	<30 dB	Low Vte, mask disconnect, apnea, low minute ventilation, unit malfunction, low/empty external battery, power failure	H
BiPAP Harmony Philips Respironics www.healthcare.philips.com/main/homehealth/ ②	Spontaneous, spontaneous/timed, CPAP	4-30 cm H2O	4-25 cm H2O CPAP: 4-20 cm H2O	0-30 BPM		100-240 V	No internal External: 12-24 V with inverter	24 L x 17 W x 11 H cm	2.6 kg	<30 dB	Disconnect, apnea, device failure, low external battery	H, O

What is a bilevel positive airway pressure ventilator? (continued)

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Bilevel Positive Airway Pressure Ventilators (continued)	Mode	IPAP	EPAP/CPAP	Breath Rate	Trigger/Tidal Volume	AC Voltage	Battery	Dimensions	Weight	Noise	Alarms	Humidifier = H Oxygen = O
BiPAP S/T Philips Respironics www.healthcare.philips.com/main/homehealth/ ③ Pediatric use	Spontaneous, spontaneous/timed, CPAP	4-25 cm H ₂ O	4-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	0-30 BPM		100-240 V	No internal External: 12 V with inverter	7" L x 5.5" W x 4" H; 18 cm x 14 cm x 10	3 lbs, 1.36 kg	<30 dB	Mask disconnect, apnea, low minute ventilation, unit malfunction, low/empty internal battery, power failure	H
BiPAP Synchrony Philips Respironics www.healthcare.philips.com/main/homehealth/ ② <i>See Consumer Comments at end of specifications</i>	Spontaneous, timed, spontaneous/timed, CPAP, pressure control	4-30 cm H ₂ O	4-25 cm H ₂ O CPAP: 4-200 cm H ₂ O	0-30 BPM (S/T); 4-30 BPM (T)	200-1500 ml	100-240 V, 50/60 Hz	No internal External: 12 V with inverter	4.4" H x 6.625" W x 9.75" H	4.2 lbs	<30 dB	Low V _{te} , mask disconnect, apnea, low minute ventilation, low external battery, power failure	H
Falco 51 Siare Engineering International Group, S.r.l. www.siare.it ②	Spontaneous, spontaneous/timed, CPAP	6-40 cm H ₂ O	0-20 cm H ₂ O	5-50 BPM	50-2500 ml; 1-9 L/min inspiratory trigger; 5-90% expiratory	100-240 V, 50/60 Hz	Internal: NiMH up to 5 hrs	240 L x 330 D x 210 H mm	3.9 lb	n/a	Low/high pressure; low/high rate/ low/high inspired tidal volume; apnea; malfunction; low internal battery; power failure	n/a
iSleep™ 25 BREAS Medical AB www.breas.com ②	Spontaneous, CPAP, spontaneous/timed, pressure assist control	4-25 cm H ₂ O	4-20 cm H ₂ O	4-30 BPM	1-9 inspiratory 1-9 expiratory	100-240 V	No internal External: 24 V DC, 12V adapter	173 mm W x 172 mm H x 201 mm D	1.9 kg	<28 dB	Device failure, malfunction, high pressure leak, power failure	H, integrated

Bilevel Positive Airway Pressure Ventilators <i>(continued)</i>	Mode	IPAP	EPAP/CPAP	Breath Rate	Trigger/Tidal Volume	AC Voltage	Battery	Dimensions	Weight	Noise	Alarms	Humidifier = H Oxygen = O
Monnal T30 Air Liquide Medical Systems, Inc. www.airliquidemedicalsystems.com ②	CPAP, S, ST, T, Pressure assist control	4-30 hPa	EPAP: 2-25 hPa CPAP: 4-20 hPa	0, and 6-40 BPM	4 inspiratory; 3 expiratory	110-230 VAC, 50/60 Hz	No internal External: 12 V	175 H x 338 L x 196 mm W	3.8 kg	30 dB	Leak, patient disconnect, power failure	H
Multilevel ST-30 Multilevel ST-30V Multilevel ST-40V Dima Italia S.r.l. www.dimaitalia.com ②	CPAP, Spontaneous, spontaneous/timed, Timed, SP	3-30 cm H ₂ O (3-40 cm H ₂ O for ST-40V)	0-25 cm H ₂ O	5-60 BPM	1-9 auto-track Target volume (ST-30V and ST-40V only): 100-1500 cc/cycle	100-240 V, 50/60 Hz	No Internal External: 50 V	18 cm W x 14 cm D x 19 cm H	1.5 kg	<25 dBA	Apnea, leak/mask disconnect, high respiratory rate, high/low inspiratory pressure, high expiratory rate, low tidal volume, empty battery, malfunction, power failure	
Nippy™ ST + B & D Electromedical www.nippyventilator.com ②	Spontaneous, spontaneous/timed, CPAP	3-38 cm H ₂ O	3-20 cm H ₂ O	6-43 BPM	Flow, 200 L/min	100-240 V, 47-63 Hz	Opt. internal 4-12 hrs External: 24 V, 4-12-hrs	30 L x 22 W x 13 H cm	3.6 kg 4.5 kg with battery		Mask off, apnea, power failure, low battery, low/high pressure, device malfunction	
Puritan Bennett™ Smartair ST Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ② <i>Discontinued; serviced through May 2015</i>	Spontaneous, spontaneous/timed, CPAP pressure control	5-30 mbar	4-20 mbar CPAP: 5-25 mbar	4-40 BPM	5 inspiratory, 200 L/min	115-230 V, 50/60 mHz	No internal	200 x 125 x 290 mm	2.7 kg	<30 dB	Optional low pressure, mask leak	
SOMNOvent ST Weinmann GmbH & Co. KG www.weinmann.de ②	Spontaneous, timed, spontaneous/timed, CPAP	4-20 mbar	4-18 mbar	5-45 BPM	5 inspiratory 5 expiratory	115-230 V, 50/60 Hz	No internal External: 12 V, 24 converters	18 W x 9 H x 32 D cm	4 kg	26 dB	Mask leak, disconnect, apnea, low external battery, power failure	H, O
VENTImotion 2 Weinmann GmbH & Co. KG www.weinmann.de ②	Timed, timed/spontaneous, timed adaptive, CPAP	6-40 hPa	4-20 hPa	6-45 L/m	6 inspiratory 6 expiratory 285 L/m	115-230 V, 50/60 Hz	No internal External: VENTIpower, 7 hrs	230 W x 120 H x 280 D mm	3.7 kg	26 dB	Low minute ventilation, low/high pressure, apnea, disconnect, device malfunction, overheating, low/empty external battery, power failure	H, O

What is a bilevel positive airway pressure ventilator? (continued)

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Bilevel Positive Airway Pressure Ventilators (continued)	Mode	IPAP	EPAP/CPAP	Breath Rate	Trigger/Tidal Volume	AC Voltage	Battery	Dimensions	Weight	Noise	Alarms	Humidifier = H Oxygen = O
VPAP™ COPD ResMed www.resmed.com ③	Spontaneous, CPAP	4-30 cm H ₂ O	3-25 cm H ₂ O		5 trigger settings	100-240 V, 50/60 Hz	No internal External: 24 VDC	153 mm L x 172 mm W x 86 mm H	1.04 kg		Low SpO ₂ , low minute ventilation, apnea, high leak, non-vented mask, circuit occlusion/disconnect, malfunction, power failure	H, O
VPAP™ ST (S7) ResMed www.resmed.com ③ <i>Discontinued in USA & Canada</i>	Spontaneous, timed, spontaneous/timed, CPAP	4-25 cm H ₂ O	3-25 cm H ₂ O CPAP: 4-20 cm	5-30 BPM	Flow 5 inspiratory 5 expiratory	100-240 V, 50/60 Hz	No internal External: 24 VDC	112 L x 145 H x 164 W mm	1.3 kg	<26 dB	Mask off, leak	H
VPAP™ ST-A with ivAPS (S9) (intelligent Average Volume Assured Pressure Support) ResMed www.resmed.com ③ Pediatric use > 13 kg	Spontaneous, spontaneous/timed, CPAP, pressure assist control, intelligent volume-assured pressure support	3-30 cm H ₂ O	3-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5-50 BPM	5 trigger settings 5 inspiratory 5 expiratory	100-240 V, 50/60 Hz	No internal External: 24 VDC	153 mm L x 172 mm W x 86 mm H; 6" L x 6.8" W x 3.4" H	2.3 lbs, 1.045 kg	<26 dB	Power failure, block tube, tube disconnect, high leak, non-vented mask, low minute volume, apnea, low SpO ₂	H
VPAP™ III ST-A (S7) ResMed www.resmed.com ③ <i>Discontinued in USA & Canada</i>	Spontaneous, timed, spontaneous/timed, CPAP	3-30 cm H ₂ O	3-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5-30 BPM	Flow 3 inspiratory 3 expiratory	100-240 V, 50/60 Hz	No internal External: 24 VDC	270 L x 230 W x 141 mm H	2.3 kg		Power failure, over pressure, over use, mask alarm, low pressure, high pressure, low minute ventilation, non-vented mask	H
VPAP™ III ST-A with QuickNav (S7) ResMed www.resmed.com ②	Spontaneous, timed, spontaneous/timed, CPAP	2-30 cm H ₂ O	2-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5-30 BPM	3 sensitivity triggers; 50-3,000 mL	100-240 V, 50/60 Hz	ResMed Power Station up to 12 hrs	270 mm L x 230 mm W x 141 mm H	2.3 kg	<30 dB	Power failure, IPAP lower pressure, check tube, leak, non-vented, low minute ventilation, high pressure, low pressure	H
VPAP™ IV ST ResMed www.resmed.com ②	Spontaneous, timed, spontaneous/timed, CPAP	4-25 cm H ₂ O	2-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5-30 BPM	5 levels. 170 L/min max. flow	100-240 V, 50/60 Hz	No internal External: 24 VDC	112 mm L x 164 mm W x 145 mm H	1.3 kg	<28 dB	None	H, O

Consumer comments for bilevel positive airway pressure ventilators: *(continued)*

BiPAP Synchrony

"The BiPAP Synchrony works very well, and its size makes it easy to carry when you are traveling. However, it is not geared to mount on a wheelchair. It is noisy and draws a lot of energy. Even when you connect it to an external battery, the battery drains very quickly. It would be better if the water chamber were much simpler to handle. It needs to be an integrated part of the overall design." –*AJK, Canada*

"I use a BiPAP Synchrony with AVAPS. Good points: it is very small; it uses an external power supply that helps to keep the equipment cooler; easy maintenance. Bad points: it is a bit noisy; the turn-on switch should not be 'electronic' – it should be a normal open/close switch. Once turned on, it takes too long to send the first breath." –*MDPO, Brazil*

VPAP™ III ST

"I've been using VPAP™ III ST with built-in humidifier for more than a year. It replaced the Philips Respironics BiPAP Pro 'S' that I used for a year and a half.

"The BiPAP, though kind of noisy, is a dependable machine with a very nice filter. It served me well through my early recovery from the 10+ years of hypoventilation, but the need for the 'timed' feature became more and more evident. I still use it for traveling and for emergency use because, unlike the VPAP, it has a 12 V port built in.

"VPAP™ III ST advantages:

1. It is so quiet that I forget I'm hooked up.
2. I am fortunate to be able to set the machine myself. The smaller IPAP and EPAP increment of .2 (compared to .5 on the BiPAP) taught me that my polio-weakened diaphragm and intercostals are more sensitive to the pressure setting than I previously thought. Understanding the way the machine settings need to balance has helped me visualize my exact breathing needs and make corrections accordingly for a greater improved quality of life.
3. The built-in humidifier gives the unit a small footprint compared to my old setup which included a separate humidifier.

"VPAP™ III ST disadvantages:

1. The filter is much too small, it can't be washed, and a finer pollen filter could be added.
2. The lowest EPAP setting is 4. Since I don't have the classic mechanical obstructive problem I prefer 3 or even 2. The lower EPAP setting also makes it easier to start a breath, increasing the percentage of self-initiated breaths." –*RDVL, California*

What is a volume-cycled ventilator?

Volume-cycled ventilators deliver a preset volume of air in a constant flow during inspiration. Volume ventilators can deliver higher volumes and pressures than bilevel units; the volume remains constant despite interface leaks. The pressure limit can be adjusted by increasing the volume and lowering the high-pressure alarm. Volume-cycled ventilators can be used for breath stacking (adding one breath to another without exhaling) to enable deeper breaths for improved cough. They also have alarms and internal batteries, but they are larger, heavier and more expensive than bilevel units, although some use less electricity to operate. If an individual needs 24-hour ventilation, a volume ventilator is recommended because it is approved by the FDA for this purpose and has the necessary safety features.

Mode Definitions:

Control: Delivers only controlled breaths at specified tidal volume and prescribed respiratory rate. Ventilator is triggered by pre-set machine rate, and the individual cannot take any spontaneous breaths.

Assist/Control: Allows individual to initiate/trigger a machine-assisted breath and to take additional breaths at prescribed tidal volume.

SIMV (Synchronized Intermittent Mandatory Ventilation): Prescribed tidal volume and respiratory rate but individual can breathe spontaneously in between delivered breaths.

PEEP (Positive End Expiratory Pressure): Airway pressure is maintained at the end of the ventilator breaths to increase volume of air remaining in the lungs at the end of expiration.

IPPB (Intermittent Positive Pressure Breathing): Intermittent delivery of deep insufflations.

Sigh: Provides an increased amount of volume at intervals to simulate a normal sigh breath.

The following equipment specifications are for volume-cycled ventilators currently on the markets. There is no "standard" form for specifications. American and European manufacturers differ in the technical information that they provide about their products. Alarms must be a certain volume. Minimum and maximum alarm volume is regulated.

What is a volume-cycled ventilator? (continued)

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Volume-cycled Ventilators	Mode	Tidal Volume	Inspiratory Flow Rate	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
LTV®800 CareFusion www.carefusion.com ❸ Pediatric use > 5 kg <i>Discontinued; serviced through October 2016</i>	Spontaneous, control, assist/control, SIMV	50-2000 ml	10-100 LPM	0-80 BPM	0-20 cm H ₂ O	Pressure	90-250 V, 47/63 Hz	Internal, 1 hr External: 3 hrs, 4 hrs, 9 hrs Automobile cigarette lighter adapter	3" H x 10" W x 12" D	12.85 lbs	Low/high pressure, empty/low battery, low minute ventilation, apnea, power failure, malfunction, disconnect	H, O
LTV®1100 CareFusion www.carefusion.com ❸ Pediatric use > 5 kg	Volume; controlled, assist/controlled, SIMV; Pressure support: S, T, ST; CPAP	50-2000 ml	10-100 LPM	0-80 BPM	0-20 cm H ₂ O; Internal	Flow-Off; 1-9 lpm	100-250 V, 50/60 Hz	Internal, up to 1 hr External: 11-15 VDC; SpringPack up to 6 hrs Automobile cigarette lighter adapter	10.5" W x 13.5" D x 3.25" H; 27 cm W x 38 cm D x 8.4 cm H	14.5 lbs, 6.5 kg	High pressure limit, high breath rate, low peak pressure, low minute volume, high/low PEEP, high/low O inlet pressure, apnea, disconnect, low/empty internal battery, malfunction, power failure	O
PLV®-100 Philips Respironics www.healthcare.philips.com/main/homehealth ❸ <i>Discontinued; serviced through 2014</i>	Control, assist/control, SIMV	0.05-3.00 L ± 10%	10-120 LPM	2-35 BPM ± 5; 36-40 ± 2			120 V, 50/60 Hz, 220-240 V, 50/60 Hz	Internal, 1 hr External: 12 V	9" H x 12.25" W x 12.25" D	28.2 lbs	Low/high pressure, apnea, low battery, power failure, malfunction	H

What is a volume-cycled ventilator? (continued)

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Volume-cycled Ventilators	Mode	Tidal Volume	Inspiratory Flow Rate	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
PLV®-102 Philips Respironics www.healthcare.philips.com/main/homehealth ③ <i>Discontinued; serviced through 2014</i>	Control, control + sigh, assist/control, assist/control + sigh, SIMV	0.05-0.20 ± 0.02 L; 0.20-3.00 L ± 10%	10-120 LPM	2-35 BPM ± 0.5; 36-40 ± 2	0-20 cm H ₂ O		120 V, 50/60 Hz, 220-240 V, 50/60 Hz	Internal, 1 hr External: 12 V	9" H x 12.25" W x 12.25" D	28.9 lbs	Low/high pressure, apnea, low battery, power failure, malfunction	H, O
PLV®-102b Philips Respironics www.healthcare.philips.com/main/homehealth ③ <i>Discontinued; serviced through 2014</i>	Control, control + sigh, assist/control, assist/control + sigh, SIMV	0.05-0.20 ± 0.02 L; 0.20-3.00 L ± 10%	10-120 LPM	2-35 BPM ± 0.5; 36-40 ± 2	0-20 cm H ₂ O		120 V, 50/60 Hz, 220-240 V, 50/60 Hz	Internal, 1 hr External: 12 V	9" H x 12.25" W x 12.25" D	28.9 lbs	Low/high pressure, apnea, low battery, power failure, malfunction	H
UniVent™ Eagle™ 754 ZOLL Medical Corporation www.zoll.com ③	Assist/control, SIMV, CPAP	0-3000 ml		1-150 BPM	1-20 cm H ₂ O	Flow	90-265 V, 47/440 Hz	Internal, 3 hrs max External: 11-15 V	8.87" x 11.5" x 4.5" D	13 lbs	Low/high pressure, low battery, malfunction, disconnect, power failure, tidal volume	O

CONSUMER COMMENTS FOR VOLUME-CYCLED VENTILATORS:

LTV®800

"The LTV®800 is easy to carry anywhere – lightweight, reasonably small and durable. I can hold it on my lap during airplane flights.

"During the day when I use mouth intermittent positive pressure with a mouthpiece. I did not need or want to use the long, multi-tubed circuits that came with the LTV®800 so I substituted simple ones (that I used with another volume ventilator). However, I now require PEEP for sleeping, and I use Pulmonetic's circuit with PEEP valve with my custom-made face mask. My husband changes the night circuit monthly and cleans/disinfects the day circuit weekly.

"The LTV®800 sits on the car's front seat beside me as I drive. It is simple to hook up to the cigarette lighter or the small battery pack. My husband thinks there's sometimes an annoying whistle to the vent when it's in the car but I'm not bothered by the sound, although it does vary more than when it is hooked to AC.

"At first, the on/off and reset buttons were very difficult for me to use because I have little push-down power in my fingers. I put little pads on the buttons to raise them just enough to provide an area my fingers can push down on. The filters are washable and easy to reach. The Pulmonetic people have been very accessible when I needed help or had questions. There are many bells and whistles to this vent that I still have not fully explored. I miss the deep breath sigh that the Bear 33 delivered to me for 15 years." –JG, Kansas

"I have owned an LTV®800 for about five years. The manufacturer (Pulmonetic Systems, Inc.) has a policy of dealing only through home health care companies, and they deal only in rentals. Therefore I cannot get maintenance and repair service for it through the manufacturer. Its relatively small size and dual voltage makes it good for travel. It is noisier than my PLV®-100 and has a smaller limit of volume delivery." –AF, Virginia

What is a pressure support ventilator? What is pressure control?

Pressure support ventilators supplement the inspiratory effort of individuals who can breathe spontaneously by providing a preset amount of positive airway pressure throughout the complete inspiration. The tidal volume can vary from breath to breath. Pressure control means that the ventilator, rather than the individual, controls the breathing rate. Pressure control maintains a preset inspiratory pressure.

The following equipment specifications are for pressure support ventilators currently on the markets. There is no "standard" form for specifications. American and European manufacturers differ in the technical information that they provide about their products. Alarms must be a certain volume. Minimum and maximum alarm volume is regulated.

KEY: ❶ = available only in USA ❷ = available only outside USA ❸ = available worldwide

Pressure Support Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	IPAP, EPAP, PIP, PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Falco 101 Siare Engineering International Group, S.r.l. www.siare.it ❷ Pediatric use >5 kg	CPAP, bilevel-S, bilevel-ST, pressure support (PSV), pressure assist/control (PCV, APCV), pressure support ventilation with guaranteed tidal volume (PSTv), Volumetric option available	50-2500 ml	6-40 cm H ₂ O	5-50 BPM	EPAP/PEEP: 0-20 cm H ₂ O IPAP: 6-40 cm H ₂ O	1-9 l/min inspiratory; 20-50% expiratory	100-240 V, 50/60 Hz	Internal: up to 4 hrs External: up to 10 hrs, 12V	210 mm H x 240 mm W x 330 mm D	3.9 kg	High/low pressure, high/low rate, high/low insp. tidal volume, overheating, malfunction, apnea, power failure, low battery, batter disconnect	H, O
iVent™ 101 Performance GE Healthcare www.gehealthcare.com/respiratorycare ❸ Pediatric use	CPAP, PSV pressure support, Adaptive Bi-Level™, A/C assist/control in VCV volume-controlled or PCV pressure-controlled	40-2500 ml	3-60 cm H ₂ O	1-80 BPM	PEEP: 0-45 cm H ₂ O	Flow and pressure 9 levels	100-240 VAC, 50/60 Hz	Internal: up to 4 or 6 hrs External: 24-28 VDC up to 10 hrs	7.5" H x 10" W x 10" D; 19 cm H x 25.5 cm W x 25.3 cm D	13.4 lbs; 6.1 kg	Low/high respiratory rate; apnea; low/high minute volume; low/high FiO ₂ ; low/high pressure; leak/occlusion; set pressure or Vt not delivered; low O ₂ pressure; disconnect; overheat; low/empty battery; battery charge; AC disconnect; battery failure; remote; power failure	O
Multilevel VP Dima Italia S.r.l. www.dimaitalia.com ❷ Pediatric use	Control, Assist/control, pressure control, pressure	10 cc - 2500 cc		5-99 BPM	IPAP: 3-60 cm H ₂ O EPAP: 0-15 cm H ₂ O PEEP	Inspiratory; expiratory	110-240 V, 50/60 Hz 80 VA	Internal: 12 V, 1-1/2 hrs External	16 x 30 x 22 cm	3.5 kg	Low/high inspiratory pressure, high expiratory pressure, apnea, low battery, power failure	H, O
Nippy 3+ B & D Electromedical, now part of BREAS www.nippyventilator.com ❷	Pressure control, pressure support, IPPV, CPAP		0-30 cm H ₂ O	6-60 BPM			100-240 VAC, 50/60 Hz	No internal External: 24 V, 2- & 8-hr portable, 4- & 8-hr backup	297 L x 223 W x 132 H mm	3.5 kg	Low/high pressure, flat/low battery, disconnect, power failure	

What is a pressure support ventilator? (continued)

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Pressure Support Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	IPAP, EPAP, PIP, PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Nippy Junior+ B & D Electromedical, now part of BREAS www.nippyventilator.com ② Pediatric use	CPAP, Pressure Support (PS), Pressure Control (PC), IPPV			6-60 BPM	IPAP: 3-30 cm H ₂ O EPAP: 3-20 cm H ₂ O	Inspiratory: 1-10 Expiratory (PS only): 1-10	100-240 VAC	Internal: 4-12 hours autonomy dependent on settings and leak, 18.75 Vdc 116 Whr External: 4-12 hours autonomy dependent on settings and leak, 18.75 Vdc 116 Whr	297 L x 223 W x 132 H mm	4.5 kg	Mask off, power failure, low flow, high flow	
Puritan Bennett™ Smartair Plus Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ② <i>Discontinued; serviced through May 2015</i>	Pressure control, pressure support, volume control, spontaneous, spontaneous/timed, CPAP	100-1250 ml	0-30 mbar	4-40 BPM in ST; 5-60 BPM in PC and AC	IPAP: 5-30 mbar EPAP: 0-20 mbar	Inspiratory: 1-5 Expiratory: -5 to -75%	115-230 V, 50/60 Hz	Internal, 2-5 hrs External: 24 V	200 x 125 x 290 mm	3.2 kg	Low/high pressure, low/high tidal volume, maximum rate, apnea, disconnect	O
Puritan Bennett™ 520 Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ② Pediatric use >5 kg	CPAP, pressure support, pressure assist/control	50-2000 ml	5-55 mbar	1-60 BPM	PIP & PEEP: 0-99 mbar	Inspiratory: 1-5 Expiratory: 5-95%	100-240 V, 50/60 Hz	Internal, <5 hrs External: 12-30 VDC Car adapter	23.5 cm W x 31.5 cm D x 15.4 cm H	4.5 kg	Apnea, high/low inspiratory tidal volume, high/low pressure, high breath rate, high/low battery temperature, leak/occlusion/patient disconnect, low/empty battery, unit overheat/malfunction, remote call, power failure	H, O
PV 403 PEEP BREAS Medical AB www.breas.com ② Pediatric use	Pressure support, pressure control, volume control	0.3-1.6 L	6-50 mbar	4-40 BPM	Optional: 0-10 cm mbar	Inspiratory; expiratory	100-240 V, 50/60 Hz	Internal, up to 15 hrs External: 12-24 V, 8-10 hrs	35 W x 18 H x 26 D cm	5.5 kg	Low/high pressure, leak, low battery, power failure, malfunction, low tidal volume	

What is a pressure support ventilator? *(continued)*

KEY: ❶ = available only in USA ❷ = available only outside USA ❸ = available worldwide

Pressure Support Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	IPAP, EPAP, PIP, PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Stellar™ 100 ResMed www.resmed.com www.stellar100.com ❸ Pediatric use >13 kg, 2 years old	CPAP, S spontaneous, T timed, S/T spontaneous timed; pressure assist control	Maximum flow >200 L/min at 20 cm H ₂ O		5-60 BPM	IPAP: 2-40 cm H ₂ O EPAP: 2-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5 settings	100-240 V, 50/60 Hz	Internal, up to 2 hrs External: 24 VDC or ResMed Power Station II up to 8 hrs	230 mm L x 170 mm W x 120 mm H	2.1 kg	Apnea, high/low pressure, high/low respiratory rate, low minute ventilation, high leak, occlusion, circuit disconnect, non-vented mask, high/low FiO ₂ , low SpO ₂ , empty internal battery, external battery switchover, unit overheat/ malfunction, power failure	H4i™, O
Stellar™ 150 ResMed www.resmed.com www.stellar150.com ❸ Pediatric use >13 kg, 2 years old	CPAP, S spontaneous, T timed, S/T spontaneous timed; pressure assist control, iVAPS (intelligent volume assured pressure support)	Maximum flow >200 L/min at 20 cm H ₂ O	2-4 cm H ₂ O Targets minute ventilation	5-60 BPM	IPAP: 2-40 cm H ₂ O EPAP: 2-25 cm H ₂ O CPAP: 4-20 cm H ₂ O	5 settings	100-240 V, 50/60 Hz	Internal, up to 2 hrs External: 24 VDC or ResMed Power Station II up to 8 hrs	230 mm L x 170 mm W x 120 mm H	2.1 kg	Apnea, high/low pressure, high/low respiratory rate, low minute ventilation, high leak, occlusion, circuit disconnect, non-vented mask, high/low FiO ₂ , low SpO ₂ , empty internal battery, external battery switchover, unit overheat/ malfunction, power failure	H4i™, O

What is a pressure support ventilator? *(continued)*

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Pressure Support Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	IPAP, EPAP, PIP, PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Vivo® 30 BREAS Medical AB www.breas.com ③	Pressure support, pressure control, CPAP			4-40 BPM	IPAP: 4-30 cm H ₂ O EPAP: 2-20 cm H ₂ O	Inspiratory 1-9; Expiratory 1-9	100-240 V	External: 12/24 V DC	185 mm W x 230 mm H x 227 mm D	3.3 kg	Low/high pressure, low volume, low/high leakage, low external & internal battery, low power, internal function failure	H
Vivo® 40 BREAS Medical AB www.breas.com ③ Pediatric use	Pressure support, pressure control, CPAP, target volume	200-1500 ml		4-40 BPM	IPAP: 4-40 cm H ₂ O EPAP: 2-20 cm H ₂ O	Inspiratory 1-9; Expiratory 1-9	100-240 V	Internal: 3.8 Ah capacity External: 12.5/24 V DC	185 mm W x 240 mm H x 227 mm D	4 kg (with internal battery and humidifier)	Low/high pressure, low volume, low/high breath rate, low/high leakage, low external & internal battery, low power, internal function failure	H
VS Integra™ ResMed www.resmed.com ② Pediatric use	Pressure control, pressure support, spontaneous, spontaneous/timed	50-2500 ml	5-50 hPa	5-50 BPM adult; 5-60 BPM pediatric	IPAP: 5-50 cm H ₂ O EPAP: 4-20 cm H ₂ O	Flow; pressure	100-230 V, 110-230 V	Internal, up to 4 hrs External, up to 8 hrs	135 x 285 x 204 mm	2.6 kg without internal battery	Minimum/maximum tidal volume, power supply, low/empty battery, low/high pressure, disconnect	O

What is a combination or multi-mode ventilator?

The current generation of ventilators can provide many modes of ventilation: pressure support, pressure control, volume control, bilevel pressure or CPAP.

The following equipment specifications are for combination ventilators currently on the markets. There is no “standard” form for specifications. American and European manufacturers differ in the technical information that they provide about their products. Alarms must be a certain volume. Minimum and maximum alarm volume is regulated.

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger/Circuits	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Astral 100 ResMed www.resmed.com ③ Life Support for patients >5 kg	Volume and pressure; Valve circuit: CPAP, ACV, PACV, P-SIMV, V-SIMV, PS Leak circuit therapy: CPAP, ST, PAC 2 preset programs	100-2500 ml, adult 50-300 ml, pediatric	2-50 cm H ₂ O, leak circuit 0-50 cm of H ₂ O, valve circuit	Off, 2-50 BPM, adult Off, 5-80 BPM, pediatric	Off, 0-20 cm H ₂ O	Single circuit with leak (Vsync) Single circuit with valve (NIV+) TiControl™ Adjustable trigger and cycle	AC 100-240V, 50-60Hz, 90 W 3.75 A continuous, 120 W / 5A peak 115V/400 Hz	Internal: Lithium-Ion battery, 14.4 V, 6.6 Ah, 95 Wh. 8 hr run time, rechargeable External: Two external (8 hr each) batteries, rechargeable	285 mm x 215 mm x 93 mm	3.2 kg	Numerous, including Low-battery, Total power failure, Low/High Pressure, Obstruction, Low/high Resp rate, High leak, Low/High SpO ₂ , Low/High FIO ₂ , Ventilation not started/stopped, Circuit fault, Low/High PEEP, Pressure line disconnected	H, O
Astral 150 ResMed www.resmed.com ③ Life Support for patients >5 kg	Volume and pressure Valve circuit: CPAP, ACV, PACV, P-SIMV, V-SIMV, PS Leak circuit therapy: CPAP, ST, PAC Manual breath Sigh breath (recruitment) 4 preset programs	100-2500 ml, adult 50-300 ml, pediatric	2-50 cm H ₂ O, leak circuit 0-50 cm of H ₂ O, valve circuit	Off, 2-50 BPM, adult Off, 5-80 BPM, pediatric	Off, 0-20 cm H ₂ O	Single circuit with leak Single circuit with valve Double circuit	AC 100-240V, 50-60Hz, 90 W 3.75 A continuous, 120 W / 5A peak 115V/400 Hz	Internal: Lithium-Ion battery, 14.4 V, 6.6 Ah, 95 Wh. 8 hr run time, rechargeable External: Two external (8 hr each) batteries, rechargeable	285 mm x 215 mm x 93 mm	3.2 kg	Numerous, including Low-battery, Total power failure, Low/High Pressure, Obstruction, Low/high Resp rate, High leak, Low/High SpO ₂ , Low/High FIO ₂ , Ventilation not started/stopped, Circuit fault, Low/High PEEP, Pressure line disconnected	H, O

What is a combination or multi-mode ventilator? *(continued)*

KEY: ❶ = available only in USA ❷ = available only outside USA ❸ = available worldwide

Combination or Multi-Mode Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger/Circuits	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
ATHENA Dima Italia S.r.l. www.dimaitalia.com ❷ Pediatric use	Volume: controlled, assist/controlled, SIMV; Pressure: controlled, assist/control, SIMV, support -S, T, ST; CPAP	10 cc-2500 cc	3-60 cm H ₂ O	5-60 BPM	0-25 cm H ₂ O	9 inspiratory and Auto Track; 10-90% expiratory	100-240 V, 50/60 Hz	Internal, up to 12 hrs Rechargeable	240 mm W x 290 mm D x 180 mm H	3.5 kg	High/low inspiratory, high expiratory pressure, high/low breath rate, minimum volume guarantee, low expiratory volume, high/low FiO ₂ , high/low SpO ₂ , high/low pulse rate, low battery, power failure	O
Elisée 150™ ResMed www.resmed.com ❷ Pediatric use	Assist/control in volume, assist pressure control, SIMV, IPPV, pressure support with backup, pressure support with tidal volume	50-500 ml, pediatric 300-2500 ml, adult	3-40 cm H ₂ O, pediatric 5-60 cm H ₂ O, adult	2-80 BPM, pediatric 2-50 BPM, adult	0-20 cm H ₂ O, pediatric 0-25 cm, adult	Inspiratory/Flow and pressure Expiratory/Flow	110-230 V, 50/60 Hz	Internal, up to 14 hrs External: 12-28 V, 20 hrs	260 x 240 x 130 mm	4-4.8 kg dependent on internal battery option	Low/empty battery, low/high pressure both insp. & exp., low/high tidal volume both insp & exp., low/high minute ventilation both insp & exp., leaks, malfunction, power failure	O
Falco 202 Siare Engineering International Group, S.r.l. www.siare.it ❷ Pediatric use >5 kg	Pressure; spontaneous, spontaneous/timed, CPAP; pressure control - assist control; pressure support with guaranteed tidal volume; volume: assist control, SIMV	50-2500 ml	6-60 cm H ₂ O	5-50 BPM	PEEP: 0-20 cm H ₂ O	1-9 l/min inspiratory; 5-90% expiratory	100-240 V, 50/60 Hz	Internal: NiMH up to 2.5 hrs External: NiMH up to 10 hrs	240 L x 330 D x 210 mm	3.9 kg	Low/high pressure; low/high rate; low/high inspired tidal volume; apnea; overheating; malfunction; low internal battery; battery disconnect; power failure	O
Flight 60® Flight Medical Innovations, Ltd. www.flight-medical.com ❸ Distributed in USA by Martab Medical, www.martab.com , and SRC Medical, www.src-medical.com Pediatric use	Volume control, assist/control, SIMV, pressure control, pressure support, spontaneous, CPAP/BiPAP, target tidal volume	30-2,200 ml	0-60 cm H ₂ O	1-99 BPM	3-30 cm H ₂ O	Pressure - 9.9 to -0.1 cm H ₂ O, Flow 1-10 LPM	100-240 V, 50/60 Hz	Internal: up to 12 hrs, rechargeable External: 12-30 VDC	29 cm W x 28 cm D x 25 cm H	6.3 kg	High/low pressure, high/low minute ventilation, high/low FiO ₂ , apnea, low/empty battery, power failure, high respiratory rate, low tidal volume	O

What is a combination or multi-mode ventilator? *(continued)*

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators <i>(continued)</i>	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP/CPAP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
iVent 101™ Expert GE Healthcare www.gehealthcare.com/respiratorycare ③ Pediatric use	CPAP, PSV pressure support, Adaptive Bi-Level™, A/C assist/control in VCV volume-controlled or PCV pressure-controlled or PRVC pressure regulated volume control; SIMV in VCV, PCV, or PRVC	40-2,500 ml	3-60 cm H ₂ O	1-80 BPM	0-45 cm H ₂ O	Flow and pressure 9 levels	100-240 VAC, 50/60 Hz	Internal, up to 4 or 6 hrs External: 24-28 VDC up to 10 hrs	7.5" H x 10" W x 10" D; 19 cm H x 25.5 cm W x 25.3 cm D	13.4 lbs; 6.1 kg	Low/high respiratory rate; apnea; low/high minute volume; low/high FiO ₂ ; low/high pressure; leak/occlusion; set pressure or Vt not delivered; low O ₂ pressure; disconnect; overheat; low/empty battery; battery charge; AC disconnect; battery failure; remote;	O
iVent 101™ Signature GE Healthcare www.gehealthcare.com/respiratorycare ③ Pediatric use	CPAP, PSV pressure support, Adaptive Bi-Level™, A/C assist/control in VCV volume-controlled or PCV pressure-controlled; SIMV in VCV, PCV	40-2,500 ml	3-60 cm H ₂ O	1-80 BPM	0-45 cm H ₂ O	Flow and pressure 9 levels	100-240 VAC, 50/60 Hz	Internal, up to 4 or 6 hrs External: 24-28 VDC up to 10 hrs	7.5" H x 10" W x 10" D; 19 cm H x 25.5 cm W x 25.3 cm D	13.4 lbs; 6.1 kg	Low/high respiratory rate; apnea; low/high minute volume; low/high FiO ₂ ; low/high pressure; leak/occlusion; set pressure or Vt not delivered; low O ₂ pressure; disconnect; overheat; low/empty battery; battery charge; AC disconnect; battery failure; remote; power failure	O
iVent 201™ VersaMed/GE Healthcare www.gehealthcare.com/respiratorycare ③	CPAP, PSV pressure support, Adaptive Bi-Level™, A/C assist/control in VCV volume-controlled or PCV pressure-controlled or PRVC pressure regulated volume control; SIMV in VCV, PCV or PRVC	50-2000 ml	0-60 cm H ₂ O 5-80 cm H ₂ O	1-50 BPM	0-20 cm H ₂ O	Flow Off; 1-20 L/min; Pressure Off -0.5 to 20 cm H ₂ O	100-240 V, 50/60 Hz	Internal, up to 2 hrs External: 12-15 VDC up to 4 hrs	13" H x 9.5" W x 10.3" D, 33 cm H x 24 cm W x 26 cm D	With battery: 22 lbs, 10 kg Without battery: 15.4 lbs, 7 kg	Low/high pressure, low battery, leak, power failure, malfunction, disconnect, low minute ventilation	O

What is a combination or multi-mode ventilator? (continued)

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
LTV®900 CareFusion www.carefusion.com ③ Pediatric use > 5 kg <i>Discontinued; serviced through October 2016</i>	Volume control, pressure support, control, assist/control, SIMV, Spontaneous, CPAP	50-2000 ml	Pressure support; 0-60 cm H ₂ O	0-80 BPM	0-20 cm H ₂ O	Flow	90-250 V, 47/63 Hz	Internal, 1 hr External: 11-15 V, 3 hrs, 4 hrs, 9 hrs, automobile cigarette lighter adapter	3" H x 10" W x 12" D	13.4 lbs	Low/high pressure, low/empty battery, power failure, malfunction, low minute ventilation, apnea, disconnect	H, O
LTV®950 CareFusion www.carefusion.com ③ Pediatric use > 5 kg <i>Discontinued; serviced through December 2016</i>	Volume control, pressure control, pressure support, control, assist/control, SIMV, spontaneous, CPAP	50-2000 ml	Pressure control 1-99 cm H ₂ O; Pressure support 0-60 cm H ₂ O	0-80 BPM	0-20 cm H ₂ O	Flow	90-250 V, 47/63 Hz	Internal, 1 hr External: 11-15 V, 3 hrs, 4 hrs, 9 hrs, automobile cigarette lighter adapter	3" H x 10" w x 12" D	13.4 lbs	Low/high pressure, low/empty battery, power failure, malfunction, low minute ventilation, apnea, disconnect	H, O
LTV®1000 CareFusion www.carefusion.com ③ Pediatric use > 5 kg <i>See Consumer Comments at end of specifications</i>	Volume control, pressure control, pressure support, control, assist/control, SIMV, CPAP	50-2000 ml	Pressure control 1-99 cm H ₂ O; Pressure support 0-60 cm H ₂ O	0-80 BPM	0-20 cm H ₂ O	Flow	90-250 V, 47/63 Hz	Internal, 1 hr External: 11-15 V, 3 hrs, 9 hrs, automobile cigarette lighter adapter	3" H x 10" W x 12" D	13.4 lbs	Low/high pressure, low/empty battery, power failure, malfunction, low minute ventilation, apnea, disconnect	H, O
LTV®1150 CareFusion www.carefusion.com ③ Pediatric use > 5 kg	Volume control, pressure control, pressure support, control, assist/control, SIMV, CPAP, spontaneous breathing trial	50-2000 ml	Pressure control 1-99 cm H ₂ O; Pressure support 0-60 cm H ₂ O	0-80 BPM	0-20 cm H ₂ O; Internal	Flow	100-250 V, 50/60 Hz	Internal, 1 hr External: 11-15 V, 3 hrs, 9 hrs, automobile cigarette lighter adapter	3" H x 10" W x 12" D	13.4 lbs	Low/high pressure, low/empty battery, power failure, malfunction, low minute ventilation, apnea, disconnect	H, O

What is a combination or multi-mode ventilator? *(continued)*

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators <i>(continued)</i>	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP/ CPAP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Monnal T50 Air Liquide Medical Systems, Inc. www.airliquidemedicalsystems.com ② Pediatric use	PSV pressure support and SIMV; (A)CMV assisted controlled and SIMV; (A) PCV assisted pressure controlled and SIMV	Adult: 100-2000 mL; Child 50-500 mL	5-50 cm H ₂ O	Adult: 5-40 BPM Child: 5-60 BMP	0-20 cm H ₂ O	Inspiratory off, then 0.5-10 L/min; Expiratory 10-90%	100-240 VAC, 50/60 Hz	Internal: Up to 6 hrs External: Up to 18 hrs	33 cm x 25 cm x 18 cm	5.3 kg	N/A	O
Newport™ HT50 Newport Medical Instruments, Inc. Division of Covidien RMS www.ventilators.com ③ Pediatric use > 10 kg <i>See Consumer Comments at end of specifications</i>	Volume control, A/CMV & SIMV w/or w/o pressure support, pressure control A/CMV & SIMV w/or w/o pressure support. Spontaneous (CPAP) w/ or w/o pressure support. Backup ventilation in all modes (responds to low-minute volume alarm)	100-2,200 ml (in Volume Control)	Pressure control; 5-60 cm H ₂ O, Volume control; 0-100 cm H ₂ O	1-99 BPM	0-30 cm H ₂ O (leak compensated)	9.9-0 cmH ₂ O relative to built-in PEEP/ CPAP	110-240 V, 50/60/400 Hz	Internal, up to 10 hrs, charges to 80% charge in 5-7 hrs from either AC or DC (12-24 V battery). Newport Supplemental Power Pack (24 V): Adds 50% more use time to internal battery. External battery: 12-30 V with auto-mobile cable	10.63" W x 7.87" D x 10.24" H	15 lbs	High/low pressure, high/low minute volume, high/low PEEP, circuit occlusion, apnea, press control level not reached, check prox line, battery low, battery empty, power switchcover, device alert, shut down alert	H, O
Newport™ HT70 Newport Medical Instruments Division of Covidien RMS www.ventilators.com ③ Pediatric use > 5 kg	Volume and pressure: A/C MV; SIMV; pressure support; pressure control; spontaneous	50-2,200 ml	Pressure control: 5-60 cm H ₂ O Pressure support: 0-60 cm H ₂ O	1-99 BPM	0-30 cm H ₂ O	Flow: 6-100 L/min Pressure trigger sensitivity	100-240 V, 50/60/400 Hz	Internal, up to 10 hrs; backup battery 30 minutes External battery: 12-24 VDC	9.75" W x 11" D x 10.25" H; 24.74 cm W x 27.94 cm D x 26.04 cm H	15.4 lbs, <7 g	High/low baseline and airway pressure, high/low inspiratory minute volume, high respiratory rate; apnea; high/low FiO ₂ ; device malfunction; low battery	H, O
Newport™ HT70 Plus Newport Medical Instruments Division of Covidien RMS www.ventilators.com ③ Pediatric use > 5 kg	Volume and pressure: A/C MV; SIMV; pressure support; pressure control; spontaneous	50-2,200 ml	Pressure control: 5-60 cm H ₂ O Pressure support: 0-60 cm H ₂ O	1-99 BPM	0-30 cm H ₂ O	Flow: 6-100 L/min Pressure trigger sensitivity	100-240 V, 50/60/400 Hz	Internal, up to 10 hrs; backup battery 30 minutes External battery: 12-24 VDC	9.75" W x 11" D x 10.25" H; 24.74 cm W x 27.94 cm D x 26.04 cm H	15.4 lbs, <7 g	High/low baseline and airway pressure, high/low inspiratory minute volume, high respiratory rate; apnea; high/low FiO ₂ ; device malfunction; low battery, high/low inspiratory minute ventilation, low O ₂ , high tidal volume, airway flow sensor disconnect	H, O

What is a combination or multi-mode ventilator? *(continued)*

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators <i>(continued)</i>	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger/Circuits	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Puritan Bennett™ Achieva® Portable Ventilator Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ③ <i>Discontinued; serviced through September 2015</i>	Volume control, pressure support, pressure control, control, assist/control, SIMV	50-2200 ml	0-50 cm H ₂ O	1-80 BPM	0 and 3-20 cm H ₂ O	Inspiratory/Flow and pressure	100-240 V, 50/60 Hz	Internal, at least 4 hrs under normal load; backup use only External: 24 V, approx 20 hrs under	10.75" H x 13.30" W x 15.60" D	31 lbs	Low/high pressure, low battery, power failure, malfunction, setting error, power switchover O ₂ failure (PSO ₂)	H, O
Puritan Bennett™ Legendair Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ② Pediatric use > 5 kg <i>Discontinued; serviced through May 2015</i>	Pressure control, pressure support with and without tidal volume, volume control, SIMV	100-1400 ml	Insp: 5-40 mbar Exp: 0-20 mbar	6-60 BPM		5 inspiratory	115-230 V, 50/60 Hz	Internal, up to 10 hrs External: 24 V	230 x 305 x 150 mm	4.5 kg	Low/high pressure, low battery, power failure, malfunction, low minute ventilation, disconnect	O
Puritan Bennett™ 540 Ventilator Puritan Bennett Division of Covidien RMS www.covidien.com/PB540 ① Pediatric use >5 kg	CPAP, pressure support, pressure assist/control, volume assist/control, volume SIMV, pressure SIMV	50-2000 ml	5-55 cm H ₂ O	1-60 BPM	0-20 cm H ₂ O	5 inspiratory	100-240 V, 50/60 Hz	Internal: up to 11 hrs External: 12-30 V	6" H x 9.25" W x 12.4" D	9.9 lb	Apnea, circuit occlusion, internal battery malfunction/failure, device malfunction, high/low pressure, high/low VTE, high/low minute ventilation, high device temperature, low/empty internal battery, power disconnect/failure	O
Puritan Bennett™ 560 Ventilator Puritan Bennett Division of Covidien RMS www.covidien.com/RMS ② Pediatric use > 5 kg	CPAP assist/control, SIMV, volume control, pressure support	50-2000 ml	5-55 cm H ₂ O	1-60 BPM	0-20 cm H ₂ O	5 inspiratory, 5-95% expiratory	100-240 V, 50/60 Hz	Internal: up to 11 hrs External: 12-30 VDC Car adapter	23.5 cm W x 31.5 cm D x 15.4 cm H	4.5 kg	Apnea, high/low inspiratory tidal volume, high/low expiratory tidal volume, high/low pressure, high breath rate, high/low battery temperature, high leak/occlusion/patient disconnect, valve detection error, high/low FiO ₂ , low/empty battery, unit overheat/malfunction, remote call, power failure	H, O

What is a combination or multi-mode ventilator? (continued)

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators (continued)	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Trilogy100 Philips Respironics http://trilogy100.respironics.com ① Pediatric use >5 kg <i>See Consumer Comments at end of specifications</i>	CPAP, bilevel S, S/T, T; volume assist/control, volume control, SIMV with pressure support, pressure control SIMV, AVAPS, AVAPS-AE	50-2000 ml	IPAP: 4-50 cm H ₂ O EPAP: 0-25 cm H ₂ O active circuit; 4-25 cm H ₂ O passive circuit; CPAP: 4-20 cm H ₂ O, Pressure differential: 0-40 cm H ₂ O	0-60 BPM in AC mode; 1-60 in all other modes	0-25 cm H ₂ O active circuit; 4-25 cm H ₂ O passive circuit	Flow trigger sensitivity; Digital Auto-Trak; Passive circuit with exhalation port; active circuit with exhalation valve with proximal pressure, "Kiss"	100-240 VAC, 50/60 Hz	Internal: up to 3 hrs Detachable external: up to 3 hrs Vehicle cable adapter External: 12 VDC	6.6" L x 11.2" W x 9.3" H	11 lb	Circuit disconnect, apnea, low internal battery, high/low tidal volume, high/low minute ventilation, high/low respiratory rate, remote capability, high/low inspiratory pressure, high/low expiratory pressure, power failure, device malfunction	H, O
Trilogy200 Trilogy202 (integrated O ₂ blender) Philips Respironics http://trilogy200.respironics.com ① Pediatric use >5 kg <i>See Consumer Comments at end of specifications</i>	CPAP, bilevel S, S/T, T; pressure control with SIMV; volume assist/control; volume control; volume SIMV with pressure support, AVAPS, AVAPS-AE	50-2000 ml	IPAP: 4-50 cm H ₂ O EPAP: 0-25 cm H ₂ O active circuit; 4-25 cm H ₂ O passive circuit; CPAP: 4-20 cm H ₂ O Pressure differential: 0-40 cm H ₂ O	0-60 BPM in AC mode; 1-60 in all other modes	0-25 cm H ₂ O active circuit; 4-25 cm H ₂ O passive circuit	Flow trigger; proximal flow trigger; Digital Auto-Trak; Passive circuit with exhalation port; active circuit with exhalation valve and proximal sensor, "Kiss"	100-240 VAC, 50/60 Hz	Internal: up to 3 hrs Detachable battery backup to 3 hrs External 12 VD; Vehical cable adapter	6.6" x 11.2" x 9.3"; 16.68 cm x 28.45 cm x 23.52 cm	11 lb, 5 kg	Circuit leak/disconnect, apnea, high/low tidal volume; high/low minute ventilation, high/low respiratory rate, high/low inspiratory pressure, high/low expiratory pressure, low internal battery, power failure, device malfunction, remote	O ₂ integrated blender with Trilogy202
Ventilogic LS Weinmann GmbH & Co. KG www.weinmann.de ②	CPAP; S spontaneous; T timed; ST spontaneous/timed; TA timed adaptive; SX and SXX; PSV; PCV; aPCV; VCV	5-3,000 ml	4-45 hPa	5-45 L/min		8 levels for separate inspiratory and expiratory	115-230 VAC; 50/60 Hz	Internal: 3 hrs External: VENTIpower, 7 hrs	230 mm W x 145 mm H x 340 mm D	6.5 kg	Low minute ventilation, high tidal volume, low/high respiratory rate, low/high control pressure, low/high oxygen; apnea, leak, mask disconnect, device malfunction, overheating, low/empty internal, external battery, power failure	H: VENTIdlick O: VENTI-O2

What is a combination or multi-mode ventilator? (continued)

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators (continued)	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
Venti/logic plus Weinmann GmbH & Co. KG www.weinmann.de ② Pediatric use	Leak: Spontaneous, timed, spontaneous/timed, timed adaptive, CPAP; Valve: Pressure control, assist/pressure control; pressure support; SIMV	5-3,000 ml	6-35 hPa leakage; 4-45 hPa valve	5-45 L/min		8 levels for separate inspiratory and expiratory; 300 l/min leakage, 270 l/min valve	115-230 VAC; 50/60 Hz	Internal: 3 hrs External: VENTIpower, 7 hrs	230 W x 145 H x 340 D mm	6.5 kg	Low minute ventilation, high tidal volume, low/high respiratory rate, low/high control pressure, low/high oxygen; apnea, leak, mask disconnect, malfunction, overheating, low/empty internal or external battery, power failure	H: VENTiClick O: VENTI-O2
Vivo® 50 BREAS Medical AB www.breas.com ② Pediatric use	PSV, PSV (T), PCV, PCV (T), PCV (A), PCV (A+T), VCV, VCV (A), CPAP	100-2500 ml	4-40 cm H ₂ O	5-50 BPM	0-30 cm H ₂ O	Off and 1-9 Inspiratory; 1-9 expiratory	100-240 V, 50/60 Hz	Internal: up to 4 hrs External: 24 V up to 8 hrs	348 W x 120 H x 264 D mm 348 W x 120 H x 290 D mm with external battery	5.2 kg; 6.7 kg with external battery	Low/high pressure, low/high PEEP; low/high breath rate, low/high inspired tidal volume, low/high minute ventilation, low/high pulse rate, low/high FiO ₂ , apnea; rebreathing, disconnect, low/empty internal/external battery, malfunction, power failure	O
Vivo® 60 BREAS Medical AB www.breas.com ② Adult and Pediatric use	PSV, PSV (TgV), SIMV PCV, PCV, PCV (TgV), SIMV VCV, PCV (A), PCV (A+TgV), CPAP, VCV, VCV (A)	50-2500 ml	4-60 cm H ₂ O	(PCV, VCV) 4-60 BPM	0-30 cm H ₂ O for Adult, 0-20 cm paediatric insp pressure, 2 cm H ₂ O or Min Insp Pressure - 2 H ₂ O	1-9 Inspiratory; 1-9 expiratory	100-240 V AC	Internal: up to 4 hrs External (click-on): 24 V DC up to 8 hrs	343 W x 125 H x 264 D mm 343 W x 125 H x 285 D mm with click-on battery	5.2 kg	High pressure, low pressure, high PEEP, low PEEP, high Vte/Vti, low Vte/Vti, high MVe/Mvi, low MVe/MVi, high breath rate, low breath rate, apnea, disconnect, rebreathing, high FiO ₂ , Low FiO ₂ , High SpO ₂ , Low SpO ₂ , High EtCO ₂ , Low EtCO ₂ , High Insp CO ₂ , High pulse rate, Low pulse rate, low last power source	O

What is a combination or multi-mode ventilator? *(continued)*

KEY: ① = available only in USA ② = available only outside USA ③ = available worldwide

Combination or Multi-Mode Ventilators <i>(continued)</i>	Mode	Tidal Volume	Pressure Range	Breath Rate	PEEP	Trigger	AC Voltage	Battery	Dimensions	Weight	Alarms	Humidifier = H Oxygen = O
VS III™ ResMed www.resmed.com ② Pediatric use	Leak - CPAP; spontaneous; spontaneous/timed; assisted pressure controlled ventilation; Valve-assisted volume controlled ventilation; pressure support with guaranteed tidal volume; assisted pressure controlled ventilation	50-2500 ml	IPAP/PS: 5-30 cm H ₂ O 6-30 H ₂ O; 5-50 H ₂ O EPAP: 4-20 cm H ₂ O	5-50 BPM; 5-60 BPM pediatric in PS.Vt &A/CV	CPAP/ PEEP: 4-20 cm H ₂ O	Inspiratory flow; 3-8; pressure: Auto, 1-6	100-240 V, 47-63 Hz	Internal: 2-4 hrs External: 26 VDC	14.5 cm x 27.5 cm x 22.1 cm	2.9 kg	High/low pressure, low V _{ti} , low V _{te} , maximum frequency, high V _t , low battery	O
VS Ultra™ ResMed www.resmed.com ② Pediatric use	Assist/control volume, assist pressure control, pressure support with or without backup, pressure support with tidal volume, spontaneous, spontaneous/timed	50-2500 ml	5-50 hPa	5-50 adult; 5-60 pediatric	4-20 cm H ₂ O	Inspiratory & Expiratory	100-230 V	Internal: 4 hrs External: 24 V, 8 hrs	135 x 285 x 204 mm	3.5 kg with battery	Low/high pressure, low/empty battery, power failure, disconnect, malfunction, remote, low/high tidal volume	O

CONSUMER COMMENTS FOR COMBINATION OR MULTI-MODE VENTILATORS:

LTV® series

"The main drawbacks of the LTV are its costs, its energy draw, and the noisiness of it. It is difficult to have a conversation or to talk on the telephone when using it, and it would be a challenge going to a concert or even a movie. Its best features are its ability to switch between volume and pressure modes and, of course, its size, which enables you to carry it on the back of your chair or easily take it with you on an airplane. Another problem with it is the size of the circuits. The vent is so lovely and small while all the tubing is quite extensive and difficult to conceal if you are a fashion conscious."

—AJK, Canada

LTV®900

"The LTV®900 is moderately noisy. I modify the circuit for my son's needs because it is difficult to change. The Y valve is very bulky especially if you use a heated wire circuit and need to add a temperature probe at the Y valve."

"The adapter for the car's cigarette lighter is a good feature. The size, of course, is the best feature." —JS, Florida

"The LTV®900 is quiet during the day and in big rooms, but it is loud in a small room and at night."

"The entire ventilator tubing circuit is changed once a week. It is easily done as it has designated connections that only fit into specific ports. You can't connect it wrong. There are two little filters. One is the computer exhaust and the other is the inlet for the air. They are both washed easily with regular water and air dried."

"I use an inline HME instead and like the Portex 1200 HME the best, which I change every day. The HME provides a little resistance (compared to the LP10 humidification chamber), but is so much smaller and convenient."

"The car adapter and three-hour battery packs are great. My AC adaptor plug has had two breakages at the connection site in the last year. This is a poor design that is too fragile for this vital connection."

"The alarm could be louder, but the alarm resets itself if the problem of high or low pressure is fixed automatically. The cover over the controls is a nice feature as it leaves only the alarm reset button available for pushing by caregivers. However, the cover needs to be able to be clipped on somehow as it just falls off sometimes – we have to tape it into place. The locking feature on the setting of all the control parameters is also nice."

"My most favorite feature is the wonderful portability. I swim with my vent connected during aquatic therapy. It also attaches easily to the back of my wheelchair and takes very little additional space."

"Its least favorite feature is the loudness during the night. Customer service with both my local medical device company and the manufacturer has been poor." —EO, Alabama

"I use a Pulmonetic LTV®900. I wish it were lighter for traveling purposes, but it is certainly more compact and portable than other models I have used. I do not mind the noise, however, it is distracting to another person when I share a room with a guest. I would like it to be quieter."

"I have had problems with my PEEP valve. The RRT will set it at 5, but it fluctuates and sometimes goes up as high as 9. Even a replacement machine fluctuated but only to 7. I wish the PEEP valve settings were more stable and reliable. At times, the alarm for "High PEEP" even sets off."

"Sometimes, the "High Pressure" alarm goes off. When I get up and suction myself, often there are very few secretions. Sometimes the "Low Pressure" alarm will go off when nothing in the circuits is disconnected. Therefore, I find that the alarms go off without apparent cause." —LB, Illinois

"I use an LTV®900 and love it. It is relatively quiet and extremely portable." —LG, New York

LTV®950

"During the day I rarely hear it unless I happen to pull my chair up near a wall where the sound is reflected. At night the bedside machine is mounted on a stand slightly above my head, but the noise does not interfere with either watching television or going to sleep."

"The only maintenance required is the weekly changing of two filters. I need to use a pair of tweezers to pull the grate over the fan motor filter. I am sure that someone with weaker arms/hands than I have would find it very difficult. For an able-bodied person it is easy. The filters are then rinsed in warm water, squeezed dry and left to totally dry for use the following week. I use disposable circuits and changing them is not difficult. I have permanent circuits to use in an emergency and find washing them to be very exhausting."

"I find the LTV®950 to be a very 'natural' way to breathe. To me it is very smooth and comfortable and the machine always seems to be in synch with me."

Consumer comments for combination or multi-mode ventilators: *(continued)*

"I use the following accessories (also from Pulmonetic Systems, Inc.) – AC power adapter, external 12V nine-hour batteries (I use three and rotate them through charging and resting), external battery DC cord, automotive lighter power cord that also works with my Husky Jump Start System, Model HSK020HD if I get in a pinch, and a table stand that supports the vent on a tabletop at bedside. I also use a heated humidifier (Fisher & Paykel Healthcare Inc.) at night.

"I particularly like the adjustable alarm volume, which I set to an audible but not ear-shattering 60db so I don't frighten people when an alarm goes off when I'm out and about.

"For me, the most favorite feature of the LTV®950 is the profile of the vent, which allows me to hang it on my wheelchair, right below the right arm of the chair. This allows me to see the vent if an alarm goes off, discover what the problem is, most often be able to fix the problem, and always be able to reset the alarm. Without this profile, the vent would have to mount on the back of my chair and I would require someone with me all the time. As it is, I am able to be by myself for major periods while my wife is at work (she works within 90 seconds of our home if I were to need her in an emergency).

"The least favorite feature is the way the low-battery power alarm goes off. It begins to signal low power when the battery is only about at 50% and then continues to go off every 90 seconds or so for an hour or more. It will then go quiet until the external battery fails and the internal battery takes over. I would prefer ONE warning at 50%, probably a warning at 10%, and the warning at fail over. While this is a real nuisance and sometimes very embarrassing, it doesn't quite overshadow my most favorite feature."
–LK, Minnesota

"I use the LTV®950 on my power chair. I prefer to be able to operate ventilator controls myself, but with this ventilator I just barely am able to do so. The ON/OFF control requires you to push down and hold for several seconds. Also true for many other controls which is difficult if you have weak hand muscles.

"The alarm level sound is adjustable which is great. The LTV®950 has so many features that it's almost overwhelming to learn how to run it at first.

"Circuits are a tad too long and more involved to clean. I'm told valves cannot be immersed in water.

"I find the breath it delivers a little jerky, but nothing too bad. The adaptor for the car's cigarette lighter is easy to use, and the charger unit is compact.

"The most favorite feature is its size and weight. It takes up considerably less space on the back of my wheelchair and of course is super for travel.

"Least favorite feature is the noise level at which it operates. The noise level is very loud compared to the PLV®-102b." –JG, Minnesota

"The small size and portability of the LTV®950 are extremely important features for an active vent user who travels frequently. The small lightweight 'flatpack' batteries are a brilliant solution to the problem of powering the unit when you're on the move and don't have access to electrical outlets. The air delivery is sophisticated and comfortable, seeming to sense what you need and readily adjust to changing breathing requirements. I fall asleep instantly with the LTV®950, and the noise of its turbine-driven operation does not bother me at all during the night.

"The multi-modal operation of the LTV®950 is definitely an asset for the person who requires the regularity and consistency of pressure ventilation at night but during the day uses intermittent volume ventilation to assist and augment regular respiration and periodically take deeper breaths. This is especially helpful during a respiratory infection.

"During daytime use, however, the noise is definitely a problem. It interferes with conversation and prevents use of my speaker phone – a dangerous safety issue when one is alone and dependent on the phone as a lifeline. Another problem is the excessive and clinically obvious tubing, which seems strangely contradictory to the non-ICU look of the LTV®950 motor unit itself – especially when it's in its backpack. Perhaps it is possible to re-engineer the tubing so as to make it less cumbersome, more cosmetic and easier to handle.

"The alarms are adjustable, and you can even turn them off, as I did during the day so I could use the volume mode intermittently.

"Most favorite features are the size, portability and natural feeling/comfort of the pressure ventilation mode. Least favorite are the noise and cumbersome, excessive tubing." –AK, Canada

"I have been using the LTV®950 for about six years. While this vent may not suit everyone, I think it is terrific. The main reason is size. I have the vent hung under the arm of my chair where I can access it and read and correct alarms. In this way, I can remain independent, only calling for help when and if it is really needed.

"Some complain about the noise, but the noise doesn't bother me in the least. I do admit that it is a bit louder than the LP10 I used as a backup vent

Consumer comments for combination or multi-mode ventilators: *(continued)*

for a number of years. But that vent doesn't allow the needed independence."
—LK, *Minnesota*

"We use a Pulmonetic LTV®950, and it's far less noisy than the old LP10, except for a person sitting right next to the user. Then, I find it's hard to hear over the vent sometimes. Other than that, I have nothing but good things to say about the LTV." —DC, *Canada*

LTV®1000

"I have been using the LTV®1000 for about five and a half years. I have had very little trouble with it, and it has met all my needs. Breathing with the vent feels very smooth and natural.

"The sound of the ventilator is similar to white noise. It is a constant, low noise with a slight increase with each breath. Most of the time I don't even notice the sound. It doesn't seem to annoy others when I am out and about.

"The maintenance of the LTV®1000 is easy. For the bedside vent, I use disposable circuits that are changed weekly. For the vent on my wheelchair, I use the reusable circuits that we clean weekly. The filters are easy to clean and change.

"The stand for the vent at bedside is sturdy and easy to move about. We occasionally use the adapter for the car's cigarette lighter when going on long trips to save the external battery. All the connections to use the external batteries, adapter for car, and electrical power are easy to use and switch from one to another.

"The alarms work well and are easy to reset. There is a message that tells you why the vent is alarming. I have not had any problems with it alarming unnecessarily.

"The thing I like best about the LTV is the size. It fits nicely against the seat back of my wheelchair and does not interfere in any way with my ability to get around and go places.

"The thing that we have had the most difficulty with is the length of time I am able to get with the external batteries. I am usually up in my wheelchair for about 15 hours a day. I have to replace the external batteries on a fairly regular basis because over time they don't seem to hold the charge. I am very active and don't like to have to plug into an electrical source while I am in my chair so the external batteries are very important to me.

"I have been trached and vented, 24/7, for the past eight years. I have used the Pulmonetics LTV®1000 and have had great success with this vent. I

haven't used anything else so I can't compare the differences. I have one vent that is attached to the back of my wheelchair and two external batteries to power it during the day. I am usually up in my chair for about 16 hours. At night I have a vent by my bed and powered by electricity with a backup battery in case of power failure. During the night the external batteries on my chair are charged so that they are ready for my next day." —BW, *Maine*

"I used the LTV®1000 and still would be except for the short battery life, in spite of the added three hours with the lithium back-up external battery. In addition, I found it virtually impossible to make any setting changes myself, as did a nurse who also tried." —CT, *Texas*

Newport™ HT50

"The noise level of the Newport™ HT50 is slightly louder than most other vents, but one gets accustomed to it. I have had no complaints at conferences, church services or movies.

"Maintenance is just as easy as any other vent that I have used. It is easy to use and easy to move. The technology is good. The Newport™ HT50 is comfortable, feels fine and delivers air smoothly. The auto DC adaptor works fine, and the internal battery usually lasts for four to five hours before the two-hour warning alarm sounds. It is somewhat annoying when the alarm repeats and repeats.

"The Newport™ HT50's light weight, small size and portability are its best features." —HH, *Virginia*

"The noise does not bother me when I'm in my own home but it does when I'm out in the public, such as the doctor's waiting room. I do not require 24-hour ventilator use so I've never used it in church.

"I find it very easy to use at home. It is light enough for me to move it without help. I place mine on the back of my wheelchair during the day. I change my own filters easily; the circuits are disposable and not hard to change.

"I use the assist control mode, volume ventilation. The air is delivered smoothly and consistently. I do not use the humidifier that comes with the unit. I use a unit that sets beside the Newport™ HT50. This works fine for me.

"My van is equipped with an inverter, so I have never used the cigarette lighter adapter in my vehicle.

Consumer comments for combination or multi-mode ventilators: *(continued)*

"The alarms are more forgiving that some because I can actually miss one breath without creating alarms. I do this often when I'm talking and using the vent. Moving about in bed does not cause alarms as long as I keep my breathing normal. The alarms are easy to turn off.

"The portability of the Newport™ HT50 and the comfortable airflow are its most favorite features. I wish it was quieter." –MD, Arkansas

"It's a lot quieter than my old Bantams. However, I only use it for sleeping so I can't comment on how distracting the noise would be in churches or concert halls or conference rooms. I use a PLV®-100 as a backup, and I find the Newport just slightly louder.

"There are only two maintenance procedures for this unit. One is replacing the filter that is located on the side of the unit. The filter cover is attached by three thumb screws. The other is to calibrate the unit whenever you change the circuits. This is done by blocking the user end of the circuit and pressing two buttons consecutively. Not very difficult.

"I find breathing very comfortable with it. One model has a built-in humidifier which would be great if you use the vent during the day. However, it is small and requires refilling every four hours or so. You can get an adapter for your car's cigarette lighter. The Newport™ HT50 has an internal battery that is claimed to last for 10 hours, but I haven't tested it that long yet.

"I can breathe on my own so I wish there was a way to shut off the alarms, but they do reset themselves quickly when the problem is fixed.

"The HT50's 10-hour internal battery and small size are its best features. I am not crazy about the calibration." –DV, New Hampshire

"With Newport's HT50, I feel like I'm on thick, lovely satin. It's quiet and user friendly. There is a handle on the top, which I think gives the appearance that it's portable and more conducive to my mobility needs. The Newport™ HT50 has enough contrasting colors and simple operations panel so that I can adjust the settings myself. Also with the Newport™ HT50, I can actually talk wearing the full face mask." –CT, Texas

Trilogy100

"The Trilogy100 is smaller, more portable, and has much better batteries. I use it about 15 hours a day. It's mounted on the back of my wheelchair, small enough to look like a backpack. The Trilogy100's operation is a little bit different from a user's standpoint. Instead of delivering a constant amount of air, it monitors the volume and adjusts it so that the user gets the correct tidal volume when averaged over time. Another plus is the alarm – it's not nearly as annoying as the PLV's. It does tweedle (my term!) with different problems, but the alarm resets itself after a short while. The only downside is that it clicks on every breath." –CE, California

"There are benefits in using the Trilogy100, particularly for traveling. First, its size and portability make it very easy to transfer on and off the airplane and to fit the ventilator under the seat in front. Second, its protected electronic panel prevents the settings from being changed inadvertently. Third, the Trilogy has six hours of battery life – three hours of internal battery and three hours of detachable battery – before an external battery would be needed. Fourth, the Trilogy provides for dual settings, making it very easy to switch back and forth between two different settings, called Primary and Secondary. Lastly, the exhalation valves for the Trilogy are a bit noisier than the older ventilators. However, the Trilogy itself is quieter, so it is a tradeoff. The biggest benefit for me is a consistency in performance, specifically with the trigger sensitivity. I have my sensitivity set very low because it is difficult for me to initiate a breath." –ML, Wisconsin

"I use it day and night. It can work as pressure or volume ventilator. Also it has two batteries that together last six hours, more or less. I definitely recommend it. It can work like a BiPAP, and it's very comfortable to breathe with it. It makes much less noise than a BiPAP. As a volume ventilator, you can adjust it the way you like." –EA, Brazil

"Excellent ventilator! I use it for 24/7 volume ventilation. I have been on the Trilogy for a little over a year now without a hitch. The battery life is very good; I get about 6 hours PLUS I get an additional 14 hours from an MU-1 external battery, so I get a total of 20 hours per day of battery life." –SS, Florida

Ventilators for infants and children

The choice of a ventilation system in infants and children involves several factors such as the child's age; degree of respiratory impairment; need for positive end expiratory pressure (PEEP), pressure support, and higher respiratory rates; and the resources and support systems at home.

Infants who are born prematurely often need a ventilator to help them breathe while in the Neonatal Intensive Care Unit (NICU). Others may have progressive and severe muscle weakness or severe aspiration that caused lung injury. These children usually require a tracheostomy to establish an artificial airway and to protect their developing airways.

Children's ventilatory needs can vary from full respiratory support to partial respiratory support with some ventilator-free time. In children who can initiate a breath and only require night-time support, the use of noninvasive ventilation is increasing. Popular ventilators for pediatric use include the Newport HT50® and Newport HT70®, LTV® series, Trilogy100, and Stellar™ 100 and 150™ with Pixi® mask system. The Nippy Junior + is the only ventilator **specifically manufactured** for infants and children (for use in the UK and Europe). In many developing countries, bilevel ventilators are often the only ventilators that are affordable and available to use.

KEY:

① = available only in USA ② = available only outside USA ③ = available worldwide

Nippy Junior +

B & D Electromedical, www.nippyventilator.com ②

Mode:	Pressure control, pressure support, CPAP, IPPV (NIV and tracheostomy)
Pressure range:	0-30 cm H ₂ O IPAP; 3-20 cm H ₂ O EPAP
BPM:	6-60
Maximum flow rate:	200L/min
AC voltage:	100-240 V, 47-63 Hz
Internal battery:	4-12 hours depending on settings and leak
External battery:	24 VDC, 4-12 hours depending on settings and leak
Dimensions:	30 L x 22 W x 13 H cm
Weight:	4.5 kg
Alarms:	Low/high pressure, low/high flow, low/empty battery, malfunction, disconnect, power failure
Humidifier:	External
O:	No

Which method and ventilator should be used?

The choice of ventilator can be made by an individual's primary physician, or the primary physician may make a referral to a pulmonologist (also known as a respirologist) who specializes in breathing-related disorders and lung conditions, and often sleep medicine. Some physical medicine and rehabilitation physicians, known as physiatrists, and some neurologists may also specialize in breathing disorders. In some countries only a pulmonologist can prescribe a ventilator.

After careful evaluation and pulmonary function tests to assess breathing and lung function and capacity (and sometimes a sleep study), the physician recommends a type of ventilator and appropriate interfaces. Individuals who need to use ventilation only at night have different equipment requirements than those who need to use a ventilator around the clock. Sometimes an individual may not be comfortable with a specific ventilator or interface and may need to change them in order to find the most comfortable and effective system.

Some ventilator users alternate modes and interfaces during the day and night.

What if something goes wrong with the ventilator?

Ventilator users and their caregivers must be prepared for equipment failure, disconnects, and power outages, especially if using 24-hour ventilation, in which case a backup ventilator and generator are prudent. Practicing regular safety drills helps prepare for emergencies. Keeping a manual resuscitator, such as an Ambu® bag, handy at all times is strongly advised.

Where do I find information about ventilator safety and reported incidents?

The FDA maintains a database for reports of problems with medical equipment, including ventilators, that is updated continually. www.fda.gov/MedicalDevices/safety

Home ventilator manufacturers in USA

CareFusion

www.carefusion.com/medical-products/respiratory/ventilation

Covidien RMS

www.covidien.com/RMS

GE Healthcare

www.gehealthcare.com/respiratorycare

Newport Medical Instruments

Division of Covidien RMS

www.ventilators.com

Philips Respironics

www.healthcare.philips.com/main/homehealth/respironics.wpd

Porta-Lung, Inc.

www.portalung.com

Pulmonetic Systems, Inc.

Division of CareFusion

www.carefusion.com

Puritan Bennett

Division of Covidien RMS

www.covidien.com/RMS

ResMed

www.resmed.com

VersaMed, Inc.

Division of GE Healthcare

www.gehealthcare.com/respiratorycare

ZOLL Medical Corporation

www.zoll.com

Home ventilator manufacturers outside USA

Air Liquide Medical Systems, Inc.

www.airliquidemedicalsystems.com

B & D Electromedical

www.nippyventilator.com

BREAS Medical AB

www.breas.com

Dima Italia S.r.l.

www.dimaitalia.com

Flight Medical Innovations Ltd.

www.flight-medical.com

Officine Coppa, S.r.l.

www.coppabiella.it

Philips Respironics

www.healthcare.philips.com

ResMed

www.resmed.com

Siare Engineering International Group, S.r.l.

www.siare.it

United Hayek Medical

www.unitedhayek.com

Weinmann GmbH & Co. KG

www.weinmann.de

IVUN
International Ventilator Users Network

An affiliate of Post-Polio Health International (PHI)

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