Vyaire Medical, Inc.		Cover Sheet
Title: REVEL OPERATOR'S MANUAL		
Part no.: 33869-001	Ver.: A	

Versions		
Ver.	Chg. Order	Description
A	102796	Initial release.

Warranty

The ReVel™ ventilator systems are warranted to be free from defects in material and workmanship and to meet the published specifications for two (2) years or 15,000 hours, whichever occurs first. The ventilator system is defined as the ReVel ventilator, PTV™ Series Docking Station and the PTM™ Graphics Monitor. The ventilator system does not include external power supplies.

The liability of Vyaire, Respiratory Care Division, (referred to as the Company) under this warranty is limited to replacing, repairing or issuing credit, at the discretion of the Company, for parts that become defective or fail to meet published specifications during the warranty period; the Company will not be liable under this warranty unless (A) the Company is promptly notified in writing by Buyer upon discovery of defects or failure to meet published specifications; (B) the defective unit or part is returned to the Company, transportation charges prepaid by Buyer; (C) the defective unit or part is received by the Company for adjustment no later than four weeks following the last day of the warranty period; and (D) the Company's examination of such unit or part shall disclose, to its satisfaction, that such defects or failures have not been caused by misuse, neglect, improper installation, unauthorized repair, alteration or accident.

Any authorization of the Company for repair or alteration by the Buyer must be in writing to prevent voiding the warranty. In no event shall the Company be liable to the Buyer for loss of profits, loss of use, consequential damage or damages of any kind based upon a claim for breach of warranty, other than the purchase price of any defective product covered hereunder.

The Company warranties as herein and above set forth shall not be enlarged, diminished or affected by, and no obligation or liability shall arise or grow out of the rendering of technical advice or service by the Company or its agents in connection with the Buyer's order of the products furnished hereunder.

Limitation of Liabilities

This warranty does not cover Routine or Extended maintenance such as cleaning, adjustment and updating of equipment parts. This warranty shall be void and shall not apply if the equipment is used with accessories or parts not manufactured by the Company or authorized for use in writing by the Company or if the equipment is not maintained in accordance with the prescribed schedule of maintenance.

The warranty stated above shall extend for a period of two (2) years from date of shipment or 15,000 hours of use, whichever occurs first, with the following exceptions:

- Elastomeric components and other parts or components subject to deterioration including the ventilator air inlet filter and cooling filter, over which the Company has no control, are warranted for sixty (60) days from date of receipt
- All batteries are warranted for ninety (90) days from the date of receipt

The foregoing is in lieu of any warranty, expressed or implied, including, without limitation, any warranty of merchantability, except as to title, and can be amended only in writing by a duly authorized representative of the Company.

Contents

Notices

Copyright

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PTV™ Series of Products

The PTV Series of products encompasses the EnVe and ReVel ventilators, a Docking Station, the PTM Graphics Monitor and various accessories (e.g. AC Adapter, SpO_2 Module/Sensor, FIO_2 Sensor, Patient Circuits, etc.) for use with the ventilators.

Contact Vyaire for a complete list of available accessories.

Documentation Updates

The information contained in this document is applicable to the product with which it was shipped. Product features are subject to change without notice.

Electromagnetic Fields and Radio Frequency Energy

PTV Series Ventilators require special precautions regarding EMC (Electromagnetic Compatibility) and need to be installed and put into service according to the EMC information provided in this manual. Portable and mobile RF (Radio Frequency) communications equipment can also affect the ventilator.

The following list of accessories and cables available for use with PTV Series Ventilators are in compliance with the requirements of 60601-1-2 IEC: 2001(E) sections 36.201 and 36.202.

- AC Adapter and its associated cables
- Docking Station and its associated cables and power supplies
- FIO_2 Sensor
- PTM Graphics Monitor and its associated cables
- SpO_2 Module and Sensor

Indications for Use

The ReVel ventilator is designed for use on patients who require respiratory support or mechanical ventilation and weigh a minimum of 5 kg (11 lbs). It is suitable for service in homecare, hospital and transport environments as a source of continuous or intermittent positive pressure ventilatory support, delivered invasively or non-invasively.

PTV Series Ventilators are restricted medical devices intended for operation by trained personnel under the direction of a physician and in accordance with all applicable state laws and regulations.

Federal law (USA) restricts the sale of this device except by or on the order of a physician.

Classification

Type of Equipment: Medical Equipment, Internally Powered Equipment, Type BF

Safety Information

Review the following safety information prior to operating the ventilator.

Operating the ReVel ventilator without a complete understanding of its attributes may cause harm to the patient or operator. It is important that this manual is read and understood in its entirety before operating the ventilator.

Any questions regarding installing, operating, or maintaining the ReVel ventilator should be directed to Vyaire or a service technician certified by Vyaire.

Vyaire Medical, Inc.

26125 North Riverwoods Blvd.

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USA

Customer and Clinical Support / Product, Accessories, and Parts Ordering:

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Website: vyaire.com

Document Conventions

For clarity, the following written conventions are used throughout this manual:

> **⚠ WARNING**
>
> **Bold Heading** - Double boxed text. Alerts the reader to potentially hazardous situations which, if not avoided, could result in death or serious injury.

> **⚠ CAUTION**
>
> **Bold Heading** - Double boxed text. Alerts the reader to potentially hazardous situations which, if not avoided, could result in equipment damage.

> **NOTE**
>
> Single boxed text. Contains additional information to assist in the proper operation of the ReVel ventilator.

Bold Text: Words that appear in **bold text** typically represent text as it appears on the ventilator itself, or as it is displayed on the ventilator user interface. Bold is also occasionally used as emphasis.

Italicized Phrases: Phrases that are *shown in italics* cross-reference other sections of the manual where the associated subject matter is addressed in greater depth.

Abbreviations: ReVel ventilator, ReVel and the ventilator are used interchangeably throughout this document. See *Appendix D - Glossary* for other abbreviations and acronyms used in this document.

Warnings and Cautions

General warnings and cautions which apply any time you use the ventilator are listed here. Specific **Warnings** and **Cautions** appear throughout the manual where pertinent.

Read these carefully before operating the ventilator.

⚠ WARNING

Use of Unapproved Cables or Accessories - The use of accessories and/or cables other than those specified, with the exception of those sold by Vyaire as replacement parts for internal components, may result in increased emissions or decreased immunity of the ReVel ventilator This could affect the safe and effective operation of the ventilator or other adjacent equipment, resulting in possible patient harm.

Adjacent or Stacked Equipment - The ReVel ventilator should not be used adjacent to or stacked with other equipment. This could adversely affect the safe and effective operation of the ventilator or other adjacent equipment, resulting in possible patient harm. If adjacent or stacked use is necessary, observe the ventilator carefully, prior to use on a patient, to verify normal operation in the configuration in which it will be used.

Risk of Electrical Shock -

- Use only Vyaire recommended Power Sources
- Do not use batteries, AC adapters, cables or external power supplies with visible signs of damage
- Do not touch internal components
- Refer all servicing or repairs to Vyaire or a service technician certified by Vyaire

Vent Inop Alarm - If a Vent Inop alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a service technician certified by Vyaire. Vyaire recommends that an alternate means of ventilation be available and the procedures to be followed if the ventilator ceases to function properly.

Operating a ventilator that does not appear to be working properly may be hazardous. If the ventilator is damaged, fails any test or malfunctions in any way, discontinue use and contact Vyaire or a service technician certified by Vyaire.

Fan Inlet and Exhaust Ports - The cooling fan inlet and exhaust ports must be kept clean and unobstructed. Failure to do so could result in a dangerous build-up of oxygen and/or damage to the ventilator due to overheating.

Review Adjustable Ventilation and Alarm Controls Regularly - Patient safety relies on appropriate, functional and properly set ventilation and alarm controls. Review and adjust (if necessary) all user adjustable ventilation and alarm control settings regularly. Periodically (per the *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning) verify that the ventilator's alarms are functioning properly. If any alarm malfunctions, contact Vyaire or a service technician certified by Vyaire. Failure to immediately identify and correct audible alarm situations may result in serious patient injury or death.

Diminished Audible Alarms – In order to avoid diminished sound levels of audible alarms and possible consequent harm to patients, do not allow the ventilator's Alarm Sounder Ports to become covered or obstructed in any way by stickers, labels, or other equipment/devices applied, set, or mounted on or over them.

⚠ WARNING

Trained Personnel – Only properly trained personnel should operate the ventilator. The ReVel ventilator is a restricted medical device designed for use by trained personnel under the direction of a physician in accordance with applicable state laws and regulations.

Patients who are dependent on a ventilator should be constantly monitored by trained personnel prepared to respond to alarms and address circumstances where equipment becomes inoperative. An alternative method of ventilation should be available for all patients dependent on the ventilator and caregivers should be familiar with emergency ventilation procedures.

Risk of Fire - Leaks at oxygen inlet connections can cause dangerous O_2 levels in the vicinity of the O_2 fitting. To avoid the risk of fire, visually inspect oxygen fittings before and after connecting high-pressure oxygen (to avoid unsealed connections) and take measures to properly ventilate the area.

Operating the ventilator in the presence of flammable gases could cause a fire or explosion. Under no circumstances operate the ventilator when explosive gases are present. The presence of flammable anesthetic gases presents a danger to patient and operator.

Operating Environment - To avoid the risk of equipment malfunction, do not operate the ventilator outside of a 0 °C to 40 °C temperature range, or a 5% to 95% relative, non-condensing humidity range.

Extreme Operating Conditions - Attempting to operate the ventilator in environmental conditions outside of those recommended in the specifications may result in ventilator failure and harm to the patient.

Exposure to Gases - To avoid the risk of exposure to gases, do not use Nitric Oxide (NO) unless external measures are taken to properly ventilate waste gases.

Patient Breathing Circuit – Exercise extreme care when adjusting or handling the patient circuit. Inadvertent disconnection of the patient from the patient breathing circuit can be dangerous.

The patient circuit must be tested for leaks (*Circuit Test*) before it is used for the first time and after any changes have been made to the configuration of the circuit. Harm to the patient or ineffective ventilation may result from failure to detect and correct leaks in the patient breathing circuit before connection to a patient.

To avoid the risk of patient injury, only use patient circuits and accessories expressly approved by Vyaire for use with PTV Series Ventilators.

Ventilator Service and Repair - To avoid ventilator malfunction and possible operator or patient injury, all servicing or repair of the ventilator must be performed by a service technician certified by Vyaire.

Electrostatic Shock – Do not use electrically conductive (anti-static) hoses or tubing with the ventilator. Use of such material increases the hazard of electrical shock to the patient.

Improperly Functioning Ventilator or Attached Accessories - Operating a ventilator that does not appear to be functioning properly may be hazardous to both patient and operator. If the ventilator or any attached accessory is damaged, fails any tests or malfunctions in any way, immediately discontinue use and contact Vyaire or a service technician certified by Vyaire.

⚠ CAUTION

Cleaning and Sterilization - To avoid irreparable damage to the ventilator, do not attempt to sterilize it.

Do not spray liquids directly on or into any part of the ventilator. Do not allow liquids to drip onto or pool on the ventilator.

Do not immerse the ventilator in liquids.

Risk of Equipment Damage - To avoid the risk of equipment damage and consequent malfunction, do not allow the ventilator to be dropped, or subjected to excessive impact or vibration. If the ventilator is dropped, perform the UVT and EST tests before placing the unit on a patient (see Chapter 2 – Functional Testing in Startup Mode). Discontinue use and contact Vyaire or a service technician certified by Vyaire if damage is evident.

Risk of Equipment Interference – Increased RF emission can be generated if Vyaire supplied cables are altered or replaced with unauthorized cables.

Risk of Equipment Malfunction – Portable and mobile RF communication equipment can affect ventilator performance.

Storage Temperature - Storing the ventilator at temperatures outside of its specified storage temperature range can damage the ventilator and its batteries.

Ventilator Functional Testing - Functional testing of the ventilator (as specified in Chapter 2 – Installation and Setup, Testing) must be performed before connecting a patient to the ventilator. Rerun the tests monthly and whenever a question about the ventilator's operation arises.

Use of the PTV Series Carry Case – The PTV Series Carry Case is a protective, portable case for PTV Series ventilators. In order to conform to the Free Fall environmental test conditions specified in International Standard IEC 68-2-32 and avoid equipment damage if accidentally dropped, the ventilator must be enclosed within the carry case.

Use of Power Adapter Cable Extensions – Once the vent-side pigtail cable extension is installed on the ventilator and the AC adapter cable extension is attached to the AC adapter/car charger, they are permanently attached and cannot be disconnected.

Symbols

The following symbols may be referenced on the device or in accompanying documentation.

Symbol	Source	Description	Usage
	ISO 7010-W001	General warning	Identifies conditions or practices that could result in serious adverse reactions or potential safety hazards.
	ISO 3864 No.B.3.1	Attention, see accompanying documents	Directs the user to the instruction manual for specific instructions involving safety.
	No. 417-IEC-5333	Type BF equipment.	To mark a type BF equipment
	No. 417-IEC-5031	Direct current	Indicates direct current (DC).
	No. 3.8 – ISO 15223	Keep Dry	Identifies an area of equipment requiring a degree of protection from liquids.
IPX1	IEC 60529	Enclosure protection	Indicates degree of enclosure protection against liquid ingress.
	Vyaire	Flow	Indicates monitored airway flow.
	Vyaire	Patient breathing circuit	Indicates connection points for the patient breathing circuit inspiratory limb, expiratory drive line and Wye flow sense lines to the ventilator.
	Vyaire	Audible signal	Indicates the Display/Alarm **Check** button.
	Vyaire	Battery/Power	Indicates the Battery/Power **Check** button.
	Vyaire	Eject	Indicates location of battery release.
	Vyaire	Nebulizer	Indicates the location of the nebulizer port.
	Vyaire	Increase/Decrease	Signifies direction of value increase or decrease on rotary knob encoder.
	Vyaire	Battery status LEDs	Indicates degree of charge remaining in the Removable Battery Pack.
	Directive 2002/96/EC	Waste Container	WEEE symbol to identify Waste Electrical and Electronic Equipment not to be disposed of as unsorted municipal waste.
	EN 980	Manufacturer	Indicates name and contact information of the manufacturer.

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Chapter 1 - INTRODUCTION

This Operator's Manual contains information and instructions to enable you to safely set up and use your ReVel ventilator.

The manual is designed for use by trained and qualified personnel, under the direction of a physician. It is very important that you familiarize yourself with the contents of this manual before attempting to operate the ventilator.

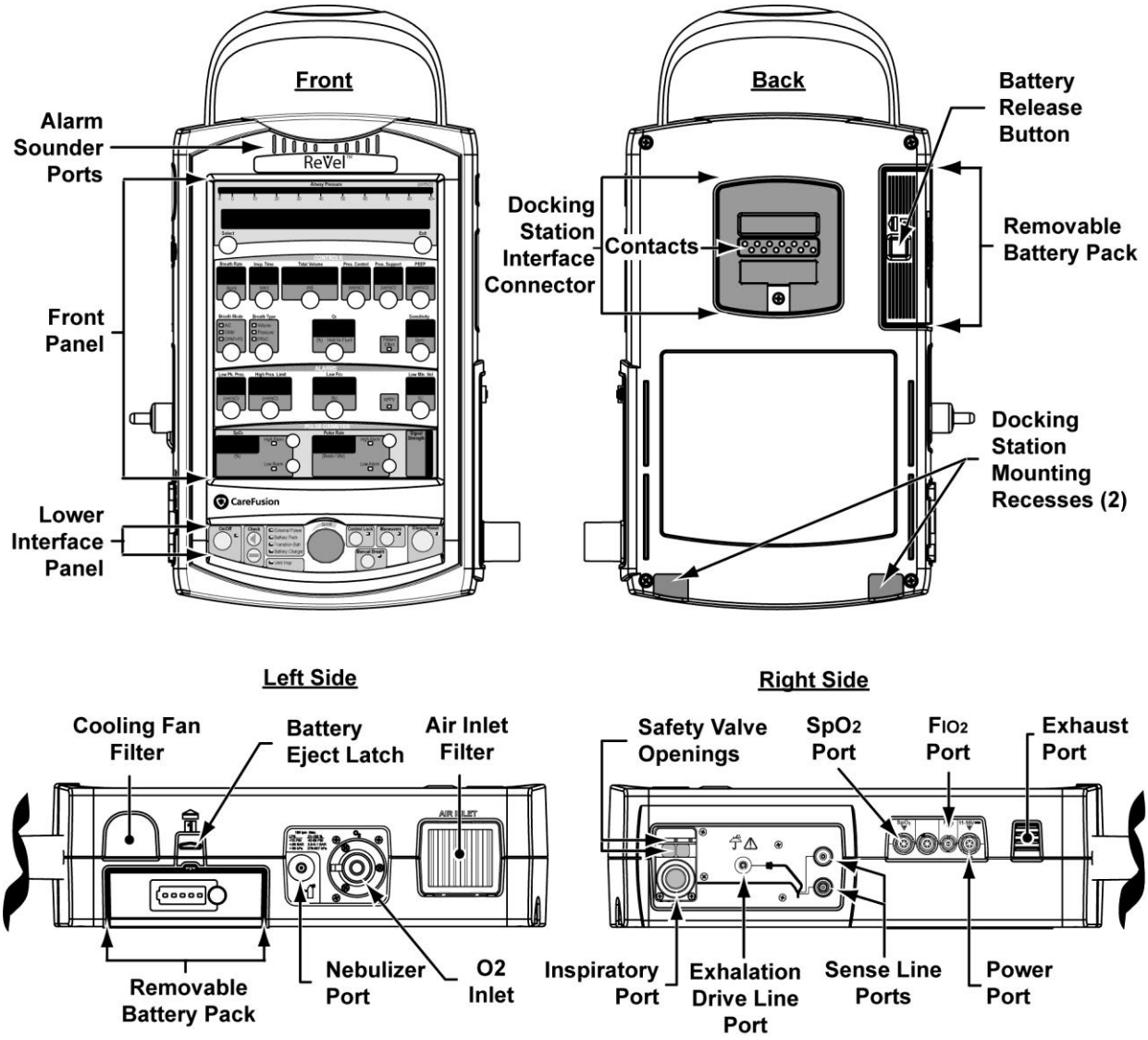
> **⚠ WARNING**
>
> **Trained Personnel** – Only properly trained personnel should operate the ventilator. The ReVel ventilator is a restricted medical device designed for use by properly trained personnel under the direction of a physician and in accordance with applicable state laws and regulations.
>
> Patients who are dependent on a ventilator should be constantly monitored by trained personnel prepared to respond to alarms and address circumstances where equipment becomes inoperative. An alternative method of ventilation should be available for all patients dependent on the ventilator and caregivers should be familiar with emergency ventilation procedures

If you have any problems or questions as you follow the instructions contained in this manual, call Vyaire using the contact information provided in *Appendix A - Contact Information.*

> **⚠ WARNING**
>
> **Ventilator Service and Repair** - To avoid ventilator malfunction and possible operator or patient injury, all servicing or repair of the PTV Series Ventilators must be performed by a service technician certified by Vyaire.

⚠ WARNING

Diminished Audible Alarms – In order to avoid diminished sound levels of audible alarms and possible consequent harm to patients, do not allow the ventilator's Alarm Sounder Ports to become covered or obstructed in any way by stickers, labels, or other equipment/devices applied, set, or mounted on or over them.



NOTE

Keep all ventilator interfaces, connectors, contacts, ports, etc. clean, dry and unobstructed.

Ventilator Overview

PTV Series Ventilators are lightweight, high performance ventilator designed for maximum functionality in an unprecedented small package.

The ReVel ventilator provides the following features:

- High performance ventilation in a small, lightweight package
- ActivCore technology, allowing the ventilator to operate without an external compressed gas source
- Four distinct breath modes offering a range of treatment options: Continuous Positive Pressure Ventilation (CPAP) with optional Pressure Support, Synchronized Intermittent Mandatory Ventilation (SIMV), and Assist/Control
- Apnea Backup ventilation, configurable in CPAP+PS and NPPV breath modes
- Non-Invasive Positive Pressure Ventilation (NPPV)
- Volume Control, Pressure Control, Pressure Support, Pressure Regulated Volume Controlled (PRVC), Volume Targeted Pressure Support and Spontaneous breath types
- A range of maneuvers including Inspiratory and Expiratory Hold
- Adjustable alarm settings including High Peak Pressure, Low Peak Pressure, Low Minute Volume, Apnea and others
- Oxygen blending from a high-pressure oxygen source or low-pressure oxygen bleed-in
- Lockable front panel controls
- A wide range of monitors including Breath Rate, I:E Ratio, Mean Airway Pressure, Exhaled Minute Volume, Positive End Expiratory Pressure (PEEP), Peak Inspiratory Pressure, and Exhaled Tidal Volume
- Real-time patient circuit pressure display
- Variable termination options for Pressure Support, Pressure Regulated Volume Support and Spontaneous breaths, including maximum inspiratory time and percentage of peak inspiratory flow
- Selectable percentage of Peak Flow termination for Pressure Control and Pressure Regulated Volume Controlled (PRVC) breaths
- Leak Compensation to improve patient triggering when an airway leak is present
- Operation from a variety of power sources including a Removable Battery Pack and external AC and DC power sources
- FIO_2 Sensor package
- SpO_2 Pulse Oximetry software

The PTV System

The Docking Station

At the bedside, the ReVel ventilator can be placed into a Docking Station, which expands its capabilities further. The Docking Station provides a stable base for the ventilator with a quick connect/disconnect mechanism to allow the ventilator to be moved quickly. It mates with the ReVel custom connector and supplies DC power to the ventilator. Docking Station enhancements include:

- interface to a nurse call system
- patient monitoring interface (e.g., VOXP system)
- interface with the PTM Graphics Monitor

A removable memory card enables information transfer between the ventilator and a computer. The Docking Station also has a service and maintenance port to allow upgrades and maintenance to be performed on the ventilator by authorized service personnel.

The ReVel™ Ventilator

The ReVel ventilator is a high performance portable critical care ventilator. It achieves a significant reduction in size, weight and power consumption over previous systems resulting in a highly portable device which can also support a wide range of life support and critical care applications.

The pneumatic system is designed around ActivCore technology, which includes a blower that draws in room air through a filter and delivers gas at the correct flow, volume and/or pressure for the patient.

The ventilator delivers blended gases from an internal oxygen blender. The blended gas delivery can be monitored with an external F_{IO_2} Sensor and the values displayed on the user interface. When high-pressure oxygen is attached to the O_2 Inlet port, the ventilator is able to drive a nebulizer to deliver aerosolized drugs to the patient while at the same time compensating for the added gas delivery.

The ventilator normally operates from external DC power. There is an external power port on the side of the ventilator enabling direct connection to a number of approved external DC power sources. The ventilator may also be powered via the custom interface to the Docking Station when the ventilator is docked at the patient bedside.

When the ventilator is portable, a Removable Battery Pack powers the unit. You can easily pull the battery from its bay and replace it with another charged battery without interruption of ventilation. While changing the Removable Battery Packs, the internal Transition Battery provides power to the ventilator for up to one (1) minute. Both the Removable Battery Pack and the Transition Battery are charged when an approved external DC power source is connected to the ventilator (see *Chapter 12 -. Power Supplies and Batteries* for more information).

PTM™ Graphics Monitor Display

The PTM Graphics Monitor is a lightweight color monitor for use with a PTV Series Ventilator when it is connected to its Docking Station and secured onto a PTV Series Rolling Stand, Table Stand, or Wall Mount. It displays real time waves, loops, controls, monitored data and trended data from the ventilator on a color LCD display. It has touch screen command capability and scalable graphics.

Optional Components

- The **SpO_2 Oximetry Module** provides portable pulse oximetry with the ventilator. SpO_2 and Pulse monitors and alarms display on the ventilator interface
- The **FIO_2 Module** enables monitoring of the oxygen concentration in the inspired airflow. FIO_2 related alarms and monitors display on the ventilator interface

Principles of Operation

Pneumatic System

The ReVel ventilator was specifically designed for high performance, high efficiency and high reliability. It uses advanced technology to achieve an unprecedented small package size and weight and enhanced battery performance in a robust modular design.

The heart of the ventilator is the ActivCore blower technology. The ActivCore draws room air into the **accumulator/filter** where it is mixed with oxygen from the **O_2 blender module**. Air from the ActivCore is precisely delivered through a **filter** and **bias valve** to the inspiratory limb of the patient circuit in a flow pattern to achieve the patient settings. A flow transducer downstream of the ActivCore (Blower) provides flow feedback to the ActivCore processor.

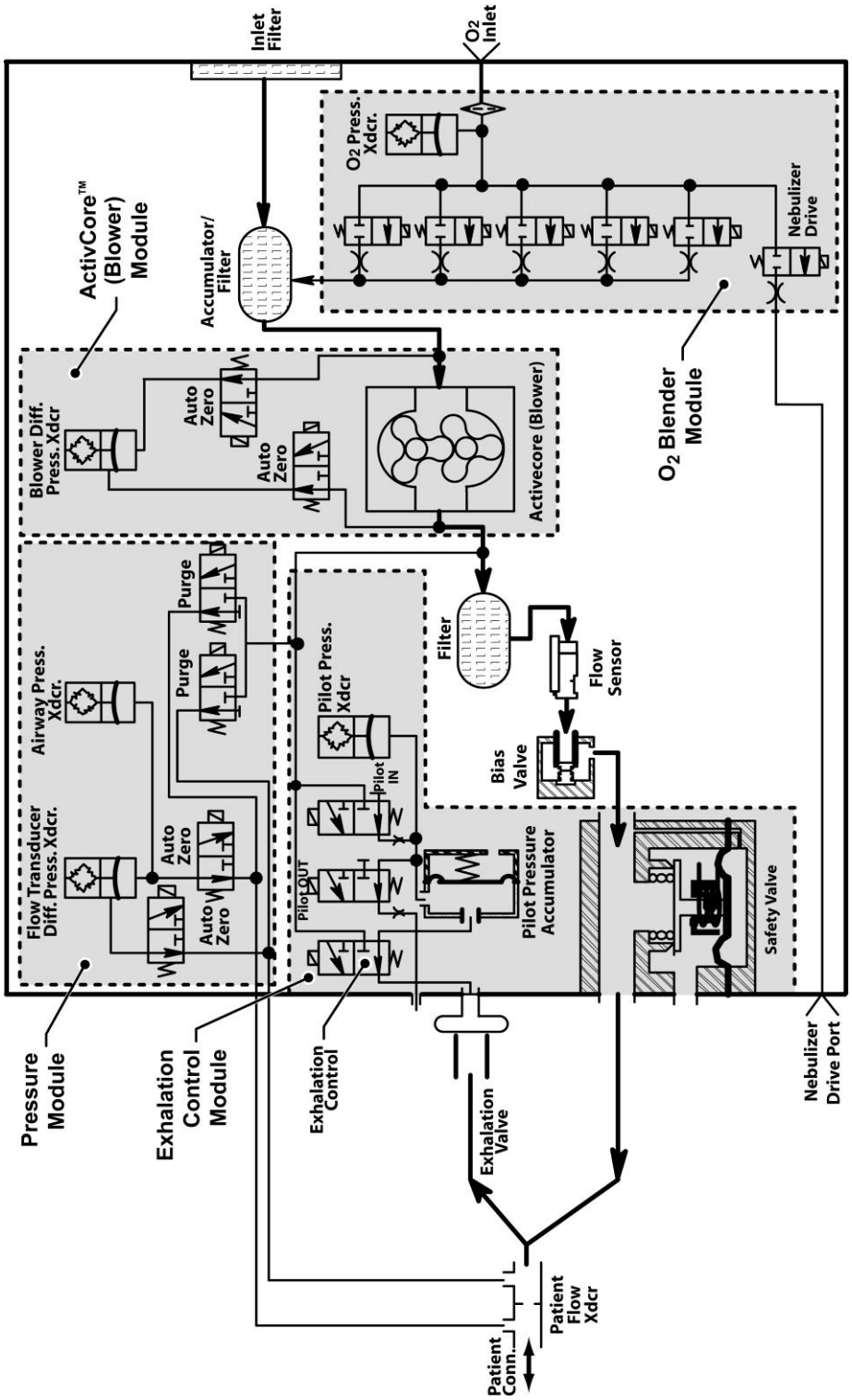
The **exhalation control module** closes the **exhalation valve** during inspiration to direct the air to the patient. During exhalation, the ActivCore delivers bias flow and the exhalation valve is servo controlled to achieve the desired amount of positive end expiratory pressure (PEEP). During exhalation, flow is monitored through the **patient flow transducer** to detect patient triggering. With leak compensation enabled, the ActivCore assures minimal work of breathing by delivering bias flow at the intended level above leak flow, thereby maintaining PEEP and patient triggering sensitivity, even in the presence of large patient leaks.

Patient flows are sensed by monitoring the differential pressure across a **patient flow transducer**. The patient flow transducer design is a fixed orifice integrated into the patient Wye - This design achieves sensitive breath detection and minimal dead space while adding robustness. It also reduces the costs of replacing/cleaning the flow sensor.

Differential pressure from the patient flow transducer is returned to the ventilator via the Sense Lines, where the pressure transducer module determines both the airway pressure and the patient flow. The transducers on the pressure transducer module are regularly auto-zeroed to assure accurate performance throughout changing environmental conditions, such as patient transport.

A **safety valve** is incorporated into the inspiratory port to ensure the patient does not receive excessive pressure in the event that the expiratory limb gets blocked and to allow the patient to inspire spontaneously if the ventilator is inoperative.

Pneumatic Diagram



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Chapter 2 - INSTALLATION AND SETUP

Unpacking the Ventilator

To unpack your ReVel ventilator;

1) Inspect the exterior of the ventilator transport container for evidence of damage during transit. If damaged, notify the delivering service immediately.
2) Carefully remove the ventilator and all accessories from the transport container. Retain the container for use in ventilator service or maintenance returns.
3) Confirm that you have received all items listed on the packing slip. Notify an authorized sales representative or Vyaire of any discrepancies.
4) Examine the ventilator and accessories for visible damage. If damaged, notify the delivering service.

Operational Setup

Equipment, Accessories and Supplies Required

To setup and operate the ReVel ventilator you will need the following additional equipment, accessories and supplies:

Power Source – The Removable Battery Pack[1] supplied with the ventilator and an approved external source of power (e.g. the AC Adapter[2], or PTV Series Docking Station[2])

- An external source of power is required for functional testing of the ventilator

Oxygen Supply – The ReVel ventilator can utilize either high or low pressure sources of oxygen (as clinically appropriate for the patient):

- A high pressure source of O_2 and an F_{IO_2} Sensor[2] or external oxygen monitor are required for functional testing of the ventilator

High Pressure

- During normal ventilation: 40 PSI (2.8 BAR, 276 kPa) to 88 PSI (6.0 BAR, 607 kPa)
- During Nebulization: 40 PSI (2.8 BAR, 276 kPa) to 66 PSI (4.5 BAR, 455 kPa)

Low Pressure: < 10 PSI (< 0.69 BAR, < 69 kPa)

Patient Circuit - See *Patient Breathing Circuits* in this chapter for patient circuit options and accessories.

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[1] Airline carriers typically allow only dry cell batteries (such as the Lithium Ion Removable Battery Pack supplied with your ventilator) on board aircraft. Some airlines may allow an electrical cord to be plugged in if arranged in advance. Check with the carrier in advance before traveling.

[2] For a current/complete list of accessories, availability and ordering information, contact Vyaire (see *Appendix A - Contact Information).*

Electromagnetic Fields and Radio Frequency Energy

The ReVel ventilator system, including the Docking Station, uses and can radiate radio frequency energy. The ventilator system, including the accessories and cables listed at the front of this manual, has been tested and complies with limitations as specified in IEC 60601-1-2 for Medical Products which provide some protection against interference when operated in accordance with the instructions in this manual.

The ventilator system also contains components that can be affected by intense electromagnetic fields. The ventilator system functioning may be adversely affected by the operation of other nearby equipment, such as high frequency surgical diathermy equipment, short-wave therapy equipment, defibrillators or MRI equipment.

Before proceeding with setup of the ventilator, refer to the tables in *EMC and RF Environments* in Appendix C – Reference Information for detailed information about the use of the ventilator in these environments.

⚠ WARNING

Use of Unapproved Cables or Accessories - The use of accessories and cables other than those specified, with the exception of those sold by Vyaire as replacement parts for internal components, may result in increased emissions or decreased immunity of the ventilator. This could affect the safe and effective operation of the ventilator or other adjacent equipment, resulting in patient harm.

Adjacent or Stacked Use of Equipment - The ventilator should not be used adjacent to or stacked with other equipment. This could adversely affect the safe and effective operation of the ventilator or other adjacent equipment, possibly resulting in possible patient harm. If adjacent or stacked use is necessary, observe the ventilator carefully, prior to use on a patient, to verify normal operation in the configuration in which it will be used.

PTV Series Carry Case

The PTV Series Carry Case is intended to provide a protective, portable case for PTV Series ventilators.

Although not shown in subsequent illustrations for clarity of individual installation and setup instructions, the PTV Series Carry Case must be installed on the ventilator in order to avoid damage if accidentally dropped.

⚠ CAUTION

Use of the PTV Series Carry Case – The PTV Series Carry Case is a protective, portable case for PTV Series ventilators. In order to conform to the Free Fall environmental test conditions specified in International Standard IEC 68-2-32 and avoid equipment damage if accidentally dropped, the ventilator must be enclosed within the carry case.

Installing/Cleaning the Carry Case

Refer to the Instructions for Use (P/N 33873-001) provided with the Carry Case for detailed installation and cleaning information.

Patient Breathing Circuits

On the ReVel ventilator, PEEP control is an integral function of the ventilator itself, and the external Exhalation Valve is integrated into the patient circuit. Vyaire offers patient circuits suitable for use with the ReVel ventilator in adult, pediatric and infant applications. Carefully follow the instructions for assembly, use and cleaning provided with each circuit:

- Contact Vyaire for a complete list of available patient circuits and accessories. See *Appendix A - Contact Information* for contact and ordering information.

⚠ WARNING

Risk of Patient Injury - To avoid the risk of patient injury, only use patient circuits expressly approved by Vyaire for use with the ReVel ventilator.

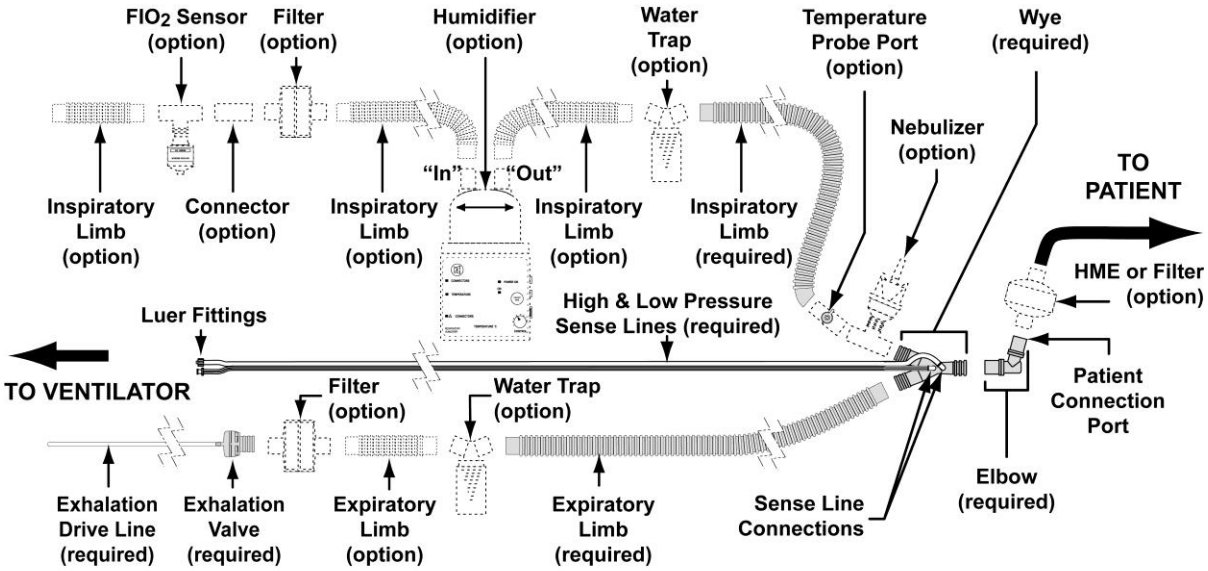
NOTE

Patient circuits and accessories are shipped clean, not sterile. The reusable patient circuit should be cleaned prior to initial use, and after each patient use.

Patient Circuit Accessories

Various patient circuit accessories are available for use with PTV Series patient circuits. The exploded view diagram shown is not intended to be representative of any particular configuration. It is a compilation of possible variations of a standard assembly with optional components and accessories, and is shown for reference only.

To assemble and clean accessories, refer to the Instructions for Use provided with each item. To order, contact Vyaire, see *Appendix A - Contact Information*. Assemble the patient circuit incorporating any optional accessories. Refer to the instructions provided with your circuit for full assembly instructions.

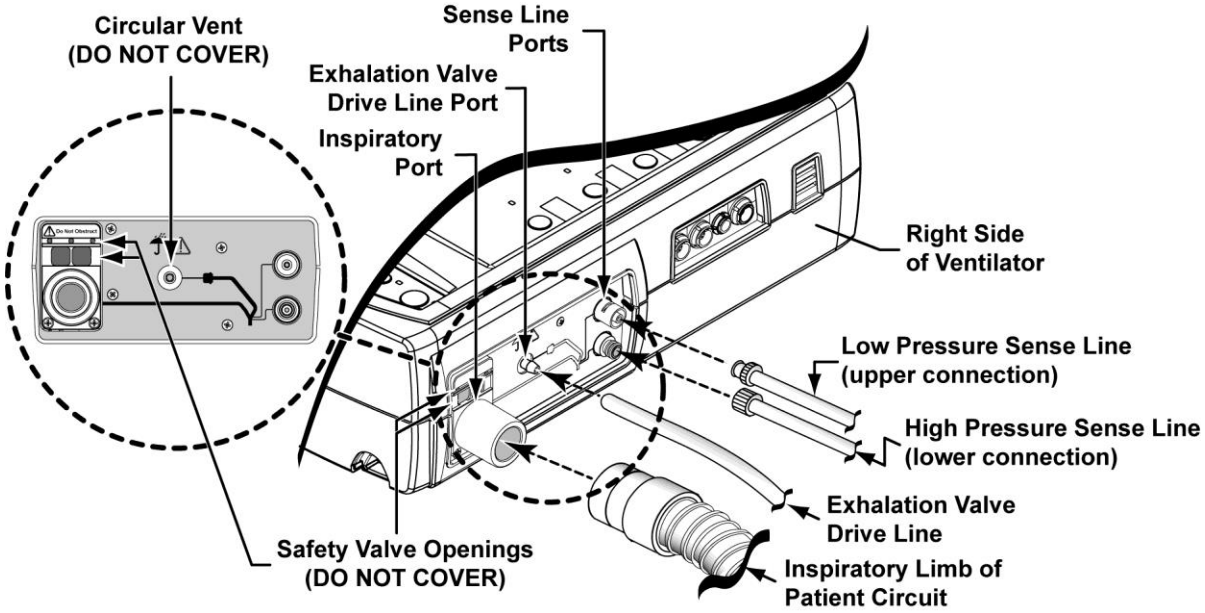


Example of Patient Circuit and Optional Accessories

Connecting the Patient Circuit

> **⚠ WARNING**
>
> **Circuit Test** –Test the patient circuit for leaks with all accessories before connection to the patient (see *Circuit Test* later in this chapter). Failing to detect and eliminate leaks can result in ineffective ventilation or patient harm. When using a heated humidifier, include it in the circuit when performing leak testing.

1) Connect the inspiratory limb of the patient breathing circuit to the inspiratory port on the right side of the ventilator, as shown below.
2) Connect the Exhalation Valve Drive Line of the patient breathing circuit to the exhalation valve Drive line port (hose barb) on the right side of the ventilator, as shown below.
3) Connect the patient circuit Wye Sense Lines (two, each with non-interchangeable Luer fittings) to the sense line ports on the right side of the ventilator, as shown below.



> **⚠ WARNING**
>
> **Risk of Patient Injury** - Do not cover or occlude the safety valve openings located above the inspiratory port of the ventilator. Patient injury could result.
>
> Use care when routing the patient circuit tubing to minimize the risk of obstructing the patient's airway.

> **⚠ CAUTION**
>
> **Patient Circuit Wye Installation** – To prevent fluids from entering the sensors, always install the Wye in the patient circuit so that the Sense Lines are oriented up during ventilation.

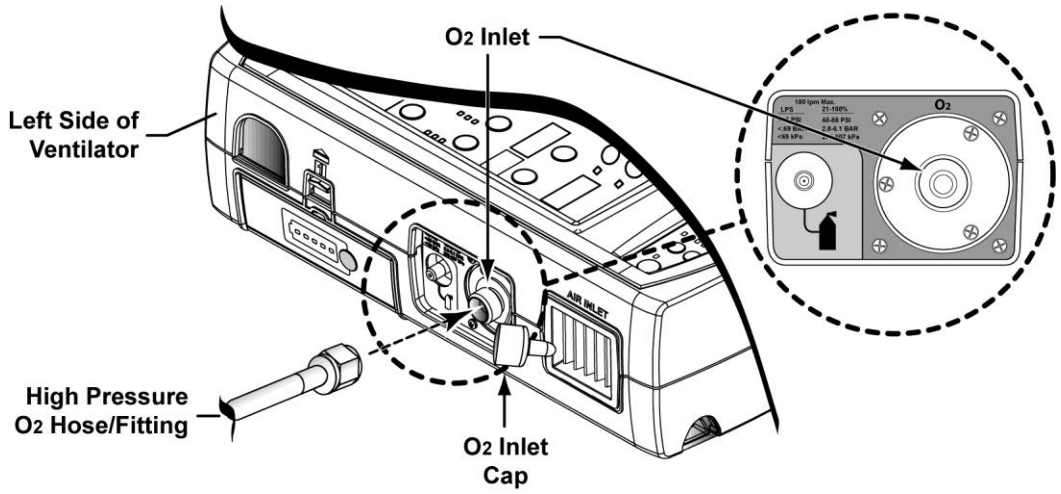
Oxygen Connection

High Pressure O_2

> **⚠ WARNING**
>
> **Risk of Fire** - Leaks at oxygen inlet connections can cause dangerous O_2 levels in the vicinity of the O_2 inlet fitting. To avoid the risk of fire, inspect oxygen fittings before and after connecting high-pressure oxygen (to avoid unsealed connections) and take measures to properly ventilate the area.
>
> **Oxygen Supply Contamination** - The accuracy of oxygen delivery can be compromised by debris contamination in the oxygen supply system. To reduce the risk of contaminants entering the ventilator, ensure that the oxygen supply connected to the ventilator is clean, medical grade oxygen. When not in use, protect the O_2 inlet fitting on the ventilator from dirt and contamination by using the plastic cap supplied.

For operation from a high pressure oxygen source, connect a compatible oxygen hose/fitting to the DISS[3] O_2 inlet port on the left side of the ventilator.

- The O_2 inlet port is labeled **O_2**

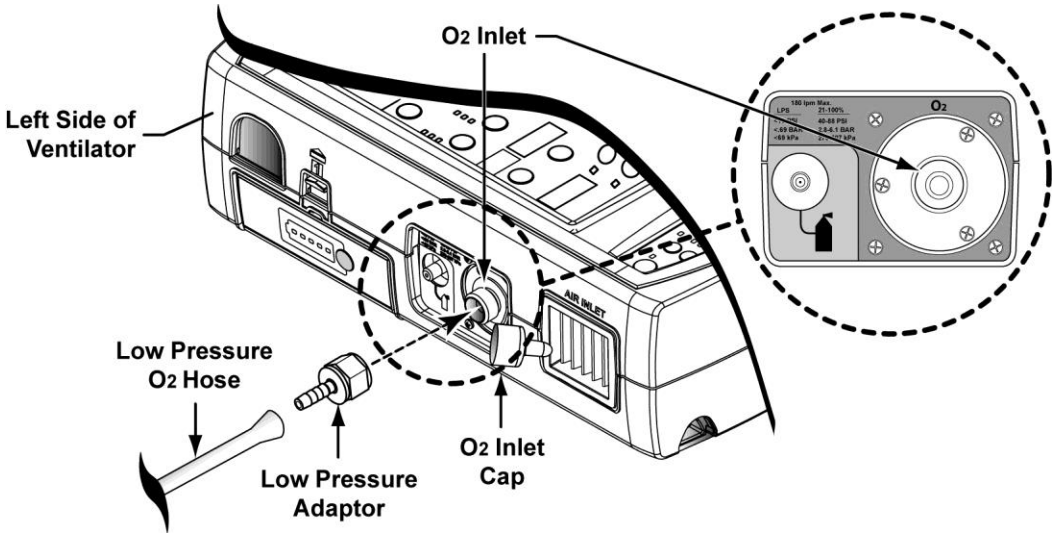


[3] DISS - Diameter-Index Safety System #1240, per GGA V5-1989

Low Pressure O_2 Source (LPS)

For operation from a low pressure (less than 10 PSIG, .69 BAR or 69 kPa) oxygen source such as a flow meter:

1) Attach a DISS[4] Low Pressure Adapter[5] to the DISS O_2 Inlet port on the left side of the ventilator.
   - The O_2 Inlet port is labeled **O_2**
2) Attach the oxygen supply hose to the hose barb on the adapter.
3) Set the **O_2** control on the front panel to **LPS** (Low Pressure Source) (see *O2 (Oxygen Percentage and Flush)* in Chapter 5 -Controls for detailed information).
4) Adjust the flow of the low pressure O_2 source as appropriate for the patient (see *Setting the Flow for Low Pressure Oxygen Blending:* in Chapter 5 – Controls for additional information).



⚠ WARNING

Inspired Oxygen (F_{IO_2}) Concentration – Minute volumes can fluctuate if the patient has a variable respiratory rate. If *exact concentrations* of inspired oxygen (F_{IO_2}) must be delivered to the patient, it is recommended that the optional F_{IO_2} Sensor or a separate oxygen analyzer with alarms be used. If using the optional F_{IO_2} Sensor set the ventilator Low FiO_2 alarm appropriately (see *Low FIO2* alarm in Chapter 8 –Ventilator Alarms for additional information).

NOTE

If a high pressure source is attached when the ventilator **O_2** setting is **LPS** (Low Pressure O_2 Source), a High O_2 Inlet Pressure alarm will activate and the ventilator will automatically switch the **O_2** setting to **21**%. See *High O2 Inlet Pressure* in Chapter 8 - Ventilator Alarms for more details.

[4] DISS - Diameter-Index Safety System #1240, per GGA V5-1989.
[5] The DISS Low Pressure Adapter is available from Vyaire.

Power Connection

The ReVel ventilator operates on Direct Current (DC) (11 to 16 VDC), which can be supplied by any one of the following sources of power:

- AC Adapter
- Automobile Adapter
- Docking Station
- Removable Battery Pack
- PTV Vent-side Pigtail Cable Extension

Refer to *Chapter 12 - Power Supplies and Batteries* for detailed information.

To Connect External Power (other than a Docking Station)

⚠ WARNING

Risk of Electrical Shock - To avoid the risk of an electrical shock or ventilator damage;

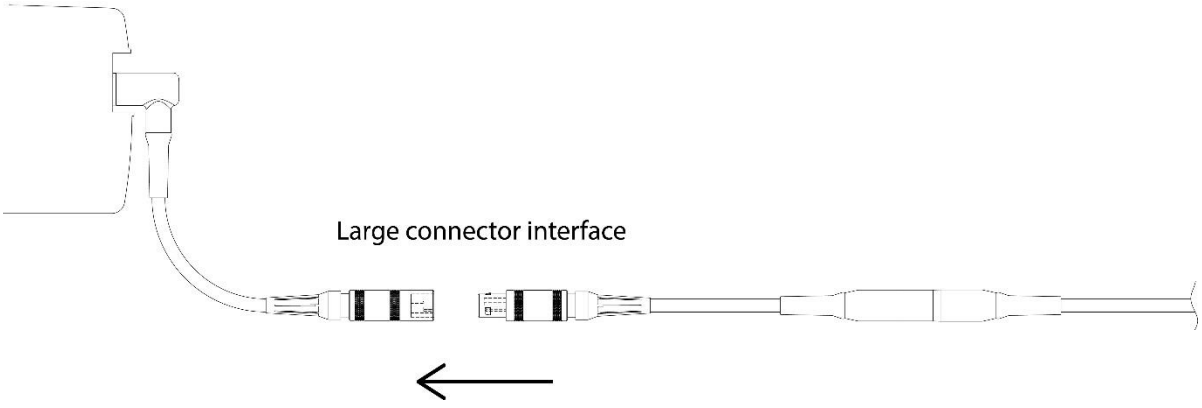
- Use only batteries, adapters, cables or external power supplies recommended by Vyaire
- Do not use batteries, adapters, cables or external power supplies with visible signs of damage
- Do not touch internal components
- Refer all servicing or repairs to Vyaire or a service technician certified by Vyaire

NOTE

When using the PTV Series Ventilators in combination with a Docking Station, Vyaire recommends connecting external power only to the Docking Station (the Docking Station in turn provides power to the ventilator).

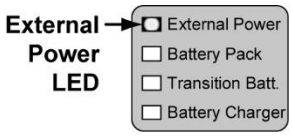
Either the optional AC Adapter or the Automobile Adapter is connected to the ventilator as follows:

1) Insert the large connector on the end of the AC adapter (13881-001) cable into the large mating connector on the end of the vent-side pigtail cable extension (24841-001) by aligning the internal half-moon keys as shown below.



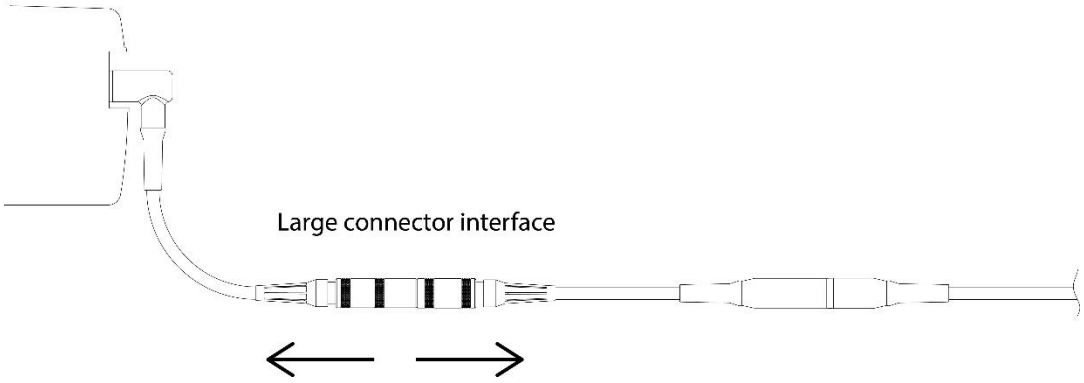
2) Connect the external power cable to a valid external power source.

3) Verify the **External Power** LED on the lower interface panel illuminates green. If not, recheck the power supply.



To Disconnect External Power

Grip the outer metal shells and pull apart the large mating connectors as shown below.



⚠ CAUTION

The vent-side pigtail cable extension is permanently attached to the ventilator and cannot be disconnected.

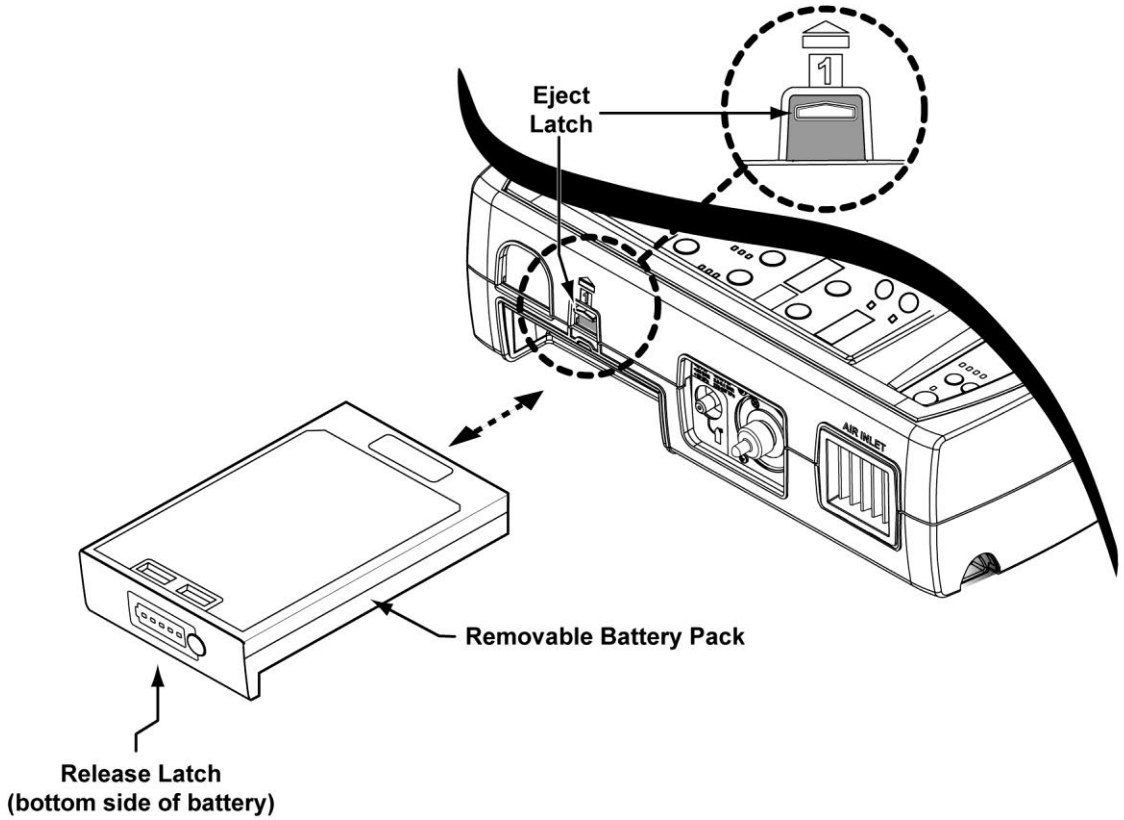
Removable Battery Pack Installation

For safety there are two latch mechanisms securing the Removable Battery Pack. The first is above the battery (see illustration). The second is on the underside of the battery at the leading edge. Both will engage when installing the battery and must be sequentially released to safely remove the battery.

To Install the Removable Battery Pack

> **NOTE**
> The Removable Battery Pack can be charged before installation using the Desktop Battery Charger. Once installed it is charged by the ventilator when connected to external power.

Position the Removable Battery Pack as shown, and push firmly into the Removable Battery Pack slot on the left side of the ventilator. If the ventilator is turned on, an audible signal sounds when the battery is acknowledged by the ventilator. The battery only fits into the slot one way (as shown) and will lock into place when fully inserted.



To Remove the Removable Battery Pack

To remove the battery, pull the Eject Latch up. The battery will partially eject. Push the Release button located on the bottom of Removable Battery Pack and pull the battery out of the battery slot as shown.

Optional Use Accessories Connection

Although the ReVel ventilator accommodates the following accessories, their connection, configuration and use is up to the discretion of the operator and the clinical needs of the patient.

- Pulse Oximetry (SpO_2) Sensor
- FIO_2 Sensor
- Nebulizer

Pulse Oximetry (SpO_2)

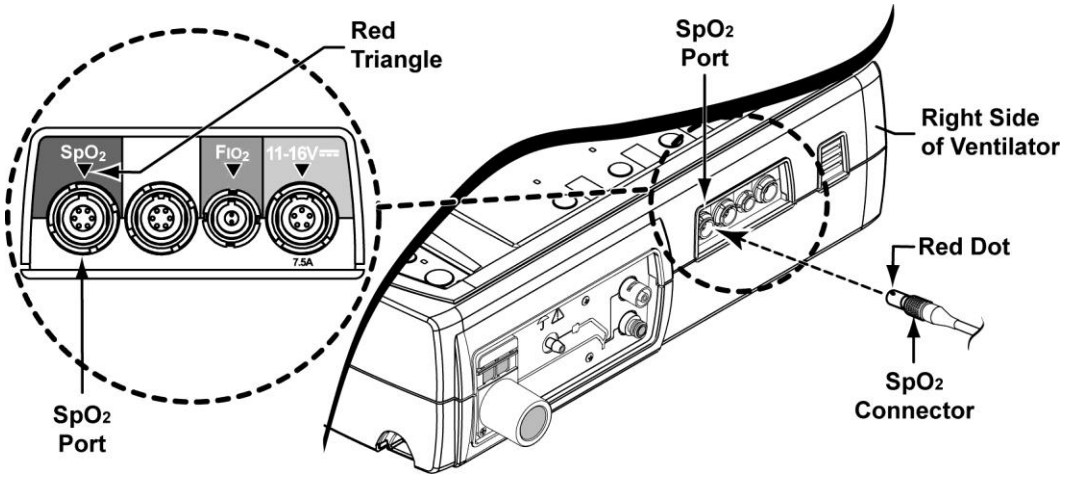
The Pulse Oximetry Module for use with PTV Series Ventilators is Vyaire P/N 18602-001. For specifications, warranty information, assembly and cleaning instructions, refer to the Instructions for Use provided with your Oximetry Module.

- See *Accessories* in Appendix C – Reference Information for additional information[6]

To Connect the Pulse Oximetry (SpO_2) Sensor

Position the module connector with the red dot on the connector aligned with the red triangle on the ventilator port labeled **SpO_2** (on a blue background). Insert as shown in the illustration**.**

- The connector is keyed to fit in only one position (when the red. dot aligns with the red triangle) and will lock into place when properly inserted



[6] For a current/complete list of accessories, availability and ordering information, contact Vyaire (see *Appendix A - Contact Information).*

To Configure Pulse Oximetry (SpO_2) Monitoring

Pulse Oximetry monitoring is enabled/disabled and it's high and low alarm limits are set using front panel controls.

- See *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator and *Front Panel, Pulse Oximeter* in Chapter 5 – Controls for additional information

Pulse Oximetry average interval and pulse tone volume configuration values are set using the Extended Features menus.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Pulse Ox (Pulse Oximetry)* in Chapter 10 – Extended Features for additional information

NOTE

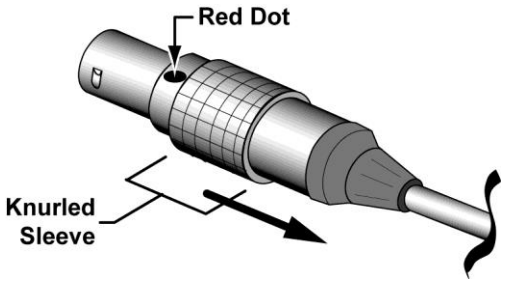
If the sensor is not on a patient when SpO_2 is enabled, an alarm will sound.

To Disconnect the Pulse Oximetry (SpO_2) Sensor

The SpO_2 Module connector has a safety locking mechanism to prevent accidental disconnection. To disconnect the safety locking mechanism, grasp the knurled sleeve of the connector and pull away from the ventilator as shown below. This retracts the locking mechanism and releases the connector from the ventilator SpO_2 port.

⚠ CAUTION

Connector Removal - To avoid damaging the ventilator or the connector, grasp only the knurled sleeve of the connector to remove it from the ventilator's port. Do not pull on the cord.



FIO_2 Sensor

In order for the ReVel ventilator to monitor/report the FIO_2 (Fraction of Inspired Oxygen) level in the inspiratory limb of the patient circuit, an optional oxygen sensor (and attendant connectors/cables) must be assembled together, inserted into a patient circuit, connected and calibrated to the ventilator.

Contact Vyaire for oxygen sensor part numbers and pricing information. See *Appendix A - Contact Information* for contact and ordering information.

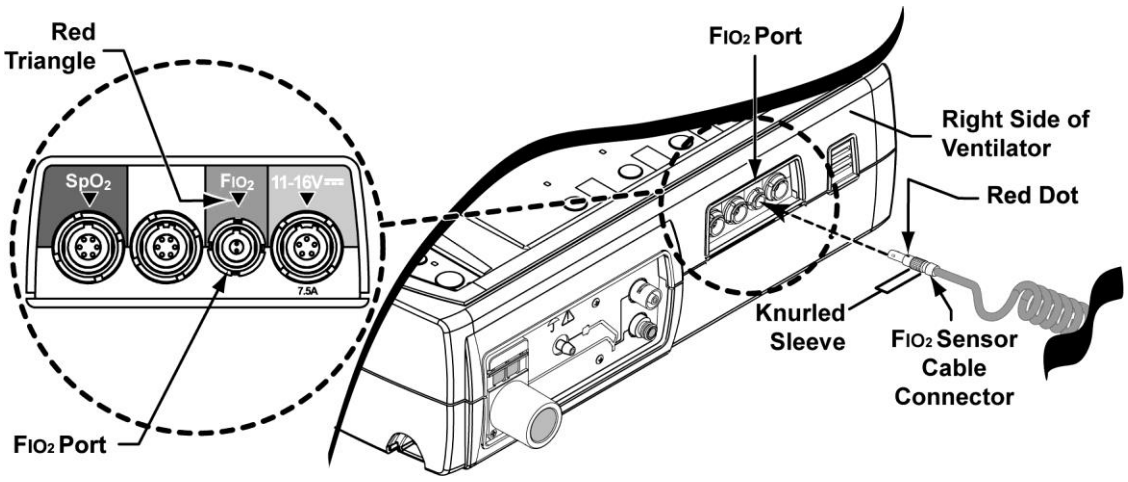
To Assemble the FIO_2 Sensor Assembly

See the Instructions for Use provided with the FIO_2 Sensor Cable Assembly for detailed instructions concerning assembling the FIO_2 Sensor Assembly and inserting it into the patient circuit.

To Connect the FIO_2 Sensor

Position the FIO_2 Sensor connector with the red dot on the connector aligned with the red triangle on the ventilator port labeled **FIO_2** (on a green background). Insert as shown in the illustration.

- The connector is keyed to fit in only one position (when the red dot aligns with the red triangle) and will lock into place when properly inserted



⚠ CAUTION

Calibration of Sensor - Accurate monitored FIO_2 readings cannot be obtained until the ventilator has been calibrated with the sensor that is connected. Follow the connection and calibration instructions given in this manual to ensure that the ventilator and the external oxygen sensor are calibrated and communicating properly.

Off Patient Calibration - All sensor calibration is performed with the ventilator off the patient and in the Startup mode of operation.

To Configure F_{IO_2} Monitoring

F_{IO_2} monitoring is enabled/disabled and calibrated while the ventilator is in Startup mode.

- See *Navigating Startup and Extended Features Menus* and *FIO2 Sensor Configuration and Calibration* in Chapter 3 – Using the Ventilator for detailed instructions

Once setup, enabled and calibrated, communication with the F_{IO_2} sensor may be enabled/disabled during normal ventilation modes using the Extended Features menus.

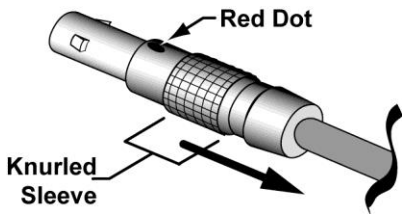
- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *FIO2 SENSOR* in the Extended Features, Option Cnfg menus in Chapter 10 – Extended Features for additional information

The Low F_{IO_2} alarm limit is set using the front panel while the ventilator is operating in a normal ventilation mode.

- See *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator and *Low FIO2* in Chapter 5 – Controls for additional information

To Disconnect the F_{IO_2} Sensor

The F_{IO_2} Sensor connector has a safety locking mechanism to prevent accidental disconnection. To disconnect the safety locking mechanism, grasp the knurled sleeve of the connector and pull away from the ventilator (as shown below). This retracts the locking mechanism and releases the connector from the ventilator port.



⚠ CAUTION

Connector Removal - To avoid damaging the ventilator or the connector, grasp only the knurled sleeve of the connector to remove it from the ventilator's port. Do not pull on the cord.

Nebulizer

The Nebulization procedure can be performed on the ReVel ventilator during Volume breaths in Assist/Control mode only. When the Nebulizer is activated, a six (6) L/min nominal flow is delivered to the nebulizer drive port. This drives an aerosol nebulizer that doses medication into the patient circuit.

To perform this procedure, the ventilator must be connected to a high pressure oxygen source and a Nebulizer.

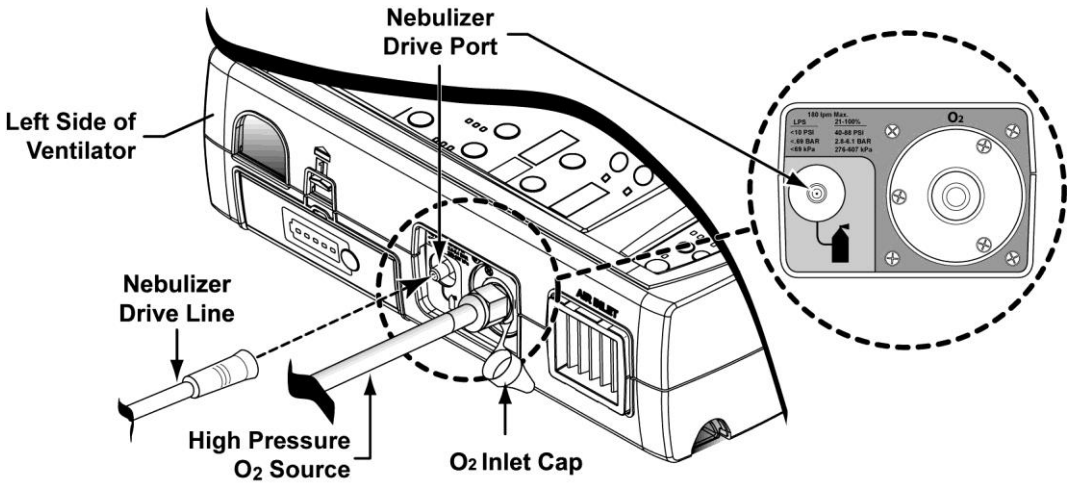
To Connect the Nebulizer

1) Align the nebulizer drive line as shown and push it straight onto the nebulizer drive port barb on the left side of the ventilator. The nebulizer drive port is labeled with the symbol shown here.

⚠ WARNING

Risk of Injury - If the nebulizer drive system fails, medication can be delivered at an incorrect rate. Monitor medication consumption rate and discontinue use if it does not meet patient needs.

If the nebulizer drive system fails, medication can be delivered during exhalation phase resulting in a release of medications into the room. Monitor medication consumption rate and discontinue use if rate is excessively high.



NOTE

The Nebulizer should be removed from the patient circuit and the ventilator when not in use.

To Configure Nebulization

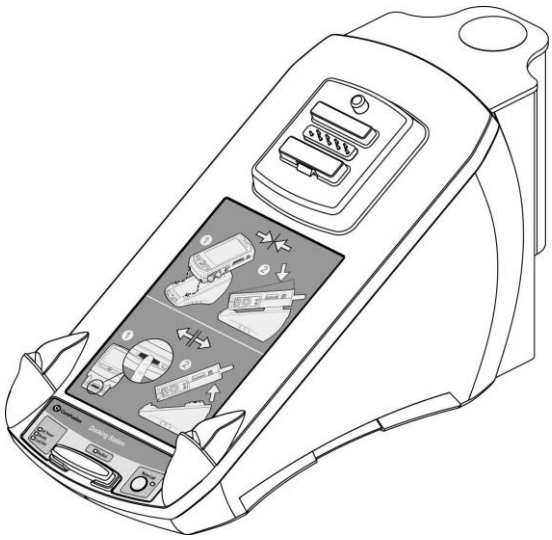
Nebulization is configured and activated using the Extended Features menus while the ventilator is in a normal ventilation mode.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Nebulization* in Chapter 9 - Maneuvers and Procedures for additional information

PTV Series Docking Station (Option)

The ventilator can be docked to a PTV Series Docking Station that provides power to the ventilator, accommodates the PTM Graphics Monitor and expands the ventilator interface capabilities to include:

- AC Power
- Memory Card Interface with automatic copying/storage of ventilation data
- Nurse Call Interface
- Patient Monitor System Interface
- PTM Graphics Monitor Mounting and Communication (Option)
- Rolling Stand Mounting (Option)
- Wall Mounting (Option)
- Table Top Stand Mounting (Option)

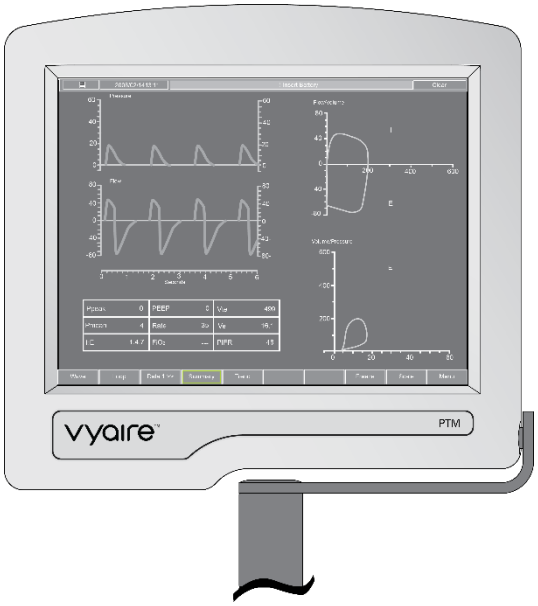


For additional information and detailed connection instructions, see the PTV Series Docking Station Operator's Manual, P/N 33870-001.

PTM Graphics Monitor (Option)

The PTM Graphics Monitor accessory is a thin, lightweight color graphics monitor for use with the PTV Series Ventilators when connected to a Docking Station and secured onto a PTV Series Rolling Stand, Table Stand, or Wall Mount. The PTM offers the following capabilities:

Data Screen	Current ventilator settings and monitored data
Loops Screen	Flow/volume and volume/pressure loops
Summary Screen	Collection of displays consisting of graphs and data from the Waveform, Loop and Data screens and ventilator settings
Trends Screen	Trend graphs for long term display of monitored data
Waves Screen	Pressure, flow, volume and plethysmograph waveforms



For instructions and detailed use information, see the PTV Series Docking Station Operator's Manual, P/N 33870-001, and the PTM Graphics Monitor Operator's Manual, P/N 33882-001.

Ventilator Testing

Perform the following tests and use the Ventilator Tests Worksheet located at the end of this chapter to record each test result.

> **⚠ WARNING**
>
> **Startup Mode** – The ventilator does not deliver gas to the patient while in Startup mode.
>
> **Improperly Functioning Ventilator or Attached Accessories** - Operating a ventilator that does not appear to be functioning properly may be hazardous to both patient and operator. If the ventilator or any attached accessory is damaged, fails any tests or malfunctions in any way, immediately discontinue use and contact Vyaire or a service technician certified by Vyaire.

To verify the functional operation of the ReVel ventilator, the following tests are to be performed as required in the *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning.

Test	Type of Test	Operating Mode Performed In
POST	Power On Self Tests	Startup mode
Button Test	User Verification Tests (UVT)	Startup mode
Circuit Test	Extended Systems Test (EST)	Startup mode
Battery/Power Test	Functional Test	Normal mode
Display/Alarm Test	Functional Test	Normal mode
Alarm Response Tests	Functional Test	Normal mode

Test Preparation

Preparation Required for All Tests:

1) Starting with the ventilator off, connect the ventilator to a valid, external source of power (see *Power Connection* in this chapter and/or the PTV Series Docking Station Operator's Manual, P/N 33870-001).
2) Insert a fully charged Removable Battery Pack (see *Removable Battery Pack Installation* in this chapter).

Additional Preparation Required for the Circuit Test:

3) Assemble the patient circuit to be used/tested (see *Patient Breathing Circuits* in this chapter and include all accessories to be used, i.e. humidifiers, water traps, filters, etc.) except:
    - Do not include a Nebulizer in the circuit
4) Connect the patient circuit to the ventilator (see *Connecting the Patient Circuit* in this chapter).
    - Do not attach an oxygen supply to the ventilator at this time
    - Do not connect the patient circuit to a patient

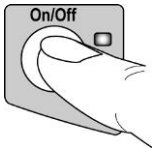
Additional Preparation Required for Alarm Response Tests:

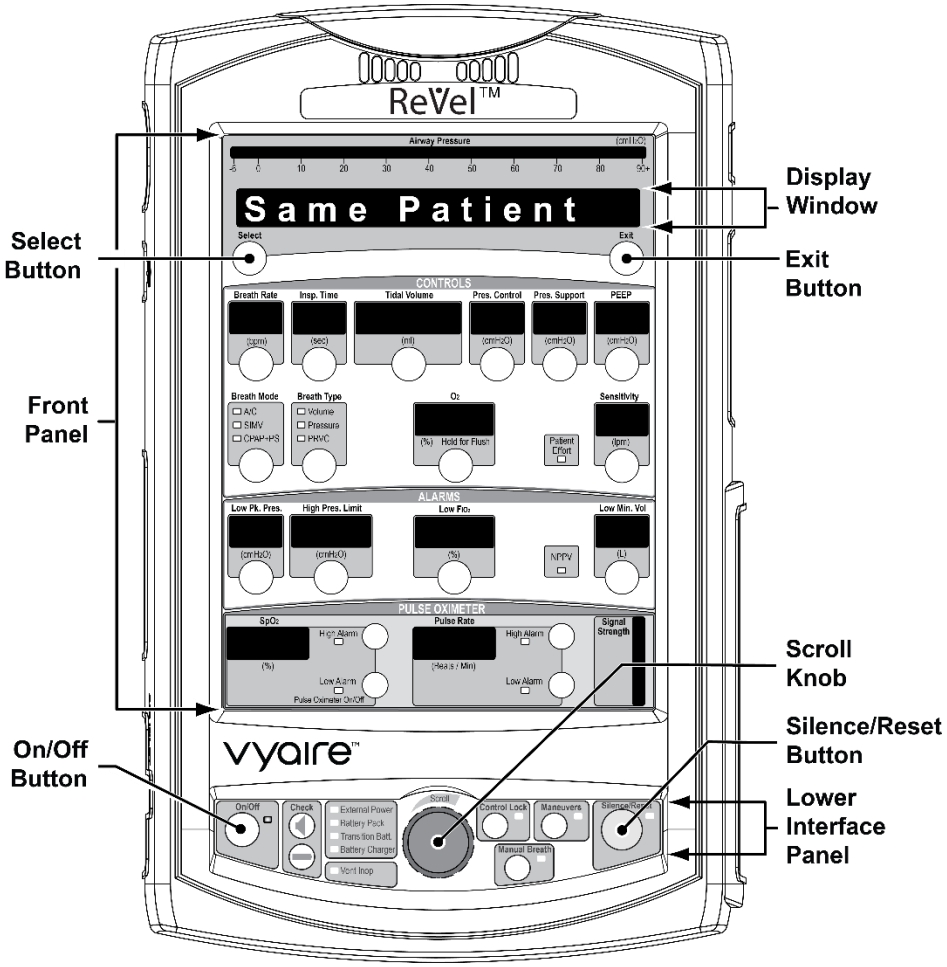
5) Connect a Test Lung to the Patient Connection Port on the Elbow of the assembled patient circuit attached to the ventilator. Refer to the patient circuit illustration under *Patient Circuit Accessories* earlier in this chapter for location of Patient Connection Port.

Power On Self Tests (POST) in Startup Mode

The Power On Self Tests (POST) are a set of self-tests the ventilator performs when turned on to verify the operational integrity and the validity of all stored configuration values, event log, RAM and program memory.

To turn the ventilator on and perform POST, momentarily push the **On/Off** button on the lower interface panel. Verify that the ventilator powers up, displays either the ventilator model name (**ReVel**) or part number (**XXXXX-XXX**) followed by **Same Patient** in the display window.



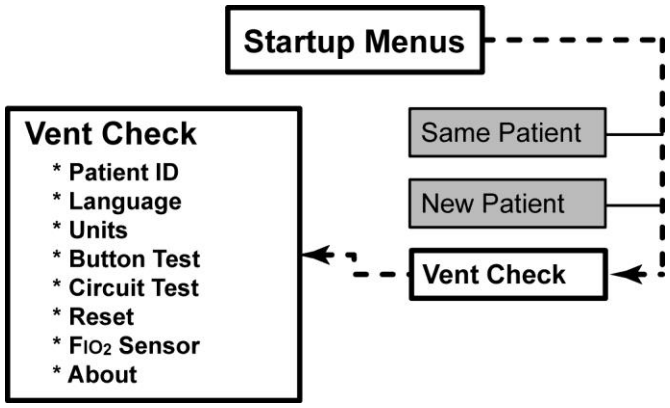


NOTE

Exiting Startup Mode – Startup mode can be exited at any time by simply holding down the **On/Off** button on the lower interface panel until the ventilator powers down.

Functional Testing in Startup Mode

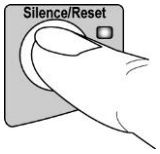
The Button Test and Circuit Test are performed while the ventilator is in the Startup mode.



⚠ WARNING

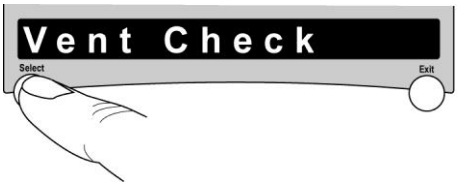
Improperly Functioning Ventilator or Attached Accessories - Operating a ventilator that does not appear to be functioning properly may be hazardous to both patient and operator. If the ventilator or any attached accessory is damaged, fails any tests or malfunctions in any way, immediately discontinue use and contact Vyaire or a service technician certified by Vyaire.

1) To perform testing in Startup mode, prepare and turn the ventilator on as previously described in this chapter and **Same Patient** is displayed in the display window on the front panel.



   - See *Test Preparation* and *Power On Self Tests (POST) in Startup Mode* in this chapter for detailed information

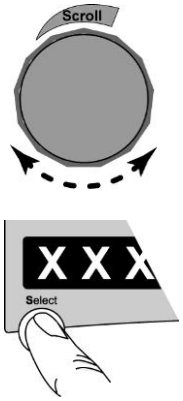
2) Rotate the **Scroll** knob on the lower interface panel until **Vent Check** is displayed. Push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. The ventilator enters the Vent Check menus and **Patient ID** is displayed.



Button Test

The Button Test checks the functioning of the mechanical controls (buttons and knob) on the ventilator's front and lower interface panels.

To Perform the Button Test:



1) When **Patient ID** is displayed, rotate the **Scroll** knob on the lower interface panel until **Button Test** is displayed and push the **Select** button. **Select** is momentarily displayed (while the **Select** button is being pushed), followed by **None Pressed** when the **Select** button is released.

2) Test the control buttons and the **Scroll** knob on the front and lower interface panels by pushing each button (except the **Exit** button), one at a time and rotating the **Scroll** knob, left and right. As each button is pushed or knob rotated, verify that the corresponding name of the control pushed/rotated replaces the displayed **None Pressed** message and matches the name of the control, as shown in the following table.

NOTE

During the Button Test the normal function of each button on the front and lower interface panels are suspended, except as follows:

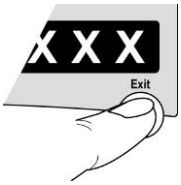
- Pushing the **Exit** button will cause the ventilator to exit the Button Test
- During testing, the **Silence/Reset** button retains its functionality and will continue to silence/reset alarms when pushed
- When testing the **On/Off** button, briefly push the button and an **On/Off** message replaces the displayed **None Pressed** message. However, pushing and holding the **On/Off** button for more than three (3) seconds will cause the ventilator to exit the Button Test and power off

Control Button	Name Displayed
Select	**Select**
Breath Rate	**Breath Rate**
Insp. Time	**Insp. Time**
Tidal Volume	**Tidal Volume**
Pres. Control	**Pres. Control**
Pres. Support	**Pres. Support**
PEEP	**PEEP**
Breath Mode	**Breath Mode**
Breath Type	**Breath Type**
O_2	**O_2 %**
Sensitivity	**Sensitivity**
Low Pk. Pres.	**Low Pres**

Control Button	Name Displayed
High Pres. Limit	**High Pres**
Low FIO_2	**Low FIO_2**
Low Min. Vol.	**Low Min Vol**
SpO_2 High Alarm	**High SpO_2**
SpO_2 Low Alarm	**Low SpO_2**
Pulse Rate High Alarm	**High Pulse**
Pulse Rate Low Alarm	**Low Pulse**
On/Off	**On/Off**
Check 	**Display Chk**
Check 	**Battery Chk**
Scroll (knob rotated to the right)	**Rotate Right**
Scroll (knob rotated to the left)	**Rotate Left**
Control Lock	**Control Lock**
Manual Breath	**Manual Brth**
Maneuvers	**Maneuvers**
Silence/Reset	**Silence**

When all controls have been pushed/rotated (except the **Exit** button) and the corresponding name has been verified as being correctly displayed, the Button Test has been successfully completed.

3) To exit the Button Test, push the **Exit** button and **Circuit Test** is displayed.



Circuit Test

The Circuit Test measures the air flow across the patient circuit Flow Sensors, checks the airway circuit for leaks and checks the ventilator's Safety Valve for over-pressure relief.

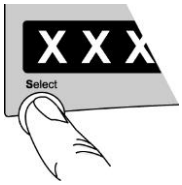
> **⚠ WARNING**
>
> **Patient Breathing Circuit** – The patient circuit must be tested for leaks (Circuit Test) before it is used for the first time and after any changes have been made to the configuration of the circuit. Harm to the patient or ineffective ventilation may result from failure to detect and correct leaks in the patient breathing circuit before connection to a patient.

To Perform the Circuit Test:

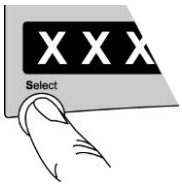
1) Attach the assembled patient circuit to be tested to the ventilator. If the patient circuit has not been previously assembled and attached to the ventilator, see *Test Preparation*, *Power On Self Tests (POST) in Startup Mode* and *Functional Testing in Startup Mode* earlier in this chapter for detailed instructions before proceeding.

2) When **Patient ID** is displayed, rotate the **Scroll** knob on the lower interface panel until **Circuit Test** is displayed and push the **Select** button.
   - **Waiting xx** (**xx** is a numeric count-down from 60 seconds) is displayed when the ventilator transducers have not yet warmed up after power up, followed by displaying **Remove Ptnt**

     OR
   - **Remove Ptnt** is initially displayed



3) When **Remove Ptnt** is displayed, push the **Select** button and the ventilator increases and displays the flow (**Flow XX.X lpm**) through the patient circuit.



> **NOTE**
>
> Do not block the patient connection port of the patient circuit Wye, or of any accessory connected to the Wye (such as a filter, inline suction catheter, etc.) at this point in the test. Flow across the sensors must be unimpeded to establish the flow measurement.

> **⚠ WARNING**
>
> **Failed Auto Zero** - If the ventilator transducers fail to "auto zero" at the beginning of the Circuit Test, a Hardware Fault alarm (**HW Fault**) will be displayed and the test will be stopped. To avoid possible harm to the patient, do not use the ventilator and contact Vyaire or a service technician certified by Vyaire.

Observe and follow the on screen instructions.

- **Unblock Wye** is displayed if the flow is less than 7 lpm
- **Failed Flow** is displayed if the flow is not 7 – 13 lpm for more than 15 seconds
- **Occlude Wye** is displayed when an acceptable flow has been maintained continuously for 3 seconds

4) When **Occlude Wye** is displayed, occlude the patient circuit at the patient end (patient connection port of the Elbow on the patient circuit Wye, filter or other attached accessory). The ventilator will maintain pressure in the circuit at 60 cmH_2O and display the delivered flow from the inspiratory port. Continue to keep the patient circuit end occluded through this step and the next step.
   - **Failed Flow** is displayed and the ventilator stops the test if the acceptance criteria (flow 0 – 0.9 lpm for 3 seconds) is not met within 15 seconds
5) When an acceptable rate of flow (or no flow) has been maintained for 3 seconds, the ventilator will reduce flow and open the safety valve. Continue to keep the circuit occluded until **Passed** or **Failed** is displayed.

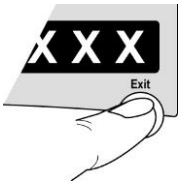
   A measured drop in pressure should occur when the safety valve opens, indicating that the valve is functioning correctly and relieving pressure in the circuit.
   - **Failed Flow** is displayed and the ventilator stops the test if the acceptance criteria (flow does not increase by more than 1 lpm for 2 seconds) is not met within 15 seconds
   - **Failed SV** is displayed if the pressure does not drop
   - **Passed** is displayed when the measured values are within acceptable limits

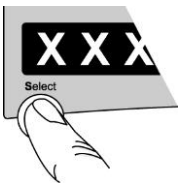
   When **Passed** is displayed, the Circuit Test has been successfully completed.

⚠ WARNING

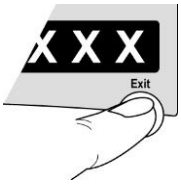
Circuit Test Failure – To avoid possible harm to the patient, do not use a system (ventilator/patient circuit) which fails the Circuit Test. See *Chapter 13 - Troubleshooting*

6) To repeat the Circuit Test, proceed as follows, otherwise skip to the next step:
   - Push the **Exit** button and **Circuit Test** is displayed
   - Push the **Select** button twice to display **Remove Ptnt** and restart the Circuit Test



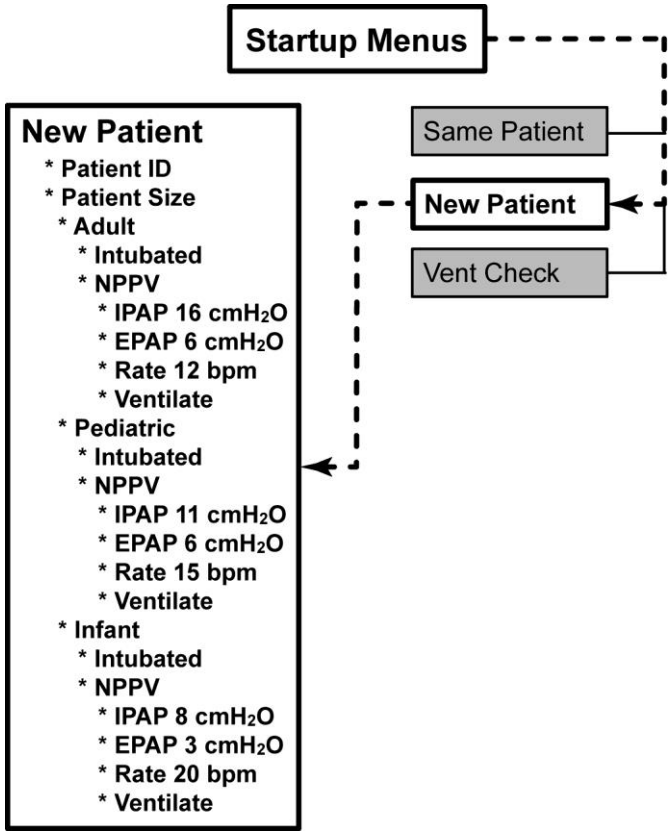


7) To prepare for testing in a normal ventilation mode, exit Vent Check menus by repeatably pushing the **Exit** button until **Same Patient** is displayed.



Functional Testing in Normal Ventilation Mode

The Battery/Power Test, the Display/Alarm Test and the Alarm Response Tests are performed while the ventilator is operating in a normal ventilation mode initiated using Presets[7] values for controls and alarm limits settings for a new patient.



NOTE

Always perform the Button Test and the Circuit Test in Startup mode to verify controls and circuit integrity before performing Functional Testing in normal ventilation mode.

⚠ WARNING

Improperly Functioning Ventilator or Attached Accessories - Operating a ventilator that does not appear to be functioning properly may be hazardous to both patient and operator. If the ventilator or any attached accessory is damaged, fails any tests or malfunctions in any way, immediately discontinue use and contact Vyaire or a service technician certified by Vyaire.

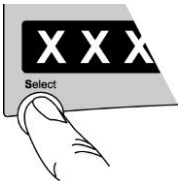
[7] Presets – Automatically set ventilation control and alarm limit values initially clinically appropriate for the patient size and patient circuit type selected by the operator during ventilator setup for a New Patient.

1) To perform testing in a normal ventilation mode, prepare and turn the ventilator on as previously described in this chapter and **Same Patient** is displayed in the display window on the front panel.

    - See *Test Preparation* and *Power On Self Tests (POST) in Startup Mode* in this chapter for detailed information

2) Rotate the **Scroll** knob on the lower interface panel until **New Patient** is displayed, push the **Select** button and **Patient ID** is displayed.

    Rotate the **Scroll** knob again, **Patient Size** is displayed, push the **Select** button and **Adult** is displayed.



3) When **Adult** is displayed, push the **Select** button and **Intubated** is displayed. Push the **Select** button once again to:

    - Clear existing Patient ID, Trend data[8] and Maneuvers history
    - Accept the New Patient settings and begin normal ventilation using Presets controls and alarm limits values initially appropriate for the Patient Size and patient circuit type selected

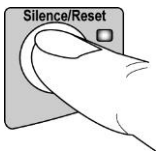
      See *Presets Values for Ventilation Controls* and *Presets Values for Alarm Configurations/Limits* in Chapter 3 – Using the Ventilator for additional information.

NOTE

The Presets **O_2** control value is **40%** and during Functional Testing in a normal ventilation mode, oxygen is not connected to the ventilator until midway through the Alarm Response Tests. Consequently, a **Low O_2 Pres** alarm is generated and must be reset in order to proceed when the ventilator begins normal ventilation.

To Reset the Low O_2 Pres Alarm:

1) When **!! Low O_2 Pres** is displayed, push the **Silence/Reset** button twice on the lower interface panel to reset the alarm (temporarily silence the sounder and clear the alarm message).



[8] Trend data stored by the Revel ventilator can be displayed on a PTM™ Graphics Monitor when the ventilator is docked to a PTV® Series Docking Station with an attached PTM™ Graphics Monitor.

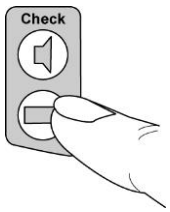
2) Push the **O_2** control button on the front panel to select it, and rotate the **Scroll** knob on the lower interface panel to change the setting to **21** (%)**.**

   Push the **O_2** control button once again to confirm the new setting.

3) Observe the front panel display window for any/all alarm messages displayed (e.g. text preceded by **!**, **!!** or **!!!**):
   - If any alarm messages are displayed, take action as necessary to resolve all alarm conditions before proceeding. See *Chapter 8 - Ventilator Alarms* and *Chapter 13 - Troubleshooting* for additional information and recommended action
   - If scrolling monitored data (**VE**, **MAP**, **PIP**, etc.) is displayed (i.e. no alarm messages), the ventilator is now in a normal ventilation mode and ready for Functional Testing

Battery/Power Test

To verify the status of the ventilator's batteries and external power supplies;



1) Push and hold the Battery/Power **Check** button on the lower interface panel (pushing this button does not interfere with ventilation).

   The ventilator displays a message for each of the four possible sources of power (scrolled in the display window at the top of the front panel), indicating their detection and current status[9]. See *Battery/Power* in Chapter 5 – Controls for a detailed list of messages possibly displayed.

2) Verify that the displayed status message for each power source is consistent with the power source actually attached to the ventilator, e.g.;

   - If a properly functioning AC Adapter is attached to a valid source of power and the ventilator, the External DC Power status message displayed should be **Ext OK**. Conversely, if the ventilator is instead powered from a Docking Station, **Ext Removed** should be displayed

If any fault message (**xxxxx Fault**) or **Batt 50%** (*or less*) is displayed, it is an indication that the displayed source of power (**Batt**, **Ext**, **Dock** or **T-Bat**) has been detected, is not adequate to power the ventilator and is a test failure for either the accessory and/or the ventilator.

- Replace Removable Battery Packs that have failed to charge to more than 50% remaining capacity when fully charged and correct any/all fault conditions prior to using the ventilator (see *Chapter 13 - Troubleshooting* for additional information).

[9] Refer to *Power Status LEDs* in Chapter 6 - Displays and Indicators for additional information concerning the status of various sources of power.

Display/Alarm Test

> **⚠ WARNING**
>
> **Check Alarms** – Alarm function should be tested periodically to ensure proper operation (see *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning, and *Display/Alarm Test* in Chapter 2- Installation and Setup for detailed instructions). If any alarm malfunctions, contact Vyaire or a service technician certified by Vyaire. Failure to immediately identify and correct alarm situations may result in serious patient injury or death.

To verify the status of the ventilator's LED displays, indicators and audible alarm without interfering with the ventilator operation:

1) Push the Display/Alarm **Check** button on the lower interface panel.

2) Verify that all front panel window displays and all lower interface panel indicator LEDs fully illuminate in the colors as indicated in the table below, the sound system generates two audible tones of similar volume followed by a High Priority Alarm Signal[10] that sounds at the set alarm volume, and no "Fault" messages are displayed.

Panel	LED Color
Front Panel:	
• Airway Pressure Manometer LEDs[11]	Amber
• Signal Strength Display LEDs[12]	Amber
• All other LED indicators and displays	Red or Green
Lower Interface Panel:	

• All Power Status indicator LEDs[13]
  • **External Power**
  • **Battery Pack**
  • **Transition Bat.**
  • **Battery Charger**
	Amber

• All other indicator LEDs	Red or Green

3) If any indicator LED, display window LED (includes all LED segments within the window) fails to fully illuminate, or illuminates in a color other than as specified above, it is a test failure.

   Any test failure must be corrected prior to using the ventilator (see *Chapter 13 - Troubleshooting* for additional information).

[10] Refer to *Sound Types, Patterns and Volumes* in Chapter 8 - Ventilator Alarms for additional information.

[11] Refer to *Airway Pressure Manometer* in Chapter 6 - Displays and Indicators for additional information.

[12] Refer to *Oximetry Signal Strength Display* in Chapter 6 - Displays and Indicators for additional information.

[13] Refer to *Power Status LEDs* in Chapter 6 - Displays and Indicators for additional information.

Alarm Response Tests

These tests verify the proper functioning of the ventilator and its alarms. To perform the Alarm Response Tests, a Test Lung must be attached to the patient circuit. See *Additional Preparation Required for Alarm Response Tests:* earlier in this chapter for detailed instructions.

Ventilator Settings and Procedure	Requirement
A) Refer to *Chapter 3 - Using the Ventilator* and *Chapter 8 - Ventilator Alarms* to configure the ventilator settings as follows: **Breath Mode:** A/C **Breath Type:** Volume **Breath Rate:** 12 bpm **Tidal Volume:** 500 ml **Insp. Time:** 1.0 sec **Pres. Support:** "- -" cmH_2O **O_2:** 21 % **Sensitivity:** 3 lpm **Low PEEP Alarm:** "- -" (off) **PEEP:** 0 cmH_2O **High Pres. Limit:** 100 cmH_2O **Low Pk. Pres.:** 5 cmH_2O **Low Min. Vol:** 1.0 L Do not attach an oxygen supply to the ventilator at this time. Run the equipment for at least two minutes.	No alarms activate Selected Monitors should read as follows: Vte: **Vte 383** to **633 ml** I:E Ratio: **I:E 1:3.8** to **1:4.2** Breath Rate: **f 12 bpm** VE: **VE 4.6** to **7.6 L** Lower Interface Panel LED Status: External Power: Green Battery Pack: Off Transition Batt.: Off
B) Set the **O_2** control to 22%.	**Low O_2 Pres** alarm activates
C) Return the **O_2** control to 21% and reset the alarm. Set the **Low Min. Vol.** alarm to 10 L.	**Low Min Vol** alarm activates
D) Return the **Low Min. Vol**. alarm to 1.0 and reset the alarm. Set the **Low Pk. Pres.** alarm to 10 cmH_2O above the Peak Inspiratory Pressure (PIP).	**Low Peak Pres** alarm activates
E) Return the **Low Pk. Pres.** alarm to 5 and reset the alarm. Set the **High Pres. Limit** alarm to 10 cmH_2O below the Peak Inspiratory Pressure (PIP) displayed.	**High Pres** alarm activates
F) Return the **High Pres. Limit** alarm to 100 and reset the alarm.	
G) Connect 40 to 88 PSI oxygen to the unit and set the **O_2** control to 60%. Connect and enable an FIO_2 Sensor (see *Chapter 2 - FIO2 Sensor* for information) and set the **Low FIO_2 Alarm** to 54 % or connect an external oxygen monitor to the patient circuit.	No alarms activate FIO_2 monitor or external oxygen monitor should read: **55** to **65% O_2** +/- the tolerances of the external oxygen monitor.

Ventilator Settings and Procedure		Requirement
H)	Return the **O_2** control to 21%, disable and disconnect the FIO_2 Sensor (see *Chapter 2 - FIO2 Sensor* for information) or external oxygen monitor. Disconnect the High Pressure Sense Line (lower connection) from the ventilator.	**Pat Circuit** alarm activates on the next breath.
I)	Reconnect the High Pressure Sense Line and reset the alarm. Disconnect the Low Pressure Sense Line (upper connection) from the ventilator.	**Pat Circuit** alarm activates on the next breath.
J)	Reconnect the Low Pressure Sense Line and reset the alarm.	
K)	Change the ventilator settings as follows: **Breath Type:** Pressure **Pres. Control:** 40 cmH_2O **High PEEP Alarm:** 25 cmH_2O **PEEP:** 20 cmH_2O **Rise Time:** 4	No alarms activate Selected Monitors should read as follows: PIP: **PIP 54** to **66 cmH_2O** PEEP: **PEEP 18** to **22 cmH_2O**
L)	Disconnect the external power source from the ventilator.	**ExtPwr Lost** alarm activates. If disconnected from a Docking Station, a **Dock Discon** alarm is also activated. Lower Interface Panel LED Status: **External Power:** Off **Battery Pack:** Green **Transition Batt.:** Off **Battery Charger:** Off or flashing amber Ventilator continues to operate
M)	Reset the alarm(s) and remove the Removable Battery Pack from the ventilator for one minute.	**Insert Batt** then **T-Batt Use** alarms display Lower Interface Panel LED Status: **External Power:** Off **Battery Pack:** Flashing red **Transition Batt.:** Green **Battery Charger:** Off Ventilator continues to operate
N)	Reinsert the Removable Battery Pack, reconnect the external power source, and reset all alarms.	No alarms activate Lower Interface Panel LED Status: **External Power:** Green **Battery Pack:** Off **Transition Batt.:** Off **Battery Charger:** Off, green, amber, or flashing amber Ventilator continues to operate
O)	Turn off the ventilator by pushing and holding the **On/Off** button. Observe the ventilator for at least 15 seconds then reset the alarm.	**Saving Config** is momentarily displayed. The Vent Inop alarm sounds for the full 15-seconds The **Vent Inop** LED flashes for the full 15-seconds

Testing is now complete.

Ventilator Testing Worksheet

Perform the testing procedures starting on page 2-17 and record each test result on this worksheet.

SERIAL NUMBER: _____ **CONDUCTED BY:** _____

DATE: _____

Tests:

TEST DESCRIPTION	MEAS. VALUE	REQUIREMENT	PASS / FAIL

Functional Testing in Startup Mode:

Power On Self Tests (POST)		The ventilator:	
		Powers up	
		Performs POST	
		Displays model name or p/n, then **Same Patient**	
Button Test		Correct messages for each control displayed:	
Circuit Test		**Passed** is displayed	

Functional Testing in Normal Ventilation Mode:

Battery/Power Tests Push & hold Battery/Power **Check** button.		Displayed messages are consistent with ventilator/power accessories configuration and no "**Fault**" messages displayed.	
		Batt _ _ _ % (Removable Battery Pack)	
		Ext _ _ _ (External DC Power)	
		Dock _ _ _ (Docking Station Power)	
		T-Bat _ _ _ (Transition Battery)	
Display/Alarm Tests Push Battery/Power **Check** button.		Display / LEDs illuminate as specified, audible alarm system sounds, and no "**Fault**" messages are displayed	
		Front Panel	
		Lower Interface Panel	
		Two audible tones & High Priority Alarm signal	
Alarm Response Tests Configure ventilator settings: **Breath Mode:** A/C **Breath Type:** Volume **Breath Rate:** 12 **Tidal Volume:** 500 **Insp. Time:** 1 **Pres. Support**: "- -" **O_2:** 21 **Sensitivity:** 3 **Low PEEP Alarm:** "- -" **PEEP:** 0 **High Pres. Limit:** 100 **Low Pk. Pres.** 5 **Low Min Vol:** 1		Control values set as specified, and no alarms activated	
		Selected Monitors should read as follows:	
		Vte: **Vte 383** to **633 ml**	
		I:E Ratio: **I:E 1:3.8** to **1:4.2**	
		Breath Rate: **f 12 bpm**	
		VE: **VE 4.6** to **7.6 L**	
		Lower Interface Panel LED Status:	
		External Power: Green	
		Battery Pack: Off	
		Transition Batt.: Off	
Set the **O_2** control to 22%.		**Low O_2 Pres** alarm activates	
Return **O_2** to 21% and reset the alarm. Set the **Low Min. Vol.** alarm to 10 L.		**Low Min Vol** alarm activates	
Return the **Low Min. Vol.** alarm to 1.0 and reset the alarm. Set the **Low Pk. Pres**. alarm to 10 cmH_2O above Peak Inspiratory Pressure (PIP).		**Low PeakPres** alarm activates	

TEST DESCRIPTION	MEAS. VALUE	REQUIREMENT	PASS / FAIL
Return the **Low Pk. Pres**. alarm to 5 and reset the alarm. Set the **High Pres. Limit** alarm to 10 cmH_2O below the PIP displayed.		**High Pres** alarm activates	
Return the **High Pres. Limit** alarm to 100 and reset the alarm.			
Connect 40 to 88 PSI O_2 to the unit and set the **O_2** control to 60. Connect and enable an F_{IO_2} Sensor and set the **Low F_{IO_2} Alarm** to 54% or connect an external O_2 monitor to the patient circuit.		No alarms activate	
		F_{IO_2} Sensor or external oxygen monitor reads: **55 to 65% O_2** +/- the tolerances of the external oxygen monitor.	
Return the **O_2** control to 21%, disable and disconnect the F_{IO_2} Sensor or external oxygen monitor. Disconnect the High Pressure Sense Line from the ventilator.		**Pat Circuit** alarm activates on the next breath	
Reconnect Sense Line and reset the alarm.			
Disconnect the Low Pressure Sense line from the ventilator.		**Pat Circuit** alarm activates on the next breath	
Reconnect Sense Line and reset the alarm.			
Change ventilator settings as follows: **Breath Type:** Pressure **Pres. Control:** 40 **High PEEP Alarm:** 25 **PEEP:** 20 **Rise Time:** 4		No alarms activate	
		Selected Monitors should read as follows:	
		PIP: **PIP 54** to **66 cmH_2O**	
		PEEP: **PEEP 18** to **22 cmH_2O**	
Disconnect external power source.		**Ext Pwr Lost** alarm activates. **Dock Discon** alarm also activates if disconnected from a Docking Station.	
		Lower Interface Panel LED Status:	
		External Power: Off	
		Battery Pack: Green	
		Transition Batt.: Off	
		Battery Charger: Off or flashing Amber	
		Ventilator continues to operate	
Reset alarm(s) and take out Removable Battery Pack for one (1) minute.		**Insert Batt** then **T-Batt Use** alarms display	
		Lower Interface Panel LED Status:	
		External Power: Off	
		Battery Pack: Flashing Red	
		Transition Batt.: Green	
		Battery Charger: Off	
		Ventilator continues to operate	
Insert Removable Battery Pack, connect external power source and reset all alarms.		No alarms activate	
		Lower Interface Panel LED Status:	
		External Power: Green	
		Battery Pack: Off	
		Transition Batt.: Off	
		Battery Charger: Off, green, amber, or flashing amber	
		Ventilator continues to operate	
Turn the ventilator off. Observe the ventilator for at least 15 seconds and reset alarm.		**Saving Config** is momentarily displayed.	
		Vent Inop audible alarm sounds for the full 15-seconds	
		Vent Inop LED flashes for the full 15-seconds	

Chapter 3 - USING THE VENTILATOR

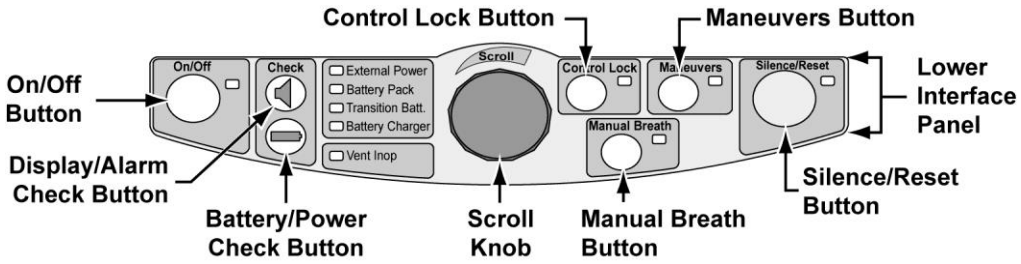
User Interface(s)

This section describes the three main user interfaces utilized by the ReVel ventilator:

Lower Interface Panel Push Buttons	Used to power the ventilator on or off, silence/reset audible alarms, check/test displays, alarms and power, or initiate specific procedures or maneuvers.
Lower Interface Panel Scroll Knob	Used to change selected feature configurations, ventilation control or alarm limit values, and scroll through monitored data, Startup and Extended Features menus.
Front Panel Push Buttons	Used to select and confirm most ventilation control and alarm limit values and Startup and Extended Features menus.

The Lower Interface Panel

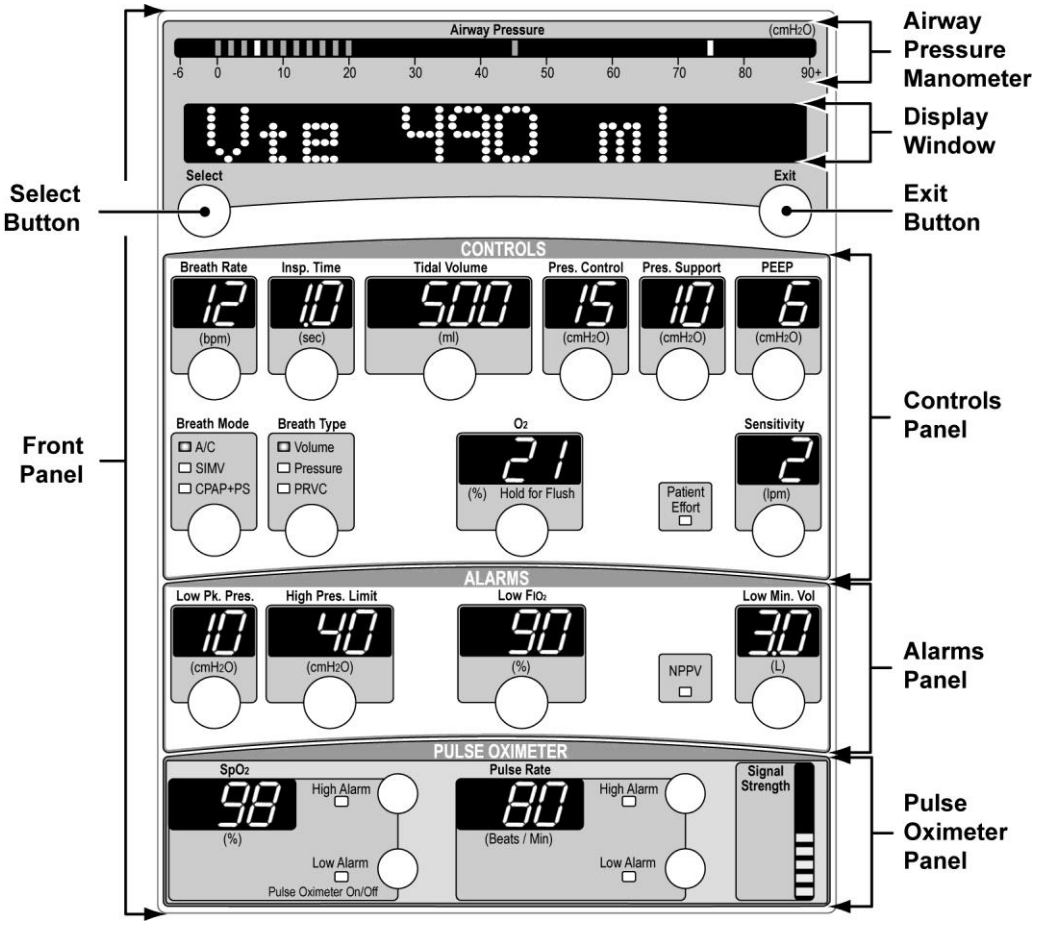
For detailed descriptions of each individual control's function and complete instructions for their use, see *Lower Interface Panel* in Chapter 5 - Controls.



The Front Panel

The front panel consists of five main areas:

- Airway Pressure Manometer
- Display Window (with associated **Select** and **Exit** buttons)
- Controls Panel
- Alarms Panel
- Pulse Oximeter Panel



For detailed descriptions of each individual display, control and alarm function, see:

- *Airway Pressure Manometer* and *Display Window* in Chapter 6 – Displays and Indicators
- *Front Panel, Display Window, Front Panel, Controls, Front Panel, Alarms* and *Front Panel, Pulse Oximeter* in Chapter 5 – Controls

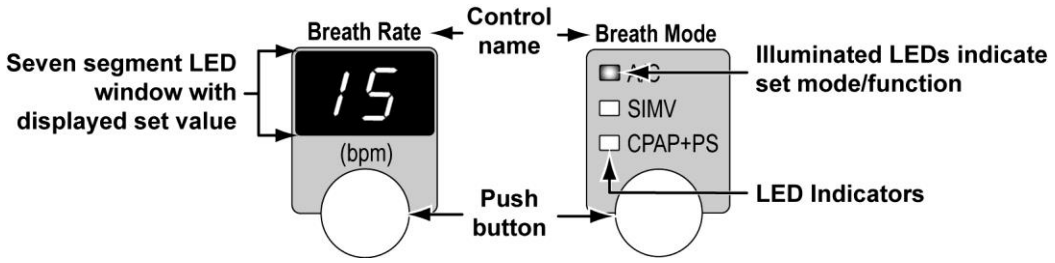
Front Panel Ventilation and Alarm Controls

There are three main types of ventilation and alarm controls on the ReVel front and lower interface panels:

- Adjustable Controls
- Push Buttons
- Scroll Knob

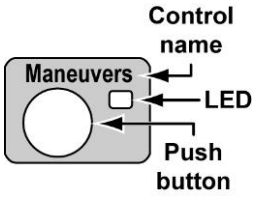
Adjustable Controls

Ventilation and alarm controls that have segmented LED front panel displays, or LED indicators with an associated push button. The ventilation settings and alarm values displayed or modes/functions indicated can be modified within a preset range.



Push Buttons

Momentary push buttons (with or without associated displays or LED indicators) used to select and confirm settings and options, or initiate a pre-determined function.



Scroll Knob

A rotary encoder knob on the lower interface panel used to change the settings of selected adjustable controls, or scroll through various configuration menus displayed in the front panel display window.

Display Characteristics

Bright, Dim and Blank Segmented LED Control Displays

Variable control segmented LED displays can be illuminated at normal or dimmed intensity, or may be blank (extinguished).

An LED display is illuminated at normal intensity:

- When it is active in the current ventilation mode. Dimmed displays are not active in the current mode
- When it is selected for change. All other displays will be dimmed

An LED display illumination is dimmed:

- When another control is selected for change
- When it is not active in the current ventilation mode

> **⚠ WARNING**
>
> **Apnea Backup Controls** - Be sure to set any controls used in Apnea Backup ventilation to appropriate values for your patient. Even though the associated displays are dimmed during normal ventilation, they will be used if Apnea should occur.

An LED display is blank:

- To conserve battery power when operating on the Transition Battery (to turn the displays back on, push any button or rotate the **Scroll** knob)
- When a control feature is not available, such as during ventilator checkout tests
- When the sensor for an installed option, such as SpO_2, is not connected to, or communicating with the ventilator

Flashing LEDs

LED displays/indicators associated with adjustable controls may display solid or flashing. A flashing display/indicator means one of the following things:

- If a control's segmented LED display is flashing, you have reached the upper or lower limit for the control, or a special condition such as the time termination of a Pressure Support breath has occurred. Control limiting is discussed in this section, for Time Termination see *Chapter 5 - Controls*
- If a control's LED indicator is flashing, it indicates that the control has been selected within the last 15 seconds and the indicated mode or function (changed or not) has not yet been confirmed
- If the **Control Lock** LED indicator is flashing, the ventilator's controls are locked and the **On/Off**, or a ventilation or alarm control button has been pushed within the last 5 seconds. For more information, see *Chapter 5 - Controls*
- If an alarm's segmented LED display is flashing, it indicates that an alarm has occurred or is occurring. See *Chapter 8 - Ventilator Alarms* for more information

Dashes Displayed

When dashes ("**- -**") are displayed in a control's segmented LED display, it's an indication that the associated control or alarm is turned off.

Setting Adjustable Front Panel Ventilation Controls and Alarm Limits

Most of the ventilators' front panel adjustable ventilation and alarm limit controls use a simple three step method of "Select, Change and Confirm" to set configuration values.

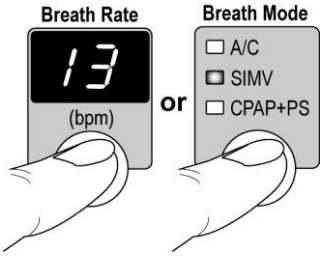
Select

Select the active control to be changed by pushing its associated control push button.

- Controls with segmented LED displays – The displays remain at full intensity and all other active control displays are dimmed

or

- Controls with LED indicators – The LED indicator begins flashing



Change

Change the displayed value or indicator illuminated by rotating the **Scroll** knob on the lower interface panel.

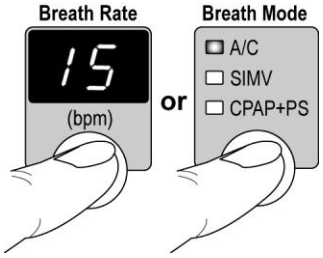
Confirm

Confirm the change by pushing the associated control push button again.

- Controls with segmented LED displays – All other active control displays return to their full intensity and the ventilator accepts the new setting

or

- Controls with LED indicators – The LED indicator stops flashing and the ventilator accepts the new setting



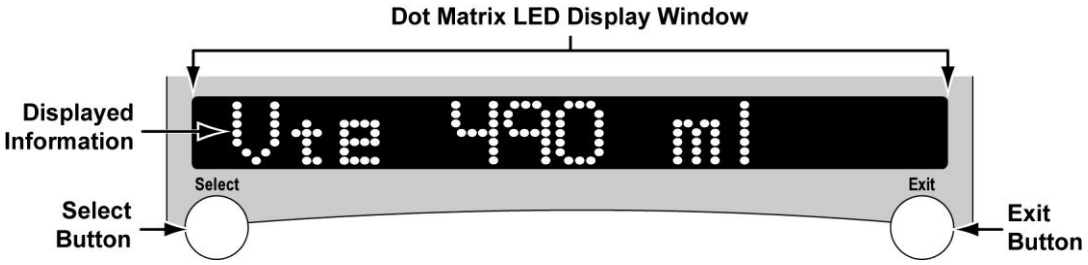
NOTE

If a selection of, or change to a control is not confirmed within 15 seconds, it automatically returns to the active state and the value, mode, or function (if changed) returns to the original value, mode, or function, unchanged.

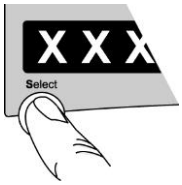
Pushing a control button while another control is already selected de-selects the previous control without changing its value, mode, or function. You must confirm a change, by pushing the associated control button a second time, before the ventilator accepts a new value, mode, or function.

Automatic or Manual Data Display Scrolling

Monitored data displays may be automatically or manually scrolled in the front panel display window during normal ventilation modes. When automatically scrolled, each value is displayed for three seconds and is updated in real time.



1) To pause automatic scrolling of displayed data, push the **Select** control button and scrolling will halt on the data currently displayed.

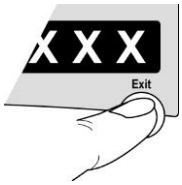


2) To cycle through data manually from a halted scan, rotate the **Scroll** knob on the lower interface panel to increment the display.

NOTE

You cannot manually scroll through monitored data while in the Extended Features menus.

3) Push the **Exit** control button to resume auto-scrolling in normal ventilation mode.

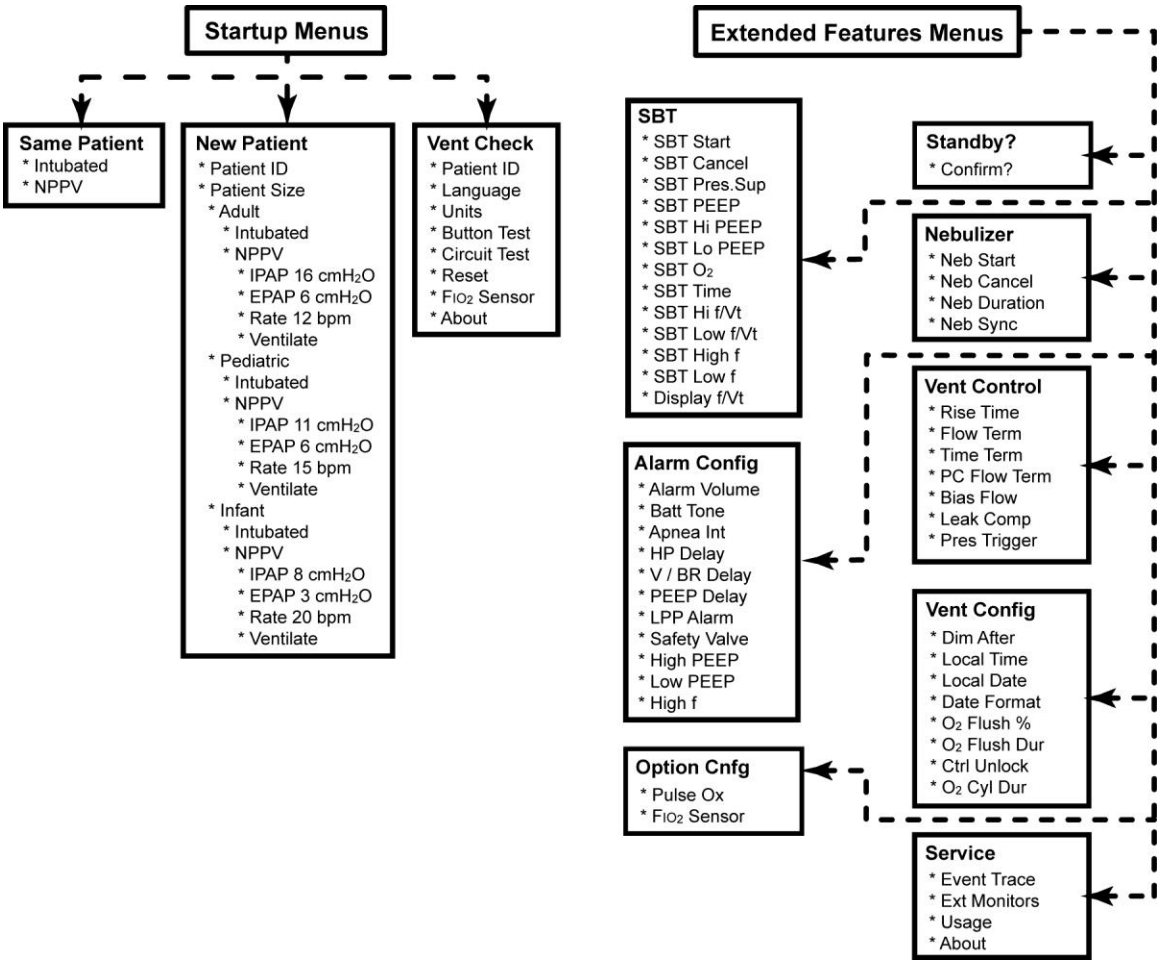


For additional information concerning monitored data displayed, see *Chapter 7 - Monitored Data.*

Navigating Startup and Extended Features Menus

When displayed in the front panel display window, Startup and Extended Features menus provide access to controls, monitors, features and options that do not have dedicated front panel controls or displays.

- For additional information concerning these menus, see *Startup Mode and Menus* later in this chapter and *Extended Features Menus* in Chapter 10 – Extended Features.



NOTE

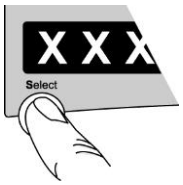
Startup menus are only displayed and accessed when the ventilator is initially turned on and the ventilator is in Startup mode.

Extended Features menus are only displayed and accessed while the ventilator is in a normal ventilation mode. Extended Features menus cannot be accessed when the front panel controls are locked.

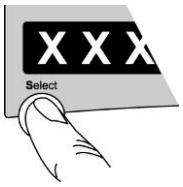
To Enter and View Startup Menus

To enter Startup menus while the ventilator is in Startup mode, rotate the **Scroll** knob on the lower interface panel until the desired menu is displayed (e.g. **Same Patient**, **New Patient** or **Vent Check**) and push the **Select** control button.

- To view the next menu item, rotate the **Scroll** knob clockwise
- To view the previous menu item, rotate the **Scroll** knob counterclockwise

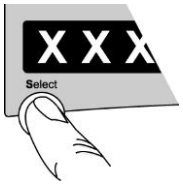


To Access, Enter and View Extended Features Menus

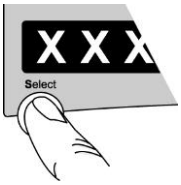


1) To access Extended Features menus while the ventilator is in a normal ventilation mode, push and hold the **Select** control button for three seconds.

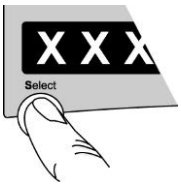
2) To enter a displayed Extended Features menu, rotate the **Scroll** knob on the lower interface panel until the desired menu is displayed (e.g. **Standby**, **SBT**, **Nebulizer**, **Alarm Config**, **Vent Control**, **Vent Config**, **Option Cnfg**, or **Service**) and push the **Select** control button.
    - To view the next menu item, rotate the **Scroll** knob clockwise
    - To view the previous menu item, rotate the **Scroll** knob counterclockwise



To Select, Change and Set Startup or Extended Features Control Values and Feature Configurations



1) To select an Extended Features displayed control value or feature configuration, push the **Select** control button.
2) To change the control value or feature configuration of a selected menu item, rotate the **Scroll** knob until the desired value or feature configuration is displayed and push the **Select** control button. The new value or configuration is accepted and the previous menu item is displayed.



To Exit Startup or Extended Features Menus

Startup Menus

To exit a selected Startup menu once entered, push the **Exit** button (repeatedly, as necessary) until the desired previous menu or **Same Patient** is displayed.

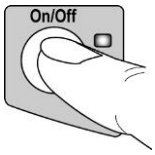
Extended Features Menus

To exit a selected Extended Features menu once entered, push the **Exit** button (repeatedly, as necessary) until the desired previous menu is displayed, or auto-scrolling of monitored data is resumed.

> **NOTE**
> You can select and configure a different menu item at any point during the exit sequence.

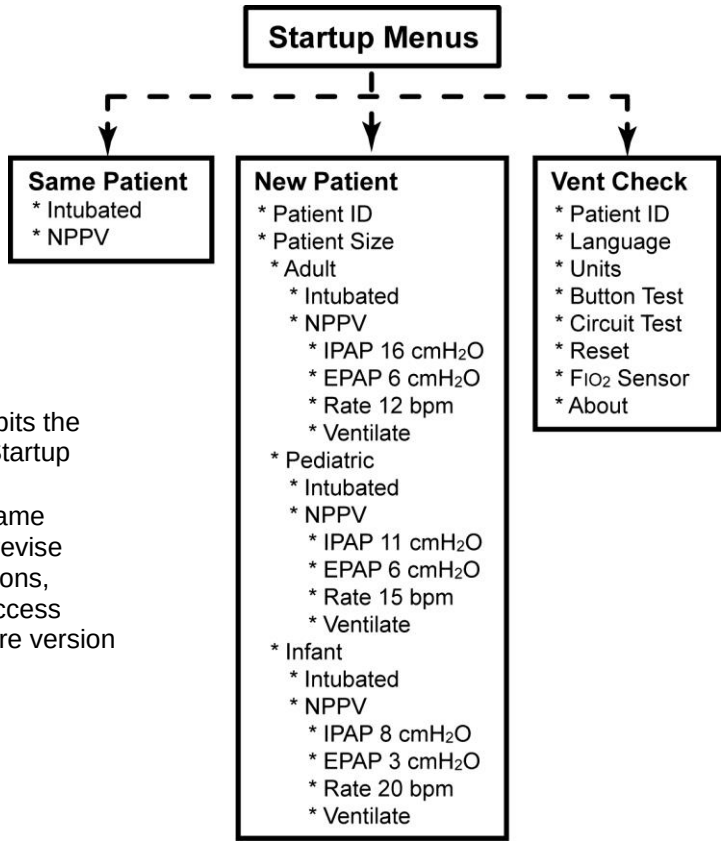
Starting the Ventilator

With the ventilator powered off, push the **On/Off** button on the lower interface panel momentarily. The ventilator powers up, performs POST (Power On Self Test), briefly displays **ReVel** followed by **Same Patient**.



Startup Mode and Menus

> **⚠ WARNING**
>
> **Startup Mode** – The ventilator does not deliver gas to the patient while in Startup mode.



While in Startup mode, the ventilator inhibits the normal delivery of gas and displays the Startup menus.

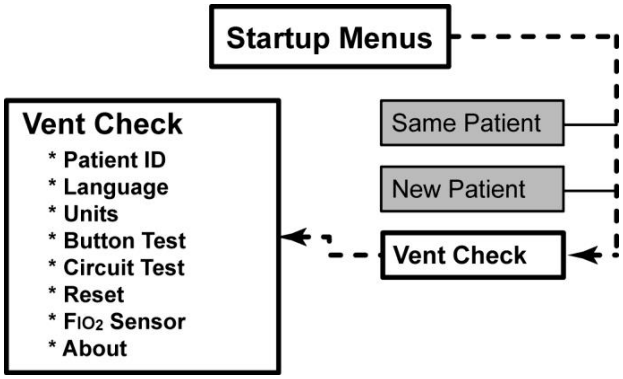
The Startup menus are used to initiate Same Patient or New Patient ventilation, enter/revise Patient ID, set basic ventilator configurations, perform specific functional testing, and access ventilator component revision and software version information.

To Exit Startup Mode

Exit the startup mode by entering a normal ventilation mode via the **Same Patient** and **New Patient** menus, or by turning the ventilator off by pushing and holding down the **On/Off** button on the lower interface panel.

To View Patient ID

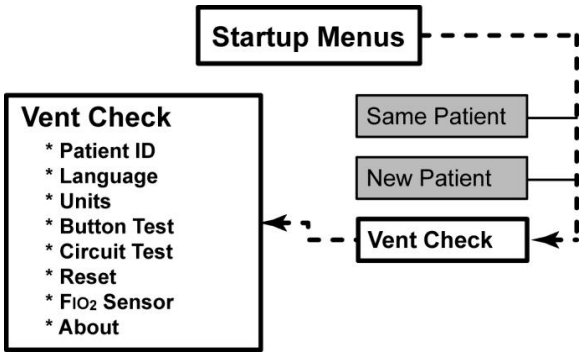
The Vent Check, Patient ID menu is used to view the current patient identification number (if any) entered into the ventilator.



1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Push the **Select** button and the last patient identification number entered is displayed.
   - 12 dashes are displayed if a patient identification number has not been entered

To Set Language and Units

The Vent Check, Language and Units menus are used to set the language and units of measure used and displayed by the ventilator. Changing these settings will have a universal affect on the language and units of measure displayed.



1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Rotate the **Scroll** knob until the **Language** or **Units** menu is displayed (as desired), push the **Select** button and the applicable current configuration setting for language (e.g. **English**[14]), or the unit of measure (e.g. **cmH_2O / PSI**[15]) is displayed.
3) Rotate the **Scroll** knob until the desired language or unit of measure is displayed, push the **Select** button, the change is accepted and the previous menu (**Language** or **Units**) is displayed.

[14] The **Language** menu options are presently fixed at **English**.
[15] The **Units** menu options are presently fixed at **cmH_2O / PSI**.

To Perform Functional Testing (Button and Circuit Test)

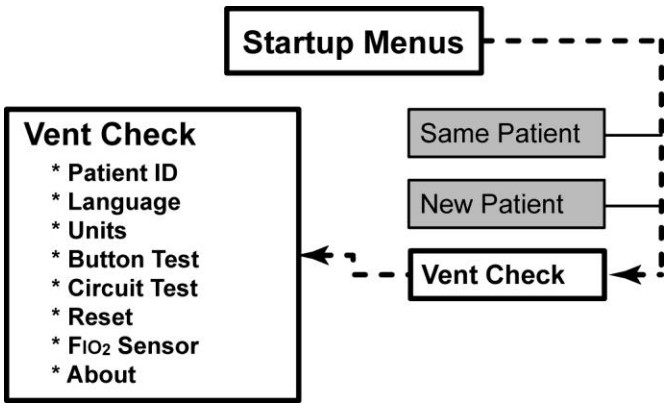
To perform functional testing in Startup mode (Button or Circuit Test), see *Functional Testing in Startup Mode* in Chapter 2 – Installation and Checkout for detailed instructions.

- See *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning for recommended periodic maintenance and testing schedules

To Reset to Default Values

The Vent Check, Reset menu is used to reset all adjustable controls, alarms and configuration settings, with the exception of the Language, Units, Date/Time settings, Patient ID, and F_{IO_2} calibration and Circuit Test results, to their original factory-set default values.

- See *Factory Settings* in Appendix C - Reference Information for a complete list of the original factory-set configuration values



NOTE

Using the **Reset** menu/function can have a universal affect on the basic configuration of the ventilator (e.g. ventilation mode used, ventilation controls and alarm limits settings, etc.).

1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Rotate the **Scroll** knob until **Reset** is displayed, push the **Select** button and **Confirm**? is displayed.
3) To confirm resetting the ventilator's adjustable controls, alarms and configuration settings to factory-set default values, push the **Select** button, **ConfigReset** is displayed and the settings changes are accepted. Push the **Exit** button twice to display the **Reset** menu.

   or

   To cancel resetting the ventilator's adjustable controls, alarms and configuration settings to factory-set default values and exit the **Confirm?** menu option, push the **Exit** button and **Reset** is displayed.

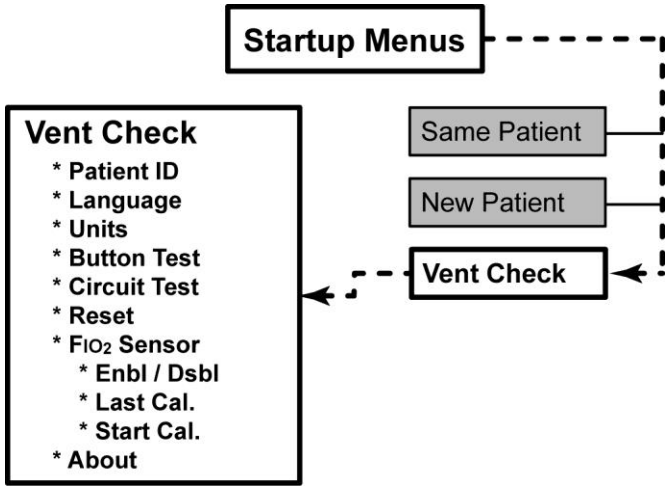
FIO_2 Sensor Configuration and Calibration

The Vent Check, FIO_2 Sensor menus are used to enable or disable ventilator communication with an FIO_2 sensor, view the date of the last successful calibration, and calibrate the sensor.

- Contact Vyaire for oxygen sensor part numbers and pricing information. See *Appendix A - Contact Information* for contact and ordering information
- To assemble the FIO_2 Sensor Assembly and insert it into the patient circuit (after calibration), see the Instructions for Use provided with the FIO_2 Sensor assembly

Once setup, enabled and calibrated, communication with the FIO_2 sensor may be enabled/disabled during normal ventilation modes using the Extended Features menus.

- See *FIO2 SENSOR* in the Extended Features, Option Cnfg menus in Chapter 10 – Extended Features for additional information



To Enable or Disable FIO_2 Monitoring

1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Rotate the **Scroll** knob until **FIO_2 Sensor** is displayed, push the **Select** button and **Enbl / Dsbl** is displayed.
3) Push the **Select** button and either **Enable** or **Disable** is displayed. If necessary, rotate the **Scroll** knob until the desired menu is displayed and push the **Select** button again. The selected communication status is set and **Enbl / Dsbl** is displayed.

To View Last Successful FIO_2 Calibration

1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Rotate the **Scroll** knob until **FIO_2 Sensor** is displayed, push the **Select** button and **Enbl / Dsbl** is displayed.
3) Rotate the **Scroll** knob until **Last Cal.** is displayed, push the **Select** button and the date of the last successful FIO_2 sensor calibration is displayed.
    - _ _ **/** _ _ **/** _ _ is displayed if no previous successful calibration data is available

To Calibrate the FIO_2 Sensor

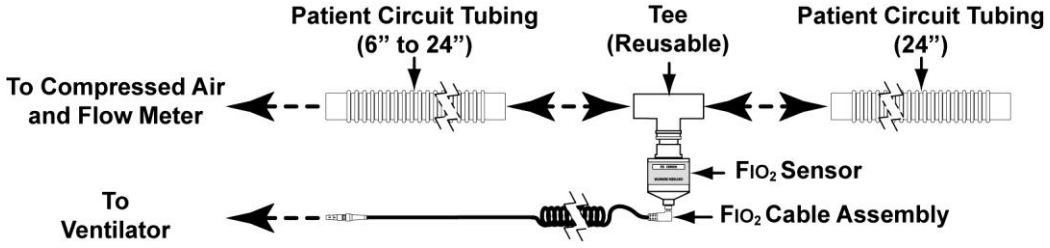
The Vent Check, FIO_2 Sensor menus are used to perform a two-point (**21%** and **100% O_2**) calibration of an attached FIO_2 Sensor.

⚠ WARNING

Calibration of Sensor - Accurate monitored FIO_2 readings cannot be obtained unless the O_2 Sensor has been enabled and properly calibrated to the ventilator. If a discrepancy is observed between the O_2 blender setting and the FIO_2 monitor reading, recalibrate the FIO_2 Sensor. If the discrepancy persists, contact Vyaire or a service technician certified by Vyaire for assistance. See *Chapter 13 - Troubleshooting* for more information.

Off Patient Calibration - All sensor calibration is performed with the ventilator off the patient and in the Startup mode of operation.

1) Assemble the reusable tee (P/N 13037-001), FIO_2 cable assembly (P/N 13897-001), and oxygen sensor (P/N 13036-001) to be calibrated.
    - See the Instructions for Use (P/N 33879-001) provided with the FIO_2 sensor assembly for detailed instructions
2) Attach the FIO_2 cable assembly to the ventilator.
    - See *To Connect the FIO2 Sensor* in Chapter 2 – Installation and Setup for detailed instructions
3) Attach a 6” to 24” length of patient circuit tubing between one end of the reusable tee and a flow metered source of compressed air, set for a flow of 5 lpm (range 3 to 10 lpm).
4) Attach a 24” length of patient circuit tubing to the other end of the reusable tee.



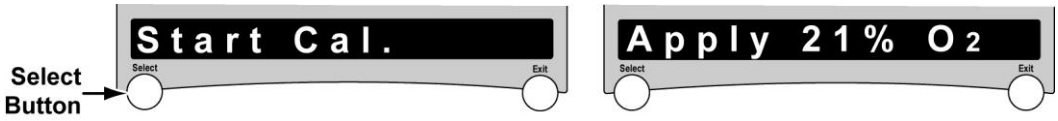
NOTE

- Calibration of the Oxygen Sensor should not be attempted until the sensor has reached thermal equilibrium with the ambient room temperature. Depending on the temperature variation the sensor may have recently been exposed to, this can take up to 2 hours. Additionally, holding the sensor in your hand for more than a few minutes can affect the temperature tracking which appears as a slow drift displayed by the ventilator.
- If the **Remove Ptnt** alarm occurs during the FIO_2 Sensor calibration, clear the alarm by pushing the Silence/Reset button two times. The FIO_2 Sensor calibration is not interrupted if the alarm occurs.

5) Turn the ventilator on and enter the Startup mode, **Vent Check** menu, as previously described, then rotate the **Scroll** knob until **FIO_2 Sensor** is displayed, push the **Select** button and **Enbl / Dsbl** is displayed.

6) Push the **Select** button and either **Enable** or **Disable** is displayed. If necessary, rotate the **Scroll** knob until **Enable** is displayed and push the **Select** button again.
   - Communication with the FIO_2sensor is enabled and **Enbl / Dsbl** is displayed

7) Rotate the **Scroll** knob until **Start Cal.** is displayed, push the **Select** button and **Apply 21% O_2** is displayed in the front panel display window.



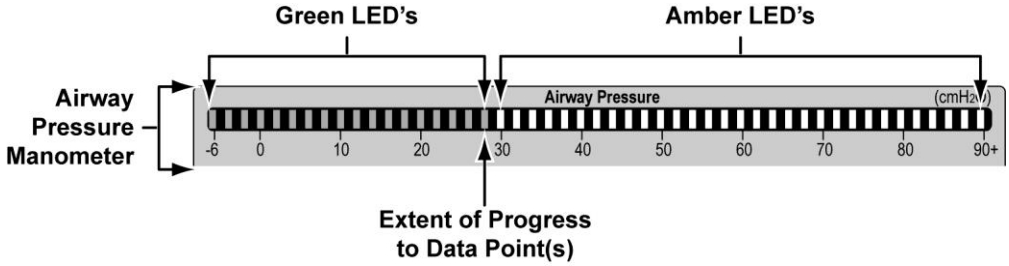
8) Expose the FIO_2 Sensor to 21% O_2 (compressed air source) for up to five (5) minutes using a Flow Meter and apply 3 to 10 lpm (nominal 5 lpm) through the patient Circuit past the FIO_2 sensor until the displayed message changes to **Apply 100% O_2**, then push the **Select** button.

NOTE

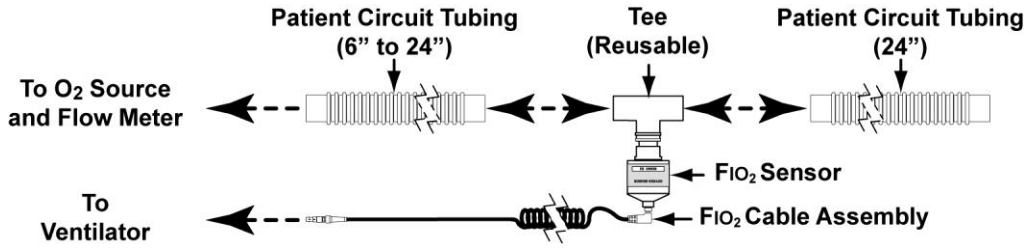
It is important to expose the sensor to 21% and 100% O_2 without an increase in pressure. Enclosing the sensor (for example in a bag) to apply the gas may increase pressure and cause inaccuracies in the calibration.

While the ventilator is processing the data, the LED's in the Airway Pressure Manometer at the top of the front panel are fully illuminated (amber) and progress toward the 21% data point is illuminated by green LED's (left to right).

When completed, **Apply 100% O_2** is displayed in the front panel display window.



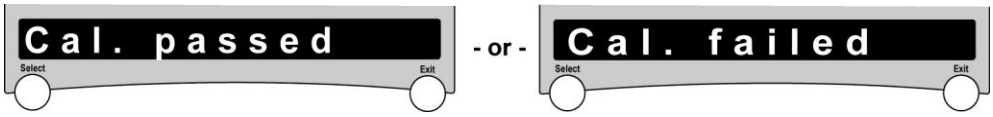
9) When **Apply 100% O_2** is displayed, disconnect the patient circuit tubing from the source of compressed air and reattach it to a flow metered source of 100% oxygen (O_2), also set for a flow of 5 lpm (range 3 to 10 lpm).



10) Turn the source of oxygen (O_2) on, exposing the sensor to a 5 lpm (range 3 to 10 lpm) of flow until the displayed message changes to **Cal. passed** or **Cal. failed** (this also, may take up to five (5) minutes).

    Again, while the ventilator is processing the data, progress toward the 100% data point is displayed in the Airway Pressure Manometer.

11) When completed, either **Cal. passed** or **Cal. failed** is displayed in the front panel display window.



    If **Cal. passed** is displayed, the most recent successful FIO_2 Sensor calibration date is updated to the current date, and the calibration process is complete.

    or

    If **Cal. failed** is displayed, calibration failed and must be performed again.

NOTE

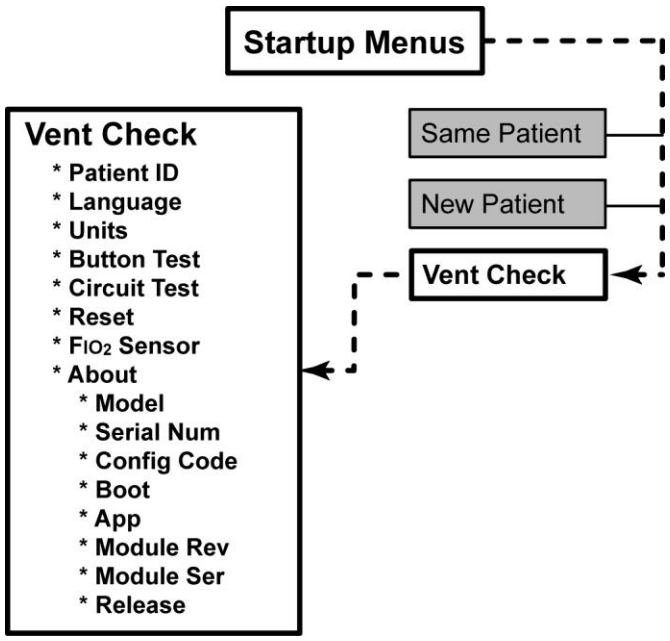
When calibration fails, it is possible that the sensor is bad. Try calibrating another sensor with the ventilator. If you are unable to calibrate the second sensor, contact Vyaire or a service technician certified by Vyaire for assistance.

To ensure accurate FIO_2 measurements, the FIO_2 Sensor must be calibrated to the ventilator upon initial ventilation of a new patient and if FIO_2 measurements become inaccurate based on the **O_2** ventilator setting.

To View Ventilator, Component and Software Configuration Information

The Vent Check, About menus are used to view specific information not accessible on the front panel, including the ventilator model name, serial number, and hardware/software versions.

- The About menu and related sub-menus/information is also available during normal ventilation via the Extended Features menus. See *About* in Chapter 10 – Extended Features for detailed information



1) While in Startup mode, rotate the **Scroll** knob until **Vent Check** is displayed, push the **Select** button and reset the Remove Patient alarm (**!!! Remove Ptnt**) by pushing the Silence/Reset button twice. **Patient ID** is displayed.
2) Rotate the **Scroll** knob until **About** is displayed, push the **Select** button and **Model** is displayed.
3) Rotate the **Scroll** knob to view the available sub-menus, push the **Select** button to view the related information of displayed menus and the **Exit** button to return to the previous menu(s).

Normal Ventilation Modes

After turning the ventilator on and silencing/resetting the alarm (see *Starting the Ventilator* earlier in this chapter for instructions), normal ventilation modes can be initiated using either the patient ventilation settings that were in effect the last time the ventilator was powered down (**Same Patient**), or ventilation controls and alarm configurations/limits automatically set to initial values clinically appropriate for a new patient (**New Patient**).

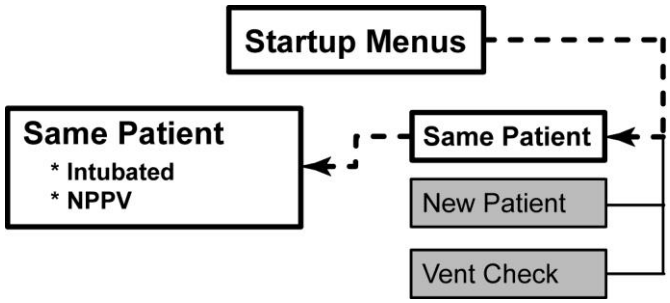
- See *Presets Values for Ventilation Controls* and *Presets Values for Alarm Configurations/Limits* later in this chapter for additional information

⚠ WARNING

Review Adjustable Control and Alarm Settings Regularly - To avoid possible harm to the patient, operators should review and adjust (if necessary) all user adjustable ventilation and alarm control settings regularly to assure they are set at appropriate values for the patient.

To Initiate Normal Ventilation Modes Using Existing Settings

The Same Patient menus are used to initiate ventilation using the ventilation control and alarm configurations/limits settings that were in effect the last time the ventilator was powered down.



NOTE

When a **ConfigReset** alarm has been generated or an operator has utilized the **Reset** control, all user adjustable settings (except Language, Units, Local Date, Local Time/Date Format, Patient ID and FIO_2 calibration, and Circuit Test results) are reset to the original factory-set default values. Selecting the **Same Patient** button/option will not restore the previous patient settings.

1) While in Startup mode, rotate the **Scroll** knob until **Same Patient** is displayed, push the **Select** button and **Intubated** is displayed.
2) To select an intubated type of patient circuit to patient interface and initiate ventilation, push the **Select** button.

   or

   To select a non-invasive type of patient circuit to patient interface and initiate ventilation, rotate the **Scroll** knob until **NPPV** is displayed and push the **Select** button.

NOTE

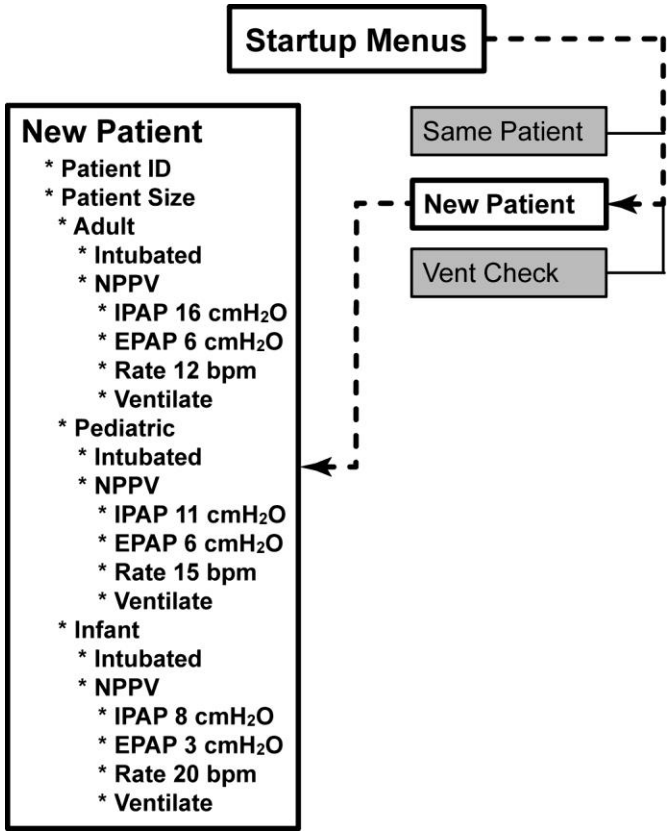
When the **Same Patient** menu is selected in Startup mode and;

- If the ventilator to patient interface selected is **Intubated** and the previous setting was **NPPV**, the Breath Mode and Breath Type will be set to their last selected / preset Intubated interface settings
- If the ventilator to patient interface selected is **NPPV** and the previous setting was **Intubated**, the Breath Mode will be set to **CPAP+PS** and the Breath Type will be set to **Pressure**

To Initiate Normal Ventilation Modes Using Presets Settings

The Presets[16] feature allows operators to use the New Patient menus to enter a patient ID number, set patient size and type of patient circuit to patient interface, and initiate ventilation using ventilation controls and alarm configurations/limits automatically set to initial values clinically appropriate for a new patient.

- See *Presets Values for Ventilation Controls* and *Presets Values for Alarm Configurations/Limits* later in this chapter for additional information



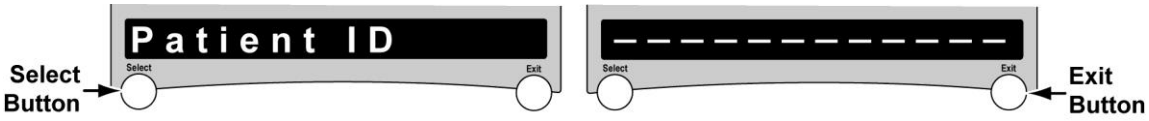
[16] Presets – Automatically set ventilation control and alarm limit values initially clinically appropriate for the patient size and patient circuit type selected by the operator during ventilator setup for a New Patient.

To Enter a Patient Identification Number (optional)

The New Patient, Patient ID menu is used to enter an up to 12 character patient identification number (if desired).

- To proceed to the next menu item without entering a Patient ID number, simply rotate the **Scroll** knob until **Patient Size** is displayed

1) While in Startup mode, rotate the **Scroll** knob until **New Patient** is displayed, push the **Select** button and **Patient ID** is displayed. Push the **Select** button again and twelve (12) dashes are displayed.



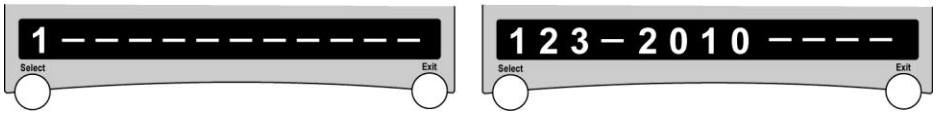
2) Push the **Select** button again and the first dash in the patient identification display begins flashing. Rotate the **Scroll** knob until the desired number or dash is displayed and push the **Select** button to confirm the selection.

   The displayed number or dash is accepted (stops flashing) and the next dash to the right begins flashing.

   Range: Each of the 12 spaces will accept numeric (**0** through **9**) digits, or a " – " (dash).

3) Repeat the process of rotating the **Scroll** knob and pushing the **Select** button to fill each of the 12 available character spaces with a number or dash, as desired.

   - To cancel Patient ID editing, push the **Exit** button at any time prior to setting the 12th (final) character. The previous Patient Identification is restored and the **Patient ID** menu is displayed



4) When all spaces have been edited, push the **Select** button again to accept the new patient identification, exit the Patient ID edit mode and display the **Patient ID** menu.

To Set the Patient Size

The New Patient, Patient Size menus are used to set the patient size to be used by the ventilator to calculate ventilation control and alarm configurations/limits to initial values clinically appropriate for a new patient of the selected size/weight.

1) While in Startup mode, rotate the **Scroll** knob until **New Patient** is displayed, push the **Select** button and **Patient ID** is displayed.

   Rotate the **Scroll** knob again, **Patient Size** is displayed, push the **Select** button and **Adult** is displayed.

2) Rotate the **Scroll** knob (if necessary) until the applicable patient size is displayed and push the **Select** button.

   Range: **Adult** (>40 kg), **Pediatric** (10-40 kg), or **Infant** (5-10 kg)

To Set the Type of Patient Circuit to Patient Interface and Initiate Ventilation

The New Patient, Intubated or NPPV menus are used to set the type of patient circuit to patient interface to be used by the ventilator to calculate ventilation control and alarm configurations/limits to initial values clinically appropriate for the type of interface selected.

1) When the applicable patient size menu (**Adult, Pediatric,** or **Infant**) has been displayed and selected (**Select** button pushed), **Intubated** is displayed.

2) To select an intubated type of patient circuit to patient interface and initiate ventilation, continue; otherwise skip to the next step.

   When **Intubated** is displayed, push the **Select** button, the ventilator clears the existing Patient ID, Trend data[17], Maneuvers history, accepts the new settings and begins a normal ventilation mode using the Presets ventilation control and alarm configurations/limits values associated with the patient size and type of patient circuit to patient interface settings selected.

3) To select a non-invasive type of patient circuit to patient interface when **Intubated** is displayed, rotate the **Scroll** knob until **NPPV** is displayed, push the **Select** button and **IPAP xx cmH_2O** is displayed.

4) To change the displayed default Inspiratory Positive Airway Pressure (IPAP) value, continue; otherwise skip to the next step.

   When the default IPAP value is displayed, push the **Select** button (all but the numeric value of the displayed message is dimmed), rotate the **Scroll** knob until the desired value is displayed and push the **Select** button. The new IPAP value is accepted and **EPAP x cmH_2O** is displayed.

   The actual default IPAP numeric value initially displayed is dependent on the patient size previously selected;

   - Adult default IPAP value: **16 cmH_2O**, Adjustable Range: **6** to **60 cmH_2O**
   - Pediatric default IPAP value: **11 cmH_2O**, Adjustable Range: **6** to **60 cmH_2O**
   - Infant default IPAP value: **8 cmH_2O**, Adjustable Range: **3** to **60 cmH_2O**

5) To accept the displayed IPAP value, rotate the **Scroll** knob until **EPAP x cmH_2O** is displayed.

[17] Trend data stored by the Revel ventilator can be displayed on a PTM™ Graphics Monitor when the ventilator is docked to a PTV® Series Docking Station with an attached PTM™ Graphics Monitor.

6) To change the default Expiratory Positive Airway Pressure (EPAP) value, continue; otherwise skip to the next step.

   When the default EPAP value is displayed, push the **Select** button (all but the numeric value of the displayed message is dimmed), rotate the **Scroll** knob until the desired value is displayed and push the **Select** button. The adjusted EPAP value is accepted and displayed.

   The actual default EPAP numeric value initially displayed is dependent on the patient size previously selected;

   - Adult default EPAP value: **6 cmH_2O**, Adjustable Range: **0** to **16 cmH_2O**
   - Pediatric default EPAP value: **6 cmH_2O**, Adjustable Range: **0** to **11 cmH_2O**
   - Infant default EPAP value: **3 cmH_2O**, Adjustable Range: **0** to **8 cmH_2O**

7) To accept the displayed EPAP value, rotate the **Scroll** knob until **Rate xx bpm** is displayed.

8) To change the displayed default breath rate (Rate) value, continue; otherwise skip to the next step.

   When the default Rate value is displayed, push the **Select** button (all but the numeric value of the displayed message is dimmed), rotate the **Scroll** knob until the desired value is displayed and push the **Select** button. The adjusted Rate value is accepted and displayed.

   The actual default Rate numeric value initially displayed is also dependent on the patient size previously selected;

   - Adult default Rate value: **12 bpm**, Adjustable Range: **0** to **80 bpm**
   - Pediatric default Rate value: **15 bpm**, Adjustable Range: **0** to **80 bpm**
   - Infant default Rate value: **20 bpm**, Adjustable Range: **0** to **80 bpm**

9) To accept the displayed Rate value, rotate the **Scroll** knob until **Ventilate** is displayed.

10) To retain the prior Patient ID, Trend data, Maneuvers history and cancel the new settings, continue; otherwise skip to the next step.

    Push the **Exit** button repeatedly until either the **New Patient** or **Same Patient** menu is displayed (as desired) and repeat the process of initiating ventilation from the beginning of this section.

    or

    Push and hold down the **On/Off** button on the lower interface panel until the ventilator powers down.

11) To clear the prior Patient ID, Trend data, Maneuvers history, accept the new settings and begin normal ventilation using the Presets configuration values as shown in the tables on the following pages, push the **Select** button when **Ventilate** is displayed.

NOTE

The Presets **O_2** control value is **40%**. Consequently, a **Low O_2 Pres** alarm is generated and must be reset in order to proceed when the ventilator begins normal ventilation.

12) When the **!! Low O_2 Pres** alarm message is displayed, push the **Silence/Reset** button twice on the lower interface panel to reset the alarm (temporarily silence the sounder and clear the alarm message).

Presets Values for Ventilation Controls

Controls	Infant (5-10 kg)	Pediatric (10-40 kg)	Adult (>40 kg)
Bias Flow	3 lpm	5 lpm	5 lpm
Breath Mode	Assist/Control	Assist/Control	Assist/Control
Breath Rate	20 bpm	15 bpm	12 bpm
Breath Type (Intubated)	Pressure[18]	Pressure[18]	Volume[18]
Breath Type (NPPV)	Pressure[19]	Pressure[19]	Pressure[19]
EPAP (NPPV Only)	3 cmH_2O	6 cmH_2O	6 cmH_2O
Flow Term	35 %	25 %	25 %
Insp. Time	0.3 sec	0.7 sec	1.0 sec
IPAP (NPPV Only)	8 cmH_2O	11 cmH_2O	16 cmH_2O
Leak Comp	On	On	On
O_2	21 %	21 %	21 %
O_2 Flush %	+20 %	+79 %	+79 %
O_2 Flush Dur	2 min	3 min	3 min
PC Flow Term	Off	Off	Off
PEEP	3 cmH_2O	6 cmH_2O	6 cmH_2O
Pres. Control	15 cmH_2O	15 cmH_2O	15 cmH_2O
Pres. Support	5 cmH_2O	5 cmH_2O	10 cmH_2O
Pres Trigger	3 cmH_2O	3 cmH_2O	3 cmH_2O
Rise Time	5	3	4
SBT O_2	21 %	21 %	21 %
SBT PEEP	3 cmH_2O	6 cmH_2O	6 cmH_2O
SBT Pres.Sup	10 cmH_2O	5 cmH_2O	10 cmH_2O
SBT Time	20 min	20 min	20 min
Sensitivity	2 lpm	2 lpm	2 lpm
Tidal Volume	50 ml	250 ml	500 ml
Time Term	0.5 sec	1.0 sec	2.0 sec

NOTE

Ventilation controls not listed in the table above are unaffected by the Presets feature and normal ventilation will begin using the settings that were in effect the last time the ventilator was powered down.

Refer to *Chapter 5 - Controls* for detailed information concerning all controls.

[18] Presets Breath Type settings when **Intubated** patient circuit to patient interface selected during Startup.
[19] Presets Breath Type settings when **NPPV** patient circuit to patient interface selected during Startup.

Presets Values for Alarm Configurations/Limits

Alarms	Infant (5-10 kg)	Pediatric (10-40 kg)	Adult (>40 kg)
Apnea Int	20 sec	20 sec	20 sec
High f	80 bpm	60 bpm	40 bpm
High PEEP	8 cmH_2O	11 cmH_2O	11 cmH_2O
High Pres	30 cmH_2O	30 cmH_2O	40 cmH_2O
HP Delay	Delay 0 Brth	Delay 0 Brth	Delay 0 Brth
Low FIO_2	18 %	18 %	18 %
Low Min Vol	0.5 L	1.0 L	3.0 L
Low PEEP	1 cmH_2O	3 cmH_2O	3 cmH_2O
Low Pk Pres	10 cmH_2O	10 cmH_2O	10 cmH_2O
LPP Alarm	Control Only	Control Only	Control Only
Pulse Rate, High Alarm	"**- - -**" (Off)	"**- - -**" (Off)	"**- - -**" (Off)
Pulse Rate, Low Alarm	"**- - -**" (Off)	"**- - -**" (Off)	"**- - -**" (Off)
Safety Valve	10 cmH_2O	10 cmH_2O	10 cmH_2O
SBT High PEEP	8 cmH_2O	11 cmH_2O	11 cmH_2O
SBT Low PEEP	1 cmH_2O	3 cmH_2O	3 cmH_2O

NOTE

Alarms not listed in the table above are unaffected by the Presets feature and normal ventilation will begin using the settings that were in effect the last time the ventilator was powered down. Refer to *Alarms, Detailed Descriptions* in Chapter 8 - Ventilator Alarms for detailed information concerning all alarms.

Before Connecting to a New Patient

Before connecting a new patient to the ventilator, perform the following procedures:

1) Connect a patient circuit appropriate for your patient size and weight. Connect any patient circuit accessories such as humidifiers, water traps or filters into the circuit. See *Connecting the Patient Circuit* in Chapter 2 – Installation and Setup for information.
2) Test the patient circuit with the ventilator as described in *Circuit Test* in Chapter 2 - Installation and Setup and ensure that all other testing as required by the *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning has been performed.

NOTE

Circuit testing should always be performed with the accessories to be used included in the circuit.

3) Connect an oxygen source to the ventilator, if required. See *Oxygen Connection* in Chapter 2 - Installation and Setup for connection information.

NOTE

If the ventilator is connected to a low pressure oxygen source, select the **LPS** (Low Pressure O_2 Source) setting on the **O_2%** control and adjust the flow of the connected source. See *O2 (Oxygen Percentage and Flush)* in Chapter 5 – Controls.

⚠ WARNING

Inspired Oxygen (FIO_2) Concentration – If *exact concentrations* of inspired oxygen (FIO_2) must be delivered to the patient, it is recommended that the optional FIO_2 Sensor or a separate oxygen analyzer with alarms be used. If using the optional FIO_2 Sensor set the ventilator Low FiO_2 alarm appropriately (see *Low FIO2* alarm in Chapter 8 –Ventilator Alarms for additional information).

4) Connect any optional accessories, such as an FIO_2 Sensor or SpO_2 Module and Sensor. See *Optional Use Accessories Connection* in Chapter 2 - Installation and Setup and *Option Cnfg (Option Configuration)* in Chapter 10 Extended Features for detailed instructions.
5) Initiate normal ventilation using the Presets settings. See *To Initiate Normal Ventilation Modes Using Presets Settings* earlier in this chapter for detailed instructions.
6) Select the desired breath type and mode and set the controls to appropriate values for your patient. See *Breath Types, Breath Modes,* and in Chapter 4 – Breath Types and Modes and *Front Panel, Controls* in Chapter 5 – Controls for detailed information.

7) Set appropriate alarm limits and Apnea Backup settings. See *Adjustable Alarms* in Chapter 8 – Ventilator Alarms.

⚠ WARNING

Factory-Set Alarm Values - To avoid patient injury, always check the set alarm limits of all adjustable alarms for appropriateness prior to using the ventilator on a patient.

Apnea Backup Settings - Always check and configure the controls affecting Apnea Backup ventilation prior to using the ventilator on a patient. If you do not set appropriate backup controls, Apnea Backup ventilation will be delivered at previous or factory-set values which may not be appropriate.

8) Set appropriate alarm, ventilator and option configuration values or settings. See *Extended Features Menus* in Chapter 10 – Extended Features for detailed information.

NOTE

To avoid an unexpected depletion of internal battery power, always check the Removable Battery Pack level of charge prior to disconnecting external power or operating the ventilator solely on the Removable Battery Pack (such as during transport situations).

See

To Check the Level of Charge: in Chapter 12 – Power Supplies and Batteries for detailed instructions.

Maneuvers

The following maneuvers are available on the ReVel ventilator.

- Inspiratory Hold
- Expiratory Hold

See *Maneuvers* in Chapter 9 – Maneuvers and Procedures for detailed information concerning maneuvers.

Procedures

The following procedures can be performed on the ReVel ventilator;

- O_2 Flush
- Nebulization
- SBT (Spontaneous Breathing Trial)

See *Procedures* in Chapter 9 - Maneuvers and Procedures for detailed information concerning these procedures.

Standby Mode

Standby mode is an operator initiated temporary suspension of patient ventilation which can be used to accommodate changing or reconfiguration of accessories, gas delivery methods, patient movement or transport, and does not require changing ventilation settings or shutting down and restarting the ventilator.

> **⚠ WARNING**
>
> **Standby Mode** – When Standby mode is initiated, patient ventilation is suspended until Standby mode is exited and normal ventilation is resumed. To avoid serious injury or death, provide alternative ventilation to the patient until such time as a normal ventilation mode is resumed and the patient is reconnected to the ventilator.

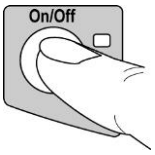
See *Standby? (Standby mode)* in Chapter 10 – Extended Features for detailed information and instructions.

Turning the Ventilator Off

To turn the ventilator off:

1) Disconnect the ventilator from the patient.

2) Push and hold the **On/Off** button for 3 seconds. The ventilator stops ventilating, the **On/Off** LED is extinguished, the audible alarm sounds continuously and the **Vent Inop** LED begins flashing red.



3) Push the **Silence/Reset** button once to silence the audible alarm and extinguish the **Vent Inop** LED.

NOTE

The ventilator continues to charge the Transition Battery and the Removable Battery Pack (when installed) as long as it is connected to an external power source. The exhaust/cooling fan may continue to run while the ventilator is off but charging a battery.

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Chapter 4 - BREATH TYPES AND MODES

This chapter contains information about the breath types and modes available on the ReVel ventilator. It details the types of breaths and how breaths are initiated, limited and cycled. It also discusses breath modes and how they are delivered by the ventilator.

Breath Types

The ReVel ventilator provides the following breath types:

- Pressure Control
- Pressure Regulated Volume Control (PRVC)
- Pressure Support
- Spontaneous
- Volume Control
- Volume Targeted Pressure Support

Breaths are defined by how they are initiated (triggered), limited and cycled.

The following terms are used in discussing how breaths are given:

Trigger is what causes a breath to be given. Breaths may be triggered by a patient demand, a push of the **Manual Breath** button, or by the ventilator based on the set **Breath Rate** and mode of ventilation.

Limit is how the breath is controlled. Breaths may be limited to a set maximum circuit pressure or a set maximum flow.

Cycle is what causes the breath to transition from the inspiratory phase to the exhalation phase. Breaths may be cycled by the ventilator when a set time has been reached, or when a preset flow or percentage of the maximum flow delivered during a breath is reached depending on the breath type and the settings. Breaths can also be cycled when an alarm condition such as a high pressure limit has been reached.

Breaths can be Machine breaths, Assist breaths or Patient breaths.

The following table gives an overview of how these different breath types are controlled:

	Machine	**Assist**	**Patient**
Triggered By	Ventilator	Patient	Patient
Limited By	Ventilator	Ventilator	Ventilator
Cycled By	Ventilator	Ventilator	Patient

The following parameters apply as indicated:

- Minimum Inspiratory Time is 300 ms (all breath types)
- Minimum Exhalation Time is 346 ms (all breath types)
- Maximum Calculated Peak Flow is 120 lpm -10%/+20% (applies to Volume breath types only)
- Maximum Spontaneous Peak Flow is 180 lpm (applies to all breath types except Volume)

NOTE

Patient triggers are detected during exhalation, after the Minimum Exhalation Time has expired.

See *Sensitivity* in Chapter 5 – Controls and *Pres Trigger (Pressure Trigger)* in Chapter 10 – Extended Features for additional information.

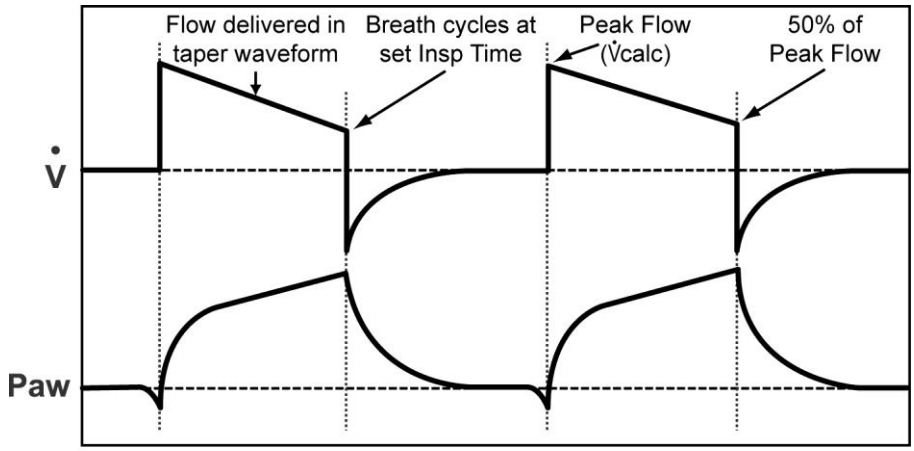
Machine Breaths

Machine and Assist Breaths may be delivered as:

- Volume Control
- Pressure Control
- Pressure Regulated Volume Control (PRVC)

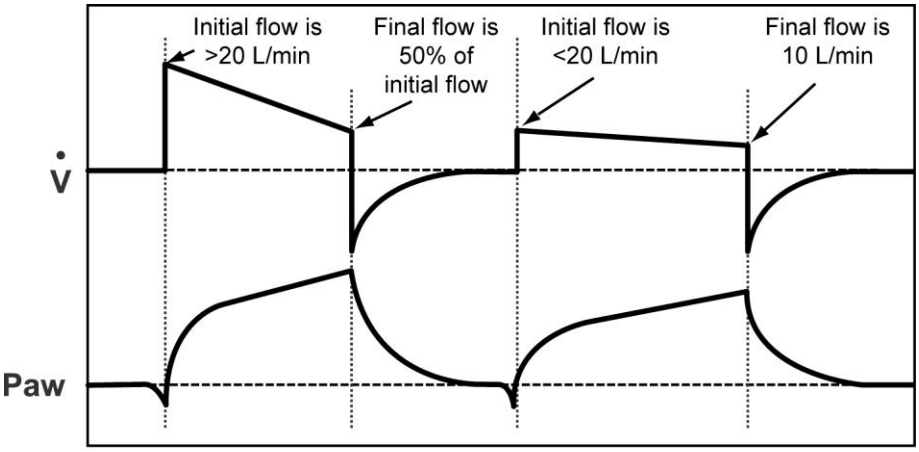
Volume Control Breaths

In volume control breaths a set Tidal Volume is delivered over a set Inspiratory Time. Flow is delivered in a decelerating waveform. Peak flow is calculated based on the **Tidal Volume** and Inspiratory Time (**Insp. Time**) settings and the final flow being 50% of the peak flow. Volume Control breaths may be Machine or Assist breaths. A Volume Control breath is cycled by time.



Volume Control Breaths

When the initial flow is <20 lpm, the final flow remains at 10 lpm and the waveform is flattened.

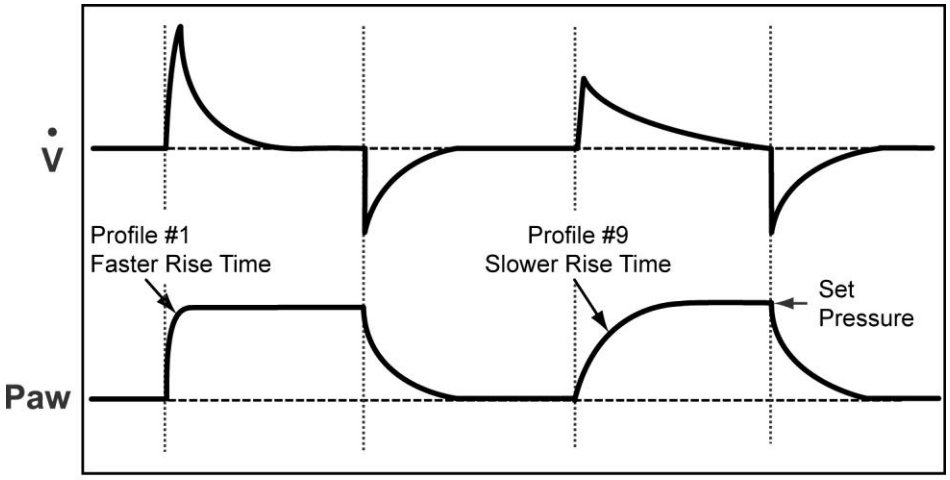


Volume Control Breaths

Pressure Control Breaths

For Pressure Control breaths, flow is delivered according to the **Rise Time** setting to elevate the circuit pressure to the Pressure Control (**Pres**. **Control**) setting (above set **PEEP**[20]) and maintain it at that pressure for the set Inspiratory Time (**Insp. Time**). Pressure Control breaths may be Machine or Assist breaths. A Pressure Control breath can be either flow or time cycled.

Adjusting the **Rise Time** setting changes the flow and pressure waveforms for Pressure Control breaths (see *Rise Time* in Chapter 10 – Extended Features).



Adjusting Rise Time on Pressure Control Breaths

If Pressure Control Flow Termination (**PC Flow Term**) is on (**Term On**), Pressure Control breaths may be flow terminated. If the flow drops to the set Flow Termination (**Flow Term**) level (e.g. **Flow 10%** - **Flow 40%**) before the inspiratory time is completed, the breath is cycled. See *PC Flow Term (Pressure Control Flow Termination)* and *Flow Term (Flow Termination)* in Chapter 10 – Extended Features.

[20] Pressure Control and Pressure Support breaths compensate for PEEP. Delivered pressure is the setting plus PEEP. e.g. a setting of 20cmH_2O with a PEEP of 10cmH_2O delivers a max pressure of 30cmH_2O.

Pressure Regulated Volume Control Breaths (PRVC)

For Pressure Regulated Volume Control (PRVC) breaths, the ventilator delivers pressure breaths at a target pressure which is calculated before each breath. The target pressure is the pressure needed to deliver a Tidal Volume equal to the **Tidal Volume** setting. The target pressure for the current breath is calculated based on the target pressure and the delivered Tidal Volume of the previous breath (measured at the ventilator) as follows.

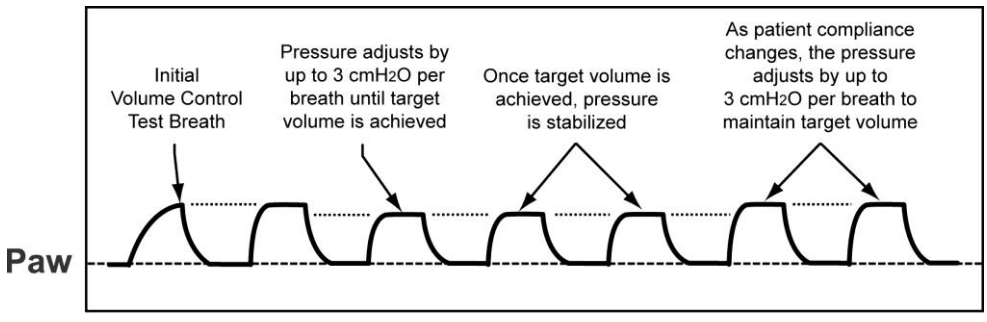
Test Breaths

The ventilator delivers a volume control Test Breath at the set **Tidal Volume** when:

- The PRVC breath mode is initiated
- The set Tidal Volume is changed
- A Volume Limited alarm (**Vol Limited**) occurs (see *Volume Limited* in Chapter 8 – Ventilator Alarms)
- The delivered Tidal Volume ≥1.5 times the set Tidal Volume
- The next breath following a High Airway Pressure alarm (**High Pres**), a Safety Valve High Pressure Relief alarm (**SVHP Relief**), a Patient Circuit Fault alarm (**Pat. Circuit**), a Low Peak Pressure alarm (**Low Pk Pres**), or active exhalation
- The set Inspiratory Time (**Insp. Time**) is changed
- The set Inspiratory Rise Time (**Rise Time**) is changed
- The set **PEEP** is changed

For breaths other than Test Breaths:

- Using the pressure and delivered volume of the previous breath as a basis for calculation, the target pressure of the next PRVC breath is adjusted to achieve the set Tidal Volume. The pressure adjustment from a previous breath however is never more than 3 cmH_2O
- The Target Pressure is at least 5 cmH_2O below the High Airway Pressure alarm (**High Pres**) setting
- Flow is delivered according to the set Inspiratory Rise Time (**Rise Time**)
- Breaths are terminated based on the set Inspiratory Time (**Insp. Time**), or the set Flow Termination (**Flow Term**) level, whichever comes first.
    - If Pressure Control Flow Termination (**PC Flow Term**) is on (**Term On**), pressure breaths may be flow terminated. If the flow drops to the set Flow Termination level (e.g. **Flow 10%** - **Flow 40%**) before the inspiratory time is completed, the breath is cycled. See *PC Flow Term (Pressure Control Flow Termination)* and *Flow Term (Flow Termination)* in Chapter 10 – Extended Features.



Pressure Regulated Volume Control Breaths

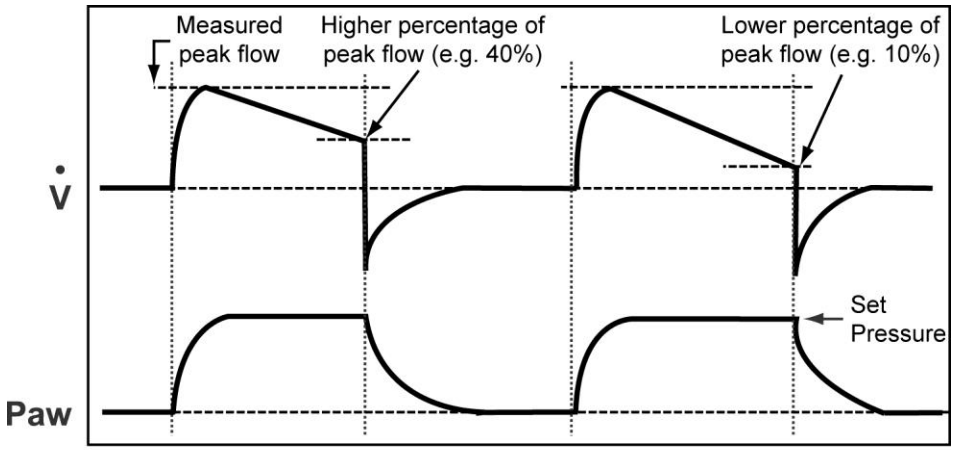
Patient Breaths

Patient breaths may be delivered as:

- Pressure Support
- Spontaneous
- Volume Targeted Pressure Support

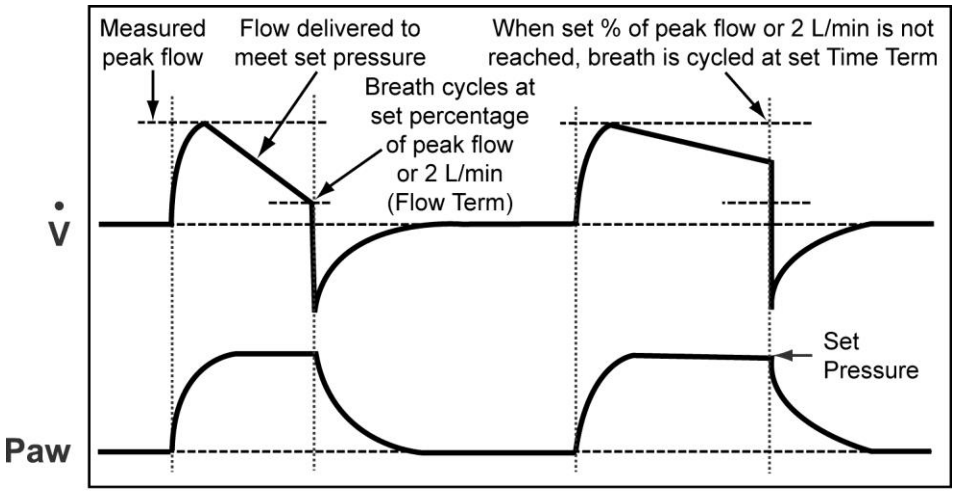
Pressure Support Breaths

In Pressure Support breaths, flow is delivered according to the set Rise Time to elevate the circuit pressure to the Pressure Support (**Pres. Support**) setting and maintain it until the flow drops below a pre-set percentage of Peak Flow for that breath, or below 2 lpm (see *Flow Term (Flow Termination)* in Chapter 10 – Extended Features). The breath then cycles to exhalation.



Adjusting Flow Term on Pressure Support Breaths

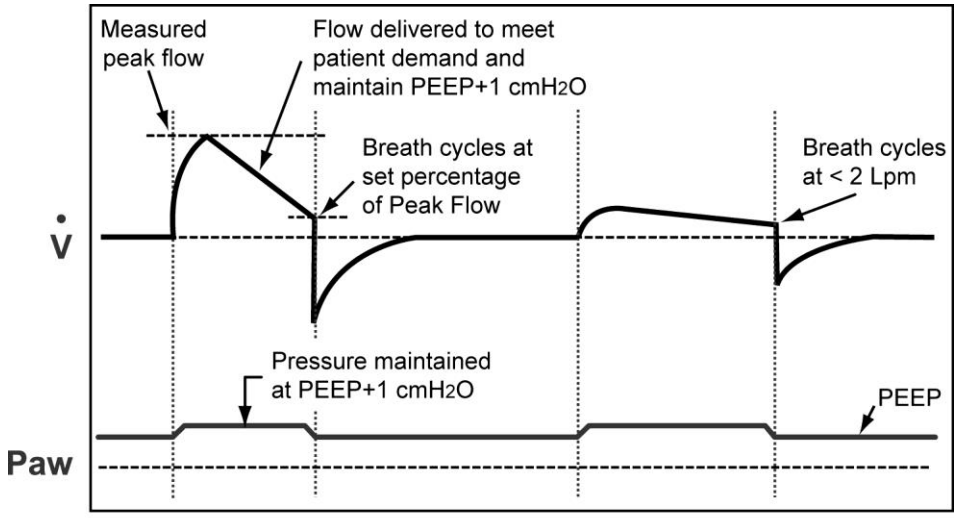
Pressure Support breaths may also be cycled by the set Time Termination (**Time Term**) (see *Time Term (Time Termination)* in Chapter 10 – Extended Features).



Pressure Support Breaths

Spontaneous Breaths

Spontaneous breaths are a subset of Pressure Support breaths, where the circuit pressure is elevated to PEEP+1 cmH_2O during inspiration. This is achieved when the Pressure Support control (**Pres. Support**) setting is either **1** or "**- -**" (off)



Spontaneous Breaths

Shown with example flow for two different patient conditions

Volume Targeted Pressure Support Breaths

Volume Targeted Pressure Support breaths are calculated and delivered the same as PRVC breaths with the following exceptions:

- The breath is terminated when the breath inspiration time exceeds the set inspiration time. The breath may also be cycled when the flow drops below the set Flow Termination (**Flow Term**) or 2 lpm, whichever comes first
- The Pressure Support control (**Pres. Support**) is inactive when Breath Mode CPAP+PS and Breath Type PRVC are selected

> **NOTE**
>
> The Inspiratory Time control (**Insp. Time**) is active during the Volume Control test breath only.

Breath Modes

The ReVel ventilator provides the following modes of breath delivery:

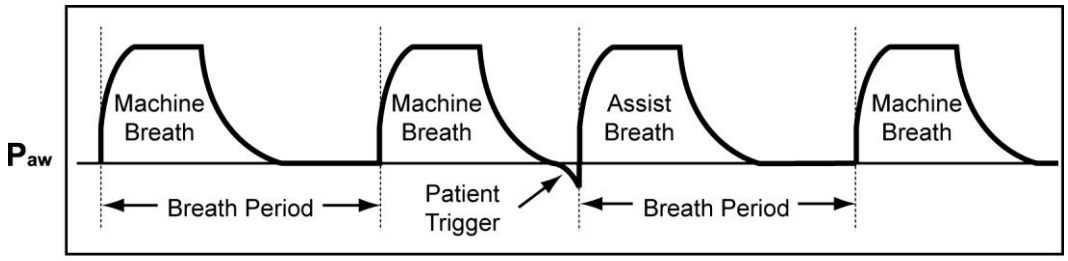
- Assist/Control (**A/C**)
- Synchronized Intermittent Mandatory Ventilation (**SIMV**)
- Continuous Positive Airway Pressure Plus Pressure Support (**CPAP+PS**)
- Apnea Backup Ventilation
- Non-Invasive Positive Pressure Ventilation (**NPPV**)

Assist/Control (A/C)

The breath period in Assist/Control mode is determined by the Breath Rate setting.

In Assist/Control mode (**Breath Mode** is set to **A/C**), both Machine Breaths and Assist Breaths may be given. When a breath period expires without a patient effort being detected, the ventilator delivers a Machine Breath and the breath period is reset. When a patient effort is detected before the breath period expires, an Assist Breath is given at the pre-selected ventilation settings and the breath period is reset.

If the patient is triggering breaths at a faster rate than the set rate, it is possible for all breaths to be patient triggered.

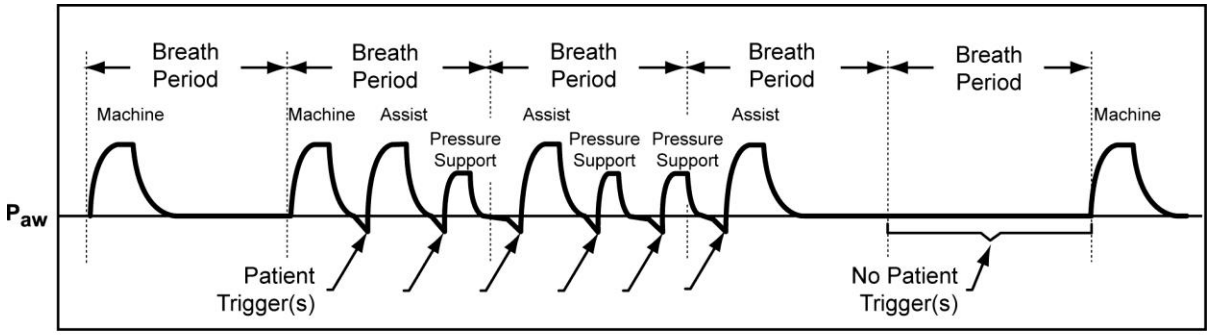


Pressure Control Machine and Assist Breaths

Synchronized Intermittent Mandatory Ventilation (SIMV)

In SIMV mode, Machine, Assist, Pressure Support and Spontaneous breaths may be given. For the first patient trigger detected within a breath period, an Assist breath is given. For all subsequent patient triggers within the same breath period, Pressure Support or Spontaneous patient breaths are given depending on the Pressure Support (**Pres. Support**) setting. Although the breath period is not reset by patient triggers, it is reset when a Manual Breath is initiated.

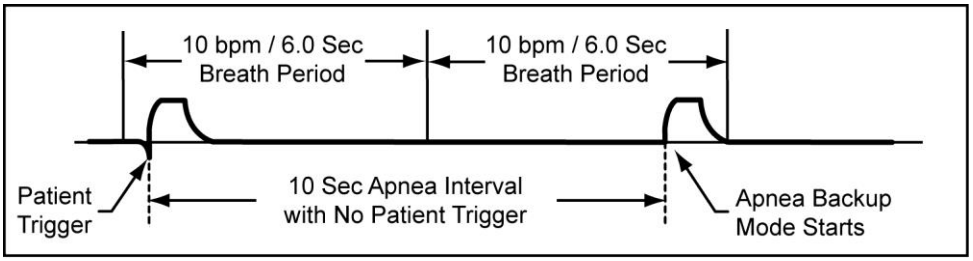
At the beginning of a breath period, if no patient breaths have occurred in the previous breath period, a Machine breath is given.



Pressure Control Machine and Assist Breaths, and Pressure Support Breaths

NOTE

If there was a patient triggered breath in the previous breath cycle, the ventilator will not give a Machine breath in the current breath period unless the set Apnea Interval (**Apnea Int**) is exceeded (see *Apnea Backup Ventilation* in this chapter).

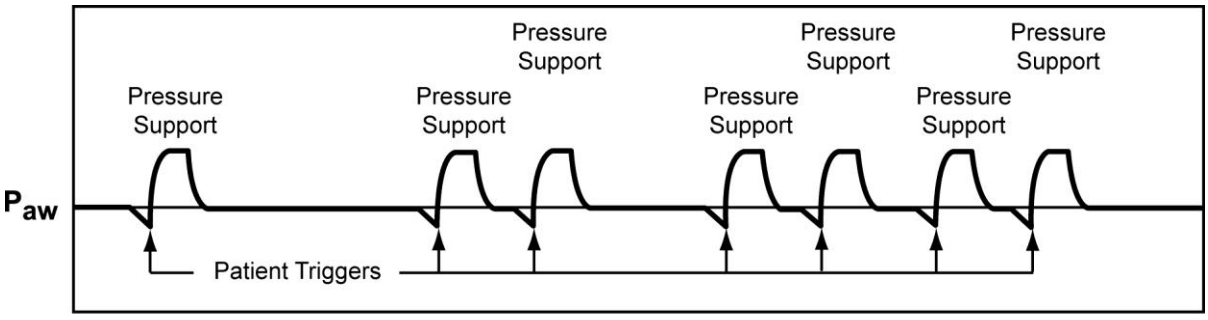


Example of SIMV Mode, Breath Rate 10 bpm, Apnea Interval 10 Seconds

Continuous Positive Airway Pressure Plus Pressure Support (CPAP+PS)

In CPAP+PS breath mode, when a patient trigger is detected, a Patient breath is given. Breaths may be Pressure Support or Spontaneous breaths depending on the Pressure Support (**Pres. Support**) setting.

For **CPAP+PS** breath mode with **PRVC** breath type settings, the breaths are PRVS.



Pressure Support Patient Breaths

NOTE

Flow Triggering Threshold Level – The flow triggering threshold level (**Sensitivity**) is automatically set to 2 lpm when the **Breath Mode** is changed to **CPAP+PS** and the **Sensitivity** control was previously set to "**P**" (Pressure Trigger).

Apnea Backup Ventilation

The ReVel ventilator provides an Apnea Backup mode of ventilation. When the set Apnea Interval (**Apnea Int**) (maximum time allowed between the beginning of one breath and the beginning of the next breath) is exceeded, the Apnea alarm is generated and the ventilator will enter Apnea Backup ventilation mode based on current ventilator settings.

⚠ WARNING

Apnea Backup Settings - Check and configure the controls affecting Apnea Backup ventilation before initiating CPAP+PS mode. If you do not set appropriate backup controls, Apnea Backup ventilation will be delivered at previous or factory-set values which may not be appropriate.

NOTE

Dimmed Controls - Controls which need to be set for Apnea Backup ventilation may be dimmed as they are not active in CPAP+PS or NPPV modes. The controls should be set while dimmed and will become active when Apnea Backup ventilation initiates.

Apnea Backup ventilation is initiated when the time since the start of the last breath exceeds the set Apnea Interval (**Apnea Int**). The Apnea Interval is set using the Extended Features menus (see *Apnea Int (Apnea Interval)* in Chapter 10 – Extended Features).

- See *Apnea* and *Apnea Interval* in Chapter 8 – Ventilator Alarms for additional information

When an apnea alarm occurs, the ventilator initiates Apnea Backup ventilation in Assist/Control mode at the previously set breath type and control settings.

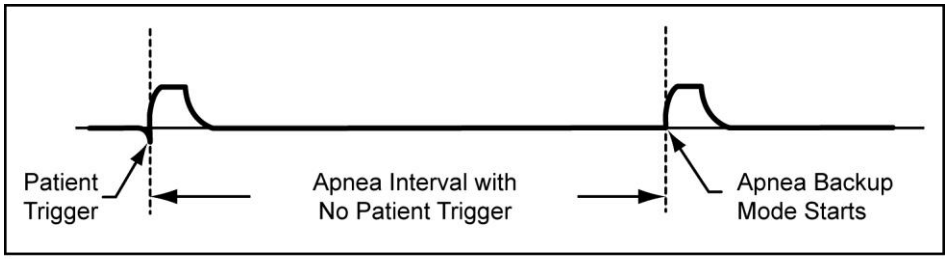
The Apnea Backup ventilation breath rate is determined as follows:

- If the set **Breath Rate** is <12 bpm, the Apnea Backup ventilation breath rate is the highest rate allowed by control limiting, up to 12 bpm

In **CPAP+PS** and **NPPV** ventilation modes only:

- If the set **Breath Rate** is equal to or higher than 12 bpm, then the Apnea Backup ventilation breath rate will be the set **Breath Rate**

The ventilator returns to the previous mode when the **Apnea** alarm is reset or when the patient triggers two consecutive breaths.



Example of Apnea Backup

Non-Invasive Positive Pressure Ventilation (NPPV)

> **⚠ WARNING**
>
> **NPPV Breath Modes** - NPPV breath modes are not life support modes and are not suitable for patients that require life support ventilation. NPPV breath modes should only be used for supplemental ventilation of non-life support patients.

The ReVel ventilator provides Non-Invasive Positive Pressure Ventilation (NPPV) as a secondary, supplementary mode that may be selected with the primary ventilation mode. When **NPPV** with **A/C** or **NPPV** with **CPAP+PS** modes are selected, ventilation is delivered according to the selected mode.

The ventilator is capable of performing non-invasive positive pressure ventilation with a standard dual-limb circuit. Adjust **Sensitivity** to accommodate patient effort without auto-cycling.

Activating leak compensation or increasing the level of **Bias Flow** may help overcome leaks and optimize the **Sensitivity** setting. Set the alarms to avoid unnecessary alerts while maintaining adequate monitoring.

When either of the NPPV modes are selected the leak compensation function (**Leak Comp**) is automatically enabled, and when either NPPV mode is exited the leak compensation function returns to its previous or default setting.

To provide non-invasive positive pressure ventilation, a face mask or nasal mask is employed to connect the patient to the ventilator. The ventilator will produce positive pressure breaths to either deliver a mandatory breath or assist the patient's inspiration in either of the NPPV modes.

Since the connection to the patient via a mask may introduce leaks, a leak compensation mechanism is employed to maintain the preset pressures even with introduced leakage up to 30 lpm.

> **NOTE**
>
> - The mask itself may introduce additional rebreathed volume when compared to a tracheal or tracheostomy tube. The user must consider that additional rebreathed volume may be introduced.
> - The volume of the oro and/or nasopharyngeal airway of the patient should be considered. Even though this volume is the same as a spontaneously breathing patient, it is an additional rebreathed volume when compared to a tracheal tube connection.
> - Normally a small amount of leakage will occur around the mask as the patient moves or the mask is repositioned. This small mask leakage, in many cases, can carry with it some of the exhaled carbon dioxide from the mask, thus reducing added dead space.
> - Only masks, specifically labeled and intended for non-invasive ventilation, should be employed on the ReVel ventilator. Masks should not have valves or leak vents.
> - Mask leakage compensation is effective up to 30 lpm.
> - It is important that a reasonably good mask seal, with the patient's face, should be achieved. Excessive leakage will adversely affect exhaled volume measurement accuracy.

NPPV with A/C Mode

NPPV with A/C breath mode is delivered as a Pressure Control breath. Any patient trigger will receive a Pressure Control breath and the breathing pattern can be terminated by PC Flow Termination.

NPPV with CPAP+PS Mode

NPPV with CPAP+PS breath mode consists of CPAP breathing at the user preset baseline pressure with the option of using Pressure Support as an adjunctive adjustable pressure. The breath will be terminated by PC Flow Termination.

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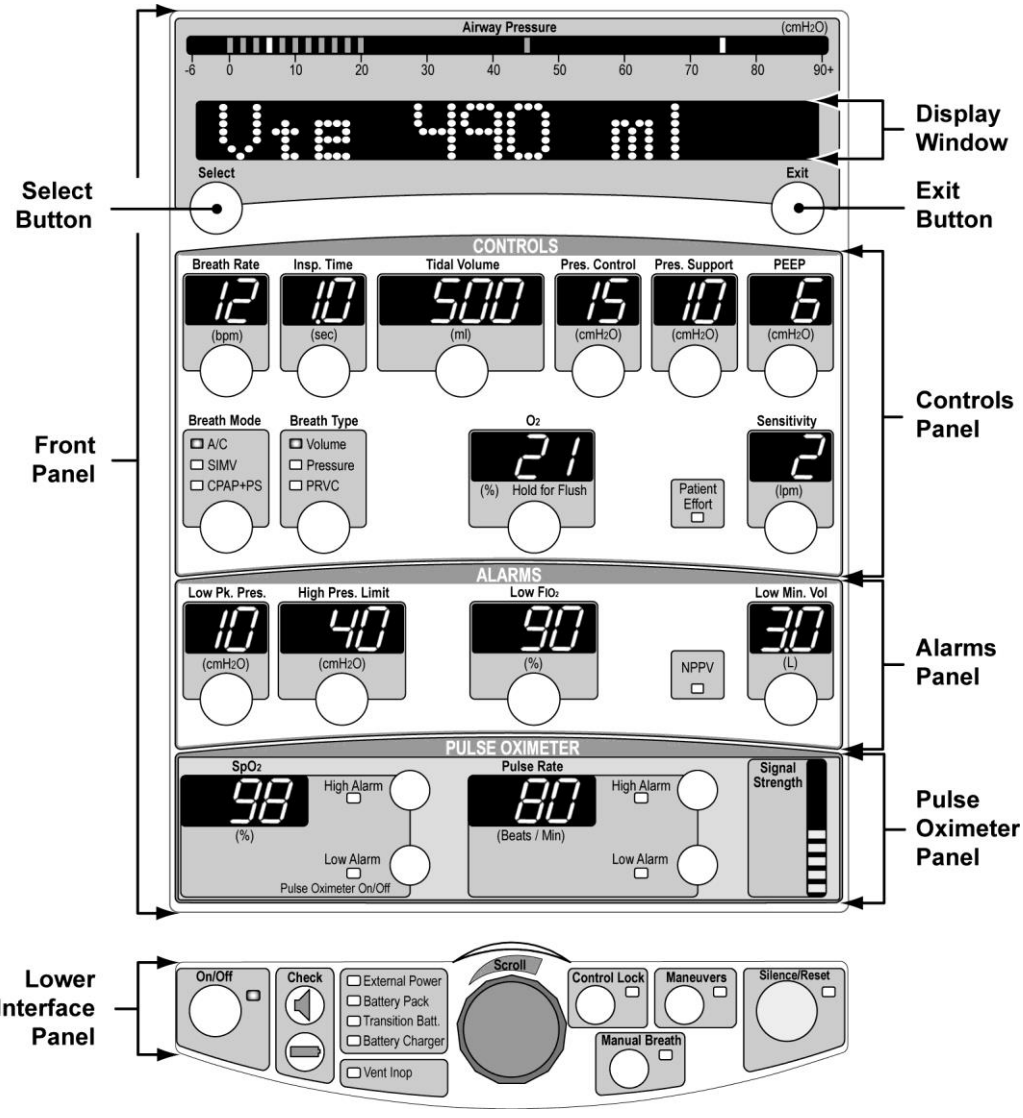
Chapter 5 - CONTROLS

This chapter provides a description of the ventilator controls on the front and lower interface panels, their use, function, ranges and limitations.

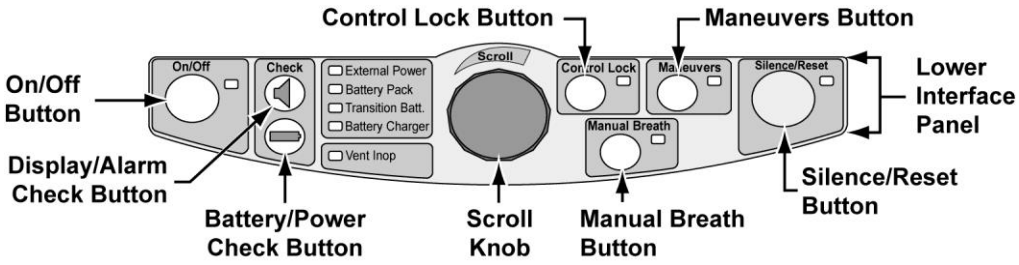
Additional adjustable controls not directly represented on the front or lower interface panels are accessed, configured and set using the Startup and Extended Features menus.

- See *Navigating Startup and Extended Features Menus* and *Startup Mode and Menus* in Chapter 3 – Using the Ventilator, and *Extended Features Menus* in Chapter 10 – Extended Features for additional information regarding available options, features and controls



Lower Interface Panel

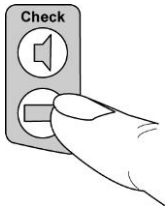
This section provides a description of the controls on the lower interface panel, their use, function, ranges and limitations.



Check Buttons

Battery/Power

The Battery/Power **Check** button is used to check the status of the battery and power system without interfering with the ventilator's operation.



If you push and hold the Battery/Power **Check** button, the ventilator displays a message in the Display Window for each of the four possible sources of power (in the sequence shown), indicating their detection and current status[21].

	Power Source			
	Removable Battery Pack	External DC Power	Docking Station	Transition Battery
Possible Status Messages Displayed	**Batt xxx%**	**Ext OK**	**Dock OK**	**T-Bat OK**
	Batt Removed	**Ext Low**	**Dock Low**	**T-Bat Low**
	Batt Fault	**Ext Removed**	**Dock Removed**	**T-Bat Remove**
		Ext Fault	**Dock Fault**	**T-Bat Chrg**
				T-Bat Fault

[21] Refer to *Power Status LEDs* in Chapter 6 - Displays and Indicators for additional information concerning the status of various sources of power.

NOTE

- **Batt xxx%** indicates the remaining percentage capacity of the Removable Battery Pack (**xxx** is the numeric percentage).
- If a Removable Battery Pack fails to charge to more than 50% remaining capacity after 12 hours, it is time to replace it.
- The power status display associated with the Battery/Power **Check** button times out after the status of all power sources has been displayed once.

If any fault message (**xxxxx Fault**) is displayed, it is an indication that the displayed source of power (**Batt, Ext, Dock** or **T-Bat**) has been detected and is not adequate to power the ventilator.

See *Chapter 13 - Troubleshooting* for additional information.

Display/Alarm

> **⚠ WARNING**
>
> **Check Alarms** – Alarm function should be tested periodically to ensure proper operation (see *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning, and *Display/Alarm Test* in Chapter 2- Installation and Setup for detailed instructions). If any alarm malfunctions, contact Vyaire or a service technician certified by Vyaire. Failure to immediately identify and correct alarm situations may result in serious patient injury or death.

The Display/Alarm **Check** button is used to check the displays, indicators and audible alarm system without interfering with the ventilator's operation.

If you push and hold the Display/Alarm **Check** button, the ventilator illuminates all front panel and lower interface panel window displays and indicator LEDs in the colors as indicated below, and sounds two audible tones of similar volume followed by the High Priority Alarm Signal [22] at the set volume.

Panel	LED Color
Front Panel:	
• Airway Pressure Manometer LEDs[23] • Oximetry Signal Strength Display LEDs[24]	Amber
• All other LED indicators and displays	Red or Green
Lower Interface Panel:	

• All Power Status indicator LEDs[25]
  • **External Power**
  • **Battery Pack**
  • **Transition Bat.**
  • **Battery Charger**
	Amber

• All other indicator LEDs	Red or Green

If the audible alarm fails to sound or any indicator or display window LED (includes all LED segments within the window) fails to fully illuminate, or illuminates in a color other than as specified above, refer to *Chapter 13 - Troubleshooting* for additional information.

[22] Refer to *Sound Types, Patterns and Volumes* in Chapter 8 - Ventilator Alarms for additional information.

[23] Refer to *Airway Pressure Manometer* in Chapter 6 - Displays and Indicators for additional information.

[24] Refer to *Oximetry Signal Strength Display* in Chapter 6 - Displays and Indicators for additional information.

[25] Refer to *Power Status LEDs* in Chapter 6 - Displays and Indicators for additional information.

Control Lock

Ventilation controls and alarm limits settings can be locked to prevent accidental changes. To turn Control Lock on, push the **Control Lock** button. The **Control Lock** LED is illuminated whenever the front panel controls are locked.

Although ventilation controls and alarm limits settings (including those in Extended Features menus) cannot be changed when the Control Lock is enabled, the **Select** and **Exit** buttons can be used to pause or restart the automatic scrolling of monitored data.

If a ventilation control or enabled alarm limits button is pushed while the controls are locked:

- The **Control Lock** LED flashes
- **Locked** is displayed in the display window
- The button push is ignored

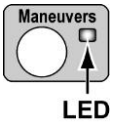
Unlocking Controls

Two levels of difficulty (**Easy** or **Hard**) can be set for the unlocking mechanism: **Easy** unlocking is the factory-set value. The unlock difficulty setting can be changed using Extended Features menus (see *Ctrl Unlock (Control Unlock)* in Chapter 10 – Extended Features for additional information*).*

1) To turn the Control Lock off with **Easy** unlocking set, simply push the **Control Lock** button. The LED is extinguished and the controls unlock.
2) To turn the Control Lock off with **Hard** unlocking set, push and hold the **Control Lock** button for 3 seconds. The LED is extinguished and the controls unlock.

> **NOTE**
>
> The O_2 Flush procedure and the **Select, Exit, Manual Breath,** Battery/Power **Check,** Display/Alarm **Check** and **Silence/Reset** controls are not affected by the Control Lock and operate even when it is on.

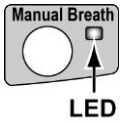
Maneuvers



The **Maneuvers** button is used to display, select and activate a maneuver.

For more details on how to set up and run maneuvers, see *Maneuvers* in Chapter 9 – Maneuvers and Procedures.

Manual Breath

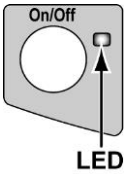


Pushing the **Manual Breath** button will deliver one (1) Machine breath. The breath is a Machine breath as defined by the current **Breath Type** settings. The **Manual Breath** LED is illuminated during the Manual Breath inspiration.

When in **CPAP+PS** breath mode, the ventilator will deliver one (1) breath based on the **A/C** setting for the current breath type.

The **Manual Breath** button is only enabled during exhalation.

On/Off



The **On/Off** button is used to turn the ventilator on or off.

- When the ventilator is on, the **On/Off** LED is illuminated
- When the ventilator is off, the **On/Off** LED is extinguished

To turn the ventilator on:

Push the **On/Off** button.

To turn the ventilator off:

Push and hold the **On/Off** button for 3 seconds. A Vent Inop alarm occurs and the **Vent Inop** LED is illuminated.

- To silence the alarm and extinguish the **Vent Inop** LED, push the **Silence/Reset** button

Scroll

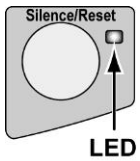
The **Scroll** knob is a rotary knob encoder used to scroll through a paused display of monitored data, change ventilation feature configurations, selected control or alarm limit values and navigate through Startup and Extended Features menus.

- Rotating the **Scroll** knob clockwise displays the next available monitored data in a paused display, increases selected control/alarm limit values, changes selected feature configurations, or displays the next available menu in Startup or Extended Features menus
- Rotating the **Scroll** knob counter-clockwise displays the previous available monitored data in a paused display, decreases selected control/alarm limit values, changes selected feature configurations, or displays the previous available menu in Startup or Extended Features menus

Monitored data, control/alarm limit values, feature configurations or Startup or Extended Features menus stop incrementing when control/alarm range limits are reached (or limited by another control setting), or no further configurations, displays or menus are available.

- The Scroll knob is speed sensitive; when rotated quickly, each detent changes selected control/alarm limit values more than when rotated slowly
- If the Scroll knob is not rotated within 15 seconds after a control has been selected, the control or alarm limit is automatically deselected
- If monitored data is not paused, controls are not selected, or Startup or Extended Features menus are not displayed, rotating the **Scroll** knob has no effect

Silence/Reset



The **Silence/Reset** button is used to temporarily silence active audible alarms, remove visible alarm messages in the display window and reset alarms:

- If pushed once when no alarms are activated, a sixty (60) second silence period is initiated and the **Silence/Reset** LED is illuminated
    - If pushed again during the 60 second silence period, the silence period is cancelled
- If pushed once during an active alarm condition (alarm sounding, alarm message flashing in the display window) the audible alarm is silenced for 60 seconds and the **Silence/Reset** LED is illuminated
    - A second push removes the visible (highest priority) flashing alarm message, and subsequent lower priority alarms (if actively occurring) are displayed
    - Each subsequent push removes the next visible alarm message in order of priority (see *Alarm Priorities* in Chapter 8 – Ventilator Alarms)
    - Active recurring alarms are suppressed for 15 seconds after the last button push to allow lower priority alarm messages to be reviewed
    - Once the lowest priority message has been removed, pushing the **Silence/Reset** button again reinstates all active alarm messages and visual alarm indicators (flashing controls), reactivates the audible alarm and extinguishes the **Silence/Reset** LED
- If alarm conditions are resolved during the 60 second silence period, the audible alarm will not be reactivated
- If the **Silence/Reset** button is pushed once all alarm conditions have been resolved, visible flashing alarm messages are removed and the **Silence/Reset** LED is extinguished

Silencing the Vent Inop alarm:

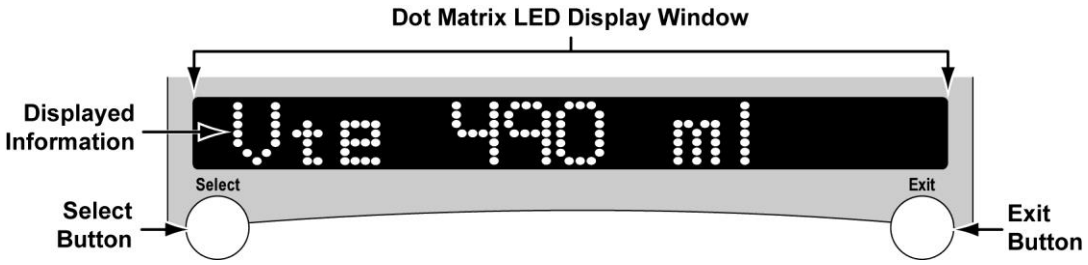
To silence the **Vent Inop** alarm, push the **Silence/Reset** button. The audible alarm is permanently silenced and the **Vent Inop** LED is extinguished.

For more about the **Vent Inop** condition, see *Vent Inop* in Chapter 8 – Ventilator Alarms.

Front Panel, Display Window

The Display Window is used to display a variety of types of information. The adjacent **Select** and **Exit** buttons are used in conjunction with the **Scroll** knob (on the lower interface panel) to access, select, initiate, cancel, change and/or exit displayed data, menus options, maneuvers or procedures.

- See *Display Window* in Chapter 6 – Displays and Indicators for additional information



Select

The **Select** button is used to pause automatic scrolling of monitored data on the LED display window, and select or confirm displayed menu options and configuration value settings displayed (in Startup and Extended Features menu options). See the following manual sections/chapters for detailed information:

- *Automatic or Manual Data Display Scrolling* and *Navigating Startup and Extended Features Menus* in Chapter 3 - Using the Ventilator
- *Chapter 9 - Maneuvers and Procedures*
- *Standby? (Standby mode)* in Chapter 10 – Extended Features

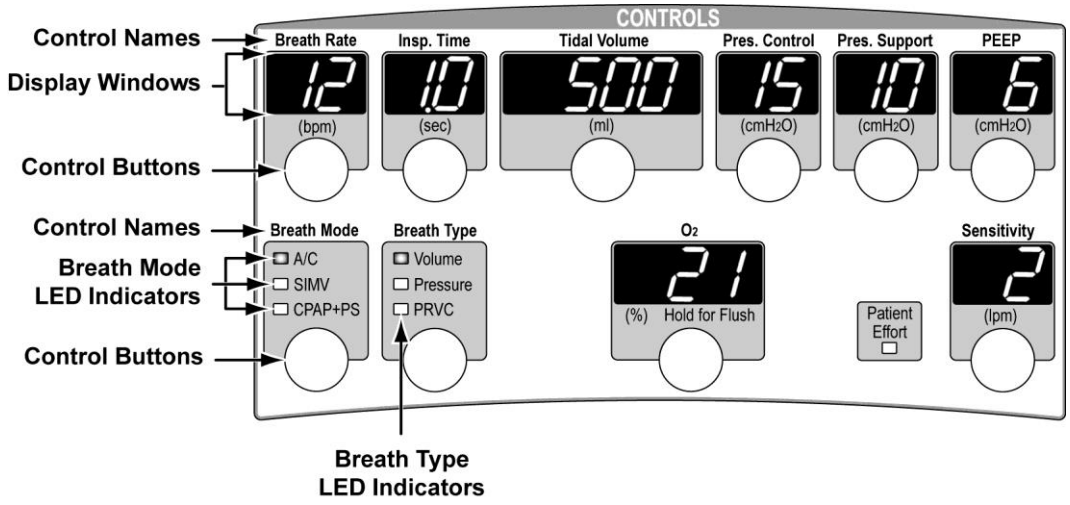
Exit

The **Exit** button is used to restart automatic scrolling of monitored data on the LED display window, exit Standby mode, and exit Startup and Extended Features menus or configuration settings displayed (without changing the setting). See the following manual sections/chapters for detailed information:

- *Automatic or Manual Data Display Scrolling* and *Navigating Startup and Extended Features Menus* in Chapter 3 - Using the Ventilator
- *Chapter 9 - Maneuvers and Procedures*
- *Standby? (Standby mode)* in Chapter 10 – Extended Features

Front Panel, Controls

This section provides a description of the controls on the Controls panel, their use, function, ranges and limitations.



Control Limiting

Adjustable control settings may be limited to less than their specified range for any of the following reasons:

- To prevent inverse I:E ratios of greater than 4:1
- To ensure a minimum inspiration time of 300 ms
- To ensure a minimum exhalation time of 346 ms
- To ensure an initial flow of 10 lpm for Volume Controlled breaths
- To ensure a maximum initial flow of 120 lpm for Volume Controlled breaths
- To ensure that flow trigger sensitivity (**Sensitivity**) is less than Bias Flow
- To ensure a maximum Pressure Control pressure of 99 cmH_2O
- To ensure a maximum Pressure Support of 60 cmH_2O

When you are updating a control and have reached a pre-imposed limit, the following things happen:

- The control stops updating and displays a constant value (the high or low limit)
- The control flashes
- The displays for other controls involved in the limited condition flash

To set the control to a value outside the limit range, you need to modify the settings for other controls involved in the limit condition. For instance, if the Breath Rate is set to 12, the maximum allowed Inspiratory Time is 4.0 seconds. To set the Inspiratory Time to more than 4.0 seconds, you must first decrease the Breath Rate.

Active Controls by Breath Mode and Type

The following matrix shows which controls are active in all **Breath Mode** and **Breath Type** settings.

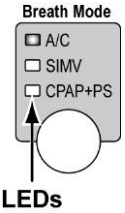
- The LED displays of active front panel controls are illuminated at normal intensity
- The LED displays of inactive front panel controls which do not affect breath delivery in a specific breath mode or breath type are dimmed

The inactive controls may still be modified for the purposes of modifying a “limit” situation or to set up Apnea Backup parameters, but they will not affect the delivery of a breath in the currently selected mode.

	Breath Mode and Type										
Controls	**A/C + Volume**	**A/C + Pressure**	**A/C + PRVC**	**SIMV + Volume**	**SIMV + Pressure**	**SIMV + PRVC**	**CPAP+PS + Volume**	**CPAP+PS + Pressure**	**CPAP+PS + PRVC**	**A/C + Pressure**	**CPAP+PS Pressure**
Bias Flow[26]	X	X	X	X	X	X	X	X	X	X	X
Breath Rate	X	X	X	X	X	X				X	
Flow Term[26]		X[27]	X[27]	X	X	X	X	X	X	X[27]	X
Insp. Time	X	X	X	X	X	X			X	X	
Leak Comp[26]	X	X	X	X	X	X	X	X	X	X	X
O_2	X	X	X	X	X	X	X	X	X	X	X
PC Flow Term[26]		X	X		X	X				X	
PEEP	X	X	X	X	X	X	X	X	X	X	X
Pres Trigger[26]	X	X	X	X	X	X	X	X	X	X	X
Pres. Control		X			X					X	
Pres. Support				X	X	X	X	X			X
Rise Time[26]		X	X	X	X	X	X	X	X	X	X
Sensitivity	X	X	X	X	X	X	X	X	X	X	X
Tidal Volume	X		X	X		X			X		
Time Term[26]				X	X	X	X	X			X
	Intubated Patient Interface									**Non-Invasive Patient Interface (NPPV)**	

[26] Control accessed while in normal ventilation modes through the Extended Features menus.
[27] Available when Pressure Control Flow Termination (PC Flow Term) is on.

Breath Mode



The **Breath Mode** control is used to select between the following ventilation breath modes:

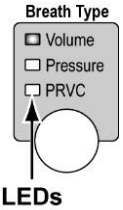
- **A/C** (Assist/Control)
- **SIMV** (Synchronized Intermittent Mandatory Ventilation)
- **CPAP+PS** (Continuous Positive Airway Pressure plus Pressure Support)

See *Breath Modes* in Chapter 4 - Breath Types and Modes for detailed descriptions of breath modes.

To Set Breath Mode:

Use the three step “Select, Change and Confirm” method to set the Breath Mode (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Breath Type



The **Breath Type** control is used to select between the following ventilation breath types:

- **Volume**
- **Pressure**
- **PRVC** (Pressure Regulated Volume Control)

See *Breath Types* in Chapter 4 - Breath Types and Modes for detailed descriptions of breath types.

To Set Breath Type:

Use the three step “Select, Change and Confirm” method to set the Breath Type (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Breath Rate

The **Breath Rate** control is used to establish the minimum number of machine or assist breaths that the ventilator delivers per minute.

Range**:** **1** through **80 bpm**

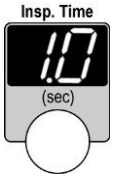
The **Breath Rate** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

> **NOTE**
>
> The calculated I:E Ratio (**I:Ecalc**) is shown in the display window while **Breath Rate** is being changed.
>
> In CPAP+PS mode, the **Breath Rate** control affects Apnea Backup ventilation. Be sure to set it appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information).

To Set Breath Rate:

Use the three step "Select, Change and Confirm" method to set the Breath Rate (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Insp. Time (Inspiratory Time)



The **Insp. Time** (Inspiratory Time) control is used to set the duration of the inspiratory phase of Volume Controlled, Pressure Controlled and PRVC (Pressure Regulated, Volume Controlled) breaths.

Range**:** **0.3** through **9.9 sec**

The **Insp. Time** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

The **Insp. Time** setting, along with the **Tidal Volume** setting is used to determine peak flow for Volume controlled breaths.

> **NOTE**
>
> - The calculated peak flow (**Vcalc**) monitor is updated while **Tidal Volume** or **Insp. Time** settings for a volume breath are being changed.
> - The calculated I:E Ratio (**I:Ecalc**) monitor is updated while **Breath Rate** or **Insp**. **Time** settings are being changed.
> - In CPAP+PS mode, the **Insp. Time** control establishes the inspiratory time in Apnea Backup ventilation. Be sure to set it appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information).

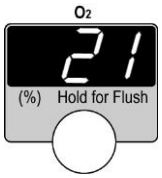
To Set Inspiratory Time:

Use the three step "Select, Change and Confirm" method to set the Inspiratory Time (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

O_2 (Oxygen Percentage and Flush)

The **O_2** control is a dual function control (also used for the O_2 Flush procedure) and for the purpose of these instructions is used to adjust the percentage of oxygen to be delivered through the ventilator's oxygen blending system. See *O2 Flush* in Chapter 9 – Maneuvers and Procedures for additional information and instructions.

Using a High Pressure O_2 Source:



When the ventilator is attached to a high pressure oxygen source of 40 PSI (2.8 bar, 276 kPa) to 88 PSI (6.1 bar, 607 kPa), this control is used to adjust the percentage of oxygen to be delivered through the ventilator's oxygen blending system.

Range**:** **LPS, 21%** through **100% O_2**

> **NOTE**
>
> During an active Nebulization procedure the High O_2 Inlet source pressure must be limited to **40 PSI** (2.8 BAR, 276 kPa) to **66 PSI** (4.5 BAR, 455 kPa).

When the ventilator is attached to a low pressure O_2 source such as an oxygen concentrator or line mounted flow meter, this control must be set to **LPS** (Low Pressure Source). See *Using a Low Pressure O2 Source:* in this chapter for additional information.

> **⚠ WARNING**
>
> **Oxygen Blending** - Oxygen blending on the ReVel ventilator requires a high pressure oxygen source and is active only when the Low Pressure Source (**LPS**) setting on the **O_2**% control is *not* selected. If **LPS** is selected and the ventilator is using a low pressure O_2 source of <10 PSI (< 0.69 bar, < 69 kPa), the percentage of oxygen in the patient circuit is *not* controlled by the ventilator's oxygen blender and must be controlled from the gas source.

To Set O_2 Percentage:

Use the three step "Select, Change and Confirm" method to set the O_2 Percentage (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

> **⚠ WARNING**
>
> **Inspired Oxygen (FIO_2) Concentration** – If *exact concentrations* of inspired oxygen (FIO_2) must be delivered to the patient, it is recommended that the optional FIO_2 Sensor or a separate oxygen analyzer with alarms be used. If using the optional FIO_2 Sensor set the ventilator Low FiO_2 alarm appropriately (see *Low FIO2* alarm in Chapter 8 –Ventilator Alarms for additional information).

Using a Low Pressure O_2 Source:

When the **O_2%** control is set to **LPS** (Low Pressure Source), oxygen can be supplied from a low pressure / low flow oxygen source of < 10 PSI (< 69 BAR, < 69 kPa) such as a flow meter. Oxygen from the low pressure source is mixed with air inside the ventilator. When connected to a low pressure source, the estimated O_2 percent delivered to the patient is determined by the O_2 inlet flow and the minute volume and is *not* regulated by the ventilator. Use the Input O_2 Flow chart (shown below) to determine the correct O_2 flow for the desired FIO_2.

When the **O_2%** control is set to **LPS**, the following conditions are applicable:

- The O_2 inlet flow must be set to obtain the desired oxygen percentage (see chart)
- The Low O_2 Inlet Pressure (**Low O_2 Pres**) alarm is inactive
- The High O_2 Inlet Pressure (**Hi O_2 Pres**) alarm activates at 10 PSI (69 BAR, 69 kPa)

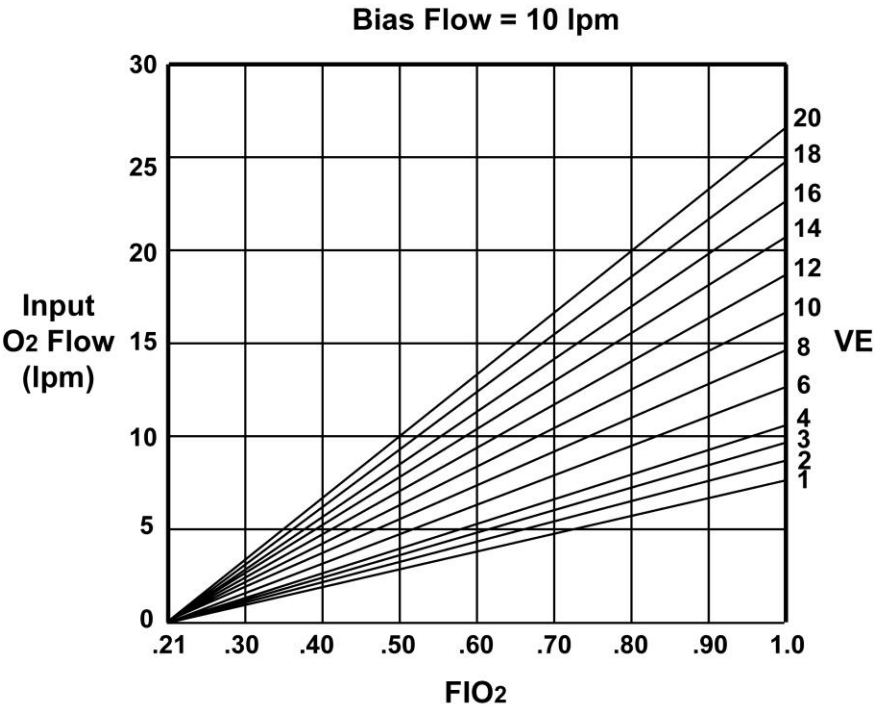
When the **O_2%** control is set greater than 21% (**22 - 100%**), the following conditions are applicable:

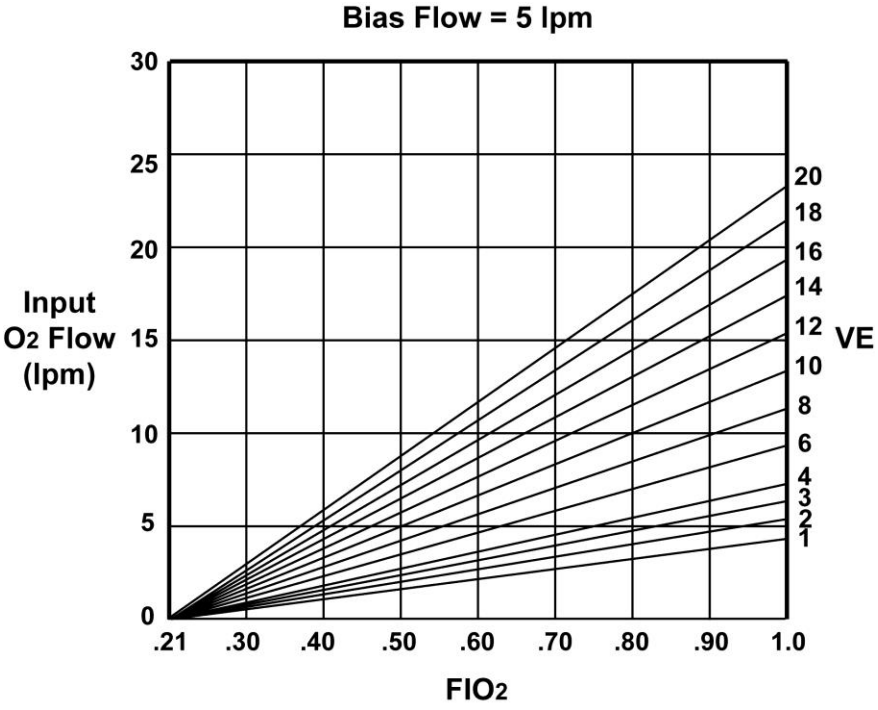
- The Low O_2 Inlet Pressure (**Low O_2 Pres**) alarm activates at 39 PSI (2.69 BAR, 269 kPa)

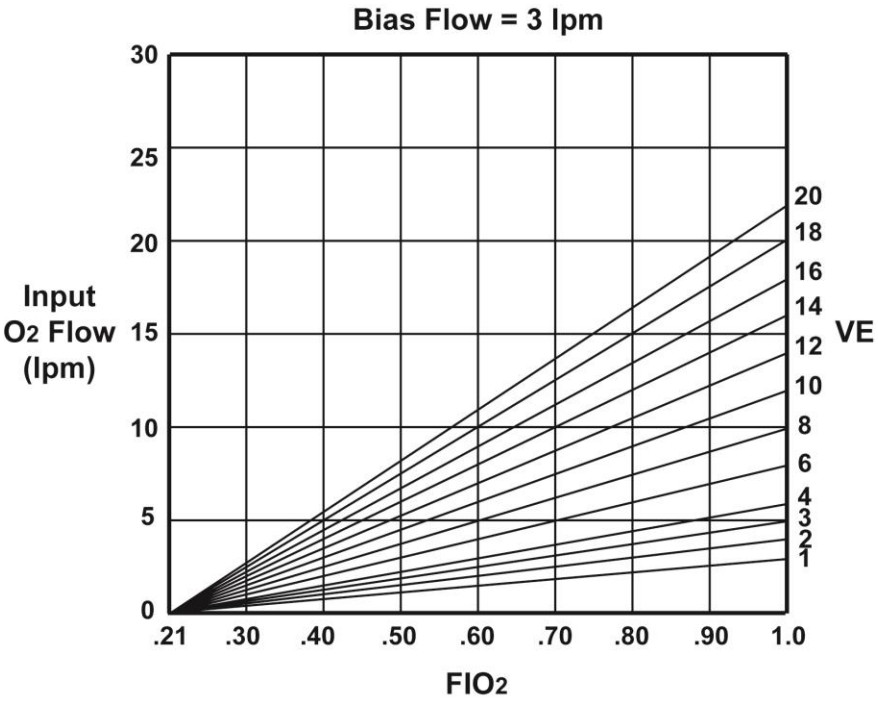
> **⚠ WARNING**
>
> **Inspired Oxygen (FIO_2) Concentration** - Minute Volume fluctuates if a patient has a variable respiratory rate. If *exact concentrations* of inspired oxygen (FIO_2) must be delivered to the patient, it is recommended that the optional FIO_2 Sensor or a separate oxygen analyzer with alarms be used. If using the optional FIO_2 Sensor set the ventilator Low FiO_2 alarm appropriately (see *Low FIO2* alarm in Chapter 8 –Ventilator Alarms for additional information).

Setting the Flow for Low Pressure Oxygen Blending:

Use one of the three (3) following charts and the accompanying instructions to determine the required low pressure O_2 flow setting to deliver the desired FIO_2.

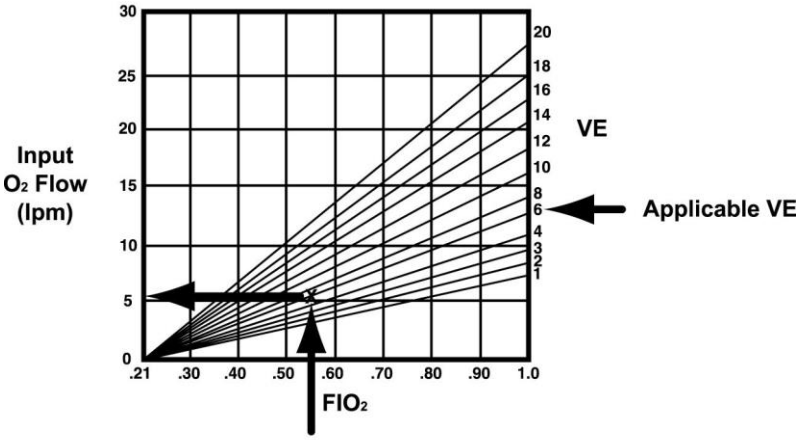



Bias Flow = 5 lpm
Input
O2 Flow
(lpm)
30
25
20
15
10
5
0
.21
.30
.40
.50
.60
.70
.80
.90
1.0
FIO2
20
18
16
14
12
10
8
6
4
3
2
1
VE


Bias Flow = 3 lpm
Input
O2 Flow
(lpm)
30
25
20
15
10
5
0
.21
.30
.40
.50
.60
.70
.80
.90
1.0
FIO2
20
18
16
14
12
10
8
6
4
3
2
1
VE

To Determine the Required O_2 Input Flow:

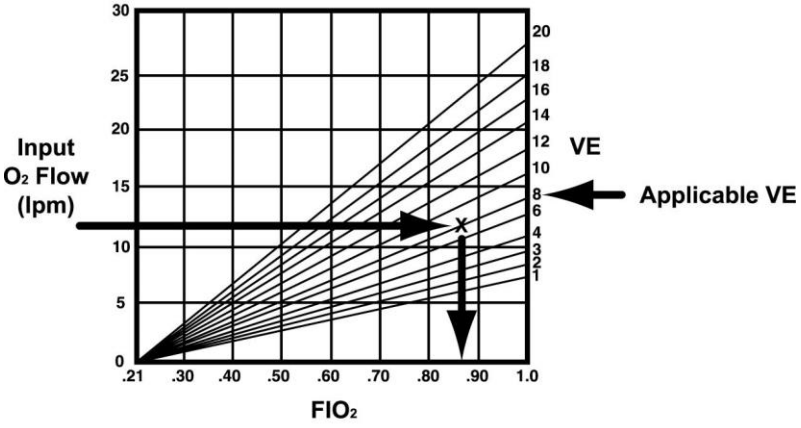
1) Select the appropriate chart based on the **Bias Flow** setting. When Leak Compensation is on, the patient leak should be added to the Bias Flow value.
2) Identify the desired F_{IO_2} (bottom of chart).
3) Calculate the patient's Minute Volume (VE) rate by using the formula: Tidal Volume X Breath Rate. Locate the Minute Volume reading (right side of chart).
4) Follow the vertical F_{IO_2} line up to the applicable slanted VE (Minute Volume) line.
5) From where they intersect, read across horizontally to the left side of chart to the required Input O_2 Flow (lpm).



Example - To determine the required O_2 input flow

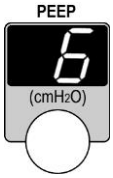
To Determine the Estimated Delivered O_2 Concentration:

1) Select the appropriate chart based on the **Bias Flow** setting. When Leak Compensation is on, the patient leak should be added to the Bias Flow value.
2) Find the Input O_2 Flow (left side of chart).
3) Follow the Input O_2 Flow across horizontally to the right to the applicable slanted VE (Minute Volume) line.
4) Read down to the F_{IO_2} (bottom of chart).



Example - To determine the delivered O_2 concentration

PEEP (Positive End Expiratory Pressure)



The **PEEP** control is used to set the Positive End Expiratory Pressure, which is the pressure maintained in the circuit at the end of exhalation.

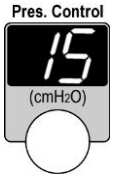
Range**:** **0** through **20 cmH_2O**

The **PEEP** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

To Set PEEP:

Use the three step "Select, Change and Confirm" method to set PEEP (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Pres. Control (Pressure Control)



The **Pres. Control** (Pressure Control) control is used to set the target pressure above PEEP for Pressure Control breaths. The ventilator controls inspiratory flow to maintain the set circuit pressure for the inspiratory time.

Range: **1** through **99 cmH_2O**

The **Pres.Control** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

To Set Pressure Control:

Use the three step "Select, Change and Confirm" method to set the Pressure Control (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

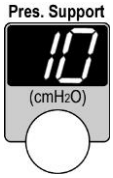
NOTE

- Flow Termination is available for Pressure Control breaths (see *Flow Term (Flow Termination)* and *PC Flow Term (Pressure Control Flow Termination)* in Chapter 10 – Extended Features for detailed instructions). The **Pres. Control** display flashes briefly after a Pressure Control breath that is flow terminated.
- The Rise Time profile for Pressure Control breaths can be adjusted using the **Rise Time** menu (see *Rise Time* in Chapter 10 – Extended Features for detailed instructions).
- In **CPAP+PS** (**Pressure**) and **NPPV CPAP+PS** (**Pressure**) settings, the **Pres. Control** control setting establishes the target pressure above PEEP in Apnea Backup ventilation.

  In **CPAP+PS** (**Volume**) and **NPPV CPAP+PS** (**Volume**) settings, the **Tidal Volume** control establishes the delivered Tidal Volume in Apnea Backup ventilation.

  Be sure to set them appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information)

Pres. Support (Pressure Support)



The **Pres. Support** (Pressure Support) control is used to set the target pressure above PEEP for Pressure Support patient breaths. If **Pres. Support** is set to "**- -**" (off), all patient breaths are given as Spontaneous breaths. Inspiratory flow for Pressure Support and Spontaneous breaths is controlled to meet the patient demand.

Range**:** **1** through **60 cmH_2O**, or **"- -"** (off)

The **Pres. Support** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

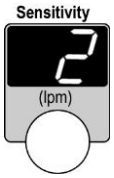
To Set Pressure Support:

Use the three step "Select, Change and Confirm" method to set the Pressure Support (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

NOTE

- Flow or Time Termination is available for Pressure Support breaths (see *Flow Term (Flow Termination)* and *Time Term (Time Termination)* in Chapter 10 – Extended Features for detailed instructions). The **Pres. Support** display flashes briefly after a Pressure Support or Spontaneous breath is Time Terminated or terminated by the elapse of two (2) breath periods.
- The Rise Time profile for Pressure Support breaths can be adjusted using the **Rise Time** menu (see *Rise Time* in Chapter 10 – Extended Features for detailed instructions).
- The Pressure Support control is inactive in **CPAP+PS** (**PRVC**) mode. Support breaths are delivered as PRVS breaths.

Sensitivity



The **Sensitivity** control is used to set the flow threshold level to allow the patient to trigger breaths.

Range**:** **P**, or **1** through **9 lpm**

- **1** is the most sensitive, **9** is the least sensitive for flow triggering
- **P** indicates pressure triggering is enabled and that flow triggers are disabled

The **Sensitivity** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

NOTE

Bias Flow - The ReVel ventilator provides a bias flow during exhalation to assist with patient triggering. The level of Bias Flow is selected using the **Bias Flow** menu (see *Bias Flow* in Chapter 10 – Extended Features).

While the flow trigger **Sensitivity** control is being set, the current Bias Flow setting is displayed and when a patient demand is detected, the **Patient Effort** indicator LED is illuminated briefly.

Flow Triggering Threshold Level – The flow triggering threshold level (**Sensitivity**) is automatically set to 2 lpm when the **Breath Mode** is changed to **CPAP+PS** and the **Sensitivity** control was previously set to "**P**" (Pressure Trigger).

Pressure Trigger Setting - A **Check P Trig** message is displayed in the front panel display window when the **Sensitivity** control value is set to "**P**" to remind the operator to check the **Pres Trigger** (Pressure Trigger) set threshold level for patient appropriateness.

- Push the **Exit** button to clear the **Check P Trig** message
- See *Pres Trigger (Pressure Trigger)* in Chapter 10 – Extended Features for additional information

A flow trigger occurs when:

- The **Sensitivity** control is set to a value from **1** to **9**
- The ventilator is in exhalation phase
- The minimum exhalation time has expired
- The flow is equal to or greater than the **Sensitivity** setting

A backup breath is delivered when:

- The airway pressure drops below -3 cmH_2O
- The ventilator is in exhalation phase
- The minimum exhalation time has expired

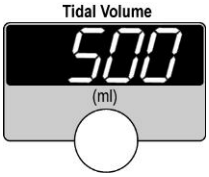
⚠ WARNING

When using the ventilator in transport situations, excessive movement of the patient circuit may cause auto cycling. To reduce the possibility of auto cycling during transport, reduce the Sensitivity setting (by increasing Flow Trigger) or consider utilizing pressure triggering ("**P**").

To Set Sensitivity:

Use the three step "Select, Change and Confirm" method to set Sensitivity (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Tidal Volume



The **Tidal Volume** control is used to set the volume of gas delivered during Volume Control, PRVC and PRVS breaths (see *Chapter 4 - Breath Types and Modes* for additional information concerning Volume and PRVC breaths).

Range**:** **50** through **2000 ml**

The **Tidal Volume** control setting may be limited to less than its specified range; see *Control Limiting* in this chapter for detailed information.

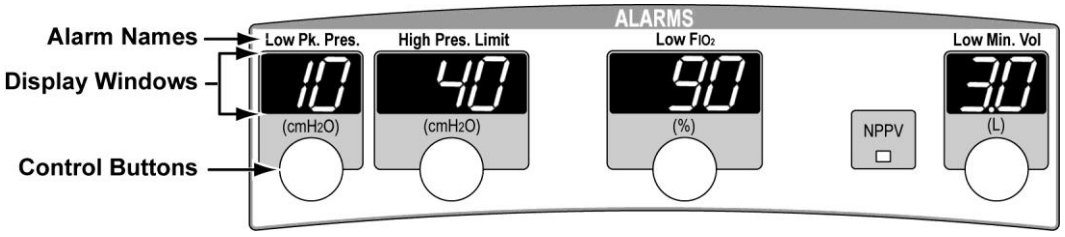
To Set Tidal Volume:

Use the three step “Select, Change and Confirm” method to set the Tidal Volume (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

> **NOTE**
>
> The Calculated Peak Inspiratory Flow (**Vcalc)** is updated in the display window while **Tidal Volume** or **Insp. Time** settings for a volume breath are being changed.
>
> In **CPAP+PS** (**Volume**) and **CPAP+PS** (**PRVC**) mode, the **Tidal Volume** control establishes the Tidal Volume for Apnea Backup ventilation. Be sure to set it appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information)

Front Panel, Alarms

This section provides a description of the controls on the Alarms panel, their use, function, ranges and limitations.



Low Pk. Pres. (Low Peak Pressure)

The **Low Pk. Pres.** (Low Peak Pressure) control is used to set the low peak pressure alarm limit value. See *Low Peak Pressure* in Chapter 8 – Alarms for detailed alarm information.

Range**:** **1** through **60 cmH_2O** in increments of 1, or **"- -"** (off)

To Set the Low Pk. Pres. Alarm:

Use the three step "Select, Change and Confirm" method to set the low peak pressure alarm (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

High Pres. Limit (High Airway Pressure Limit)

The **High Pres. Limit** (High Airway Pressure Limit) control is used to set the high airway pressure limit alarm value. See *High Airway Pressure* in Chapter 8 – Alarms for detailed alarm information.

Range**:** **5** through **100 cmH_2O** in increments of 1

To Set the High Pres. Limit Alarm:

Use the three step "Select, Change and Confirm" method to set the high pressure limit alarm (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Low FIO_2

> **NOTE**
>
> To enable the Low FIO_2 alarm control, the FIO_2 Sensor option must first be enabled using the Startup, **FIO_2 Sensor** menus. Once setup, enabled and calibrated, communication with the FIO_2 sensor may also be enabled/disabled during normal ventilation modes using the Extended Features, **FIO_2 Sensor** menus.
>
> - See *Navigating Startup and Extended Features Menus* and *FIO2 Sensor Configuration and Calibration* in Chapter 3 – Using the Ventilator and *FIO2 Sensor* in Chapter 10 – Extended Features for additional information

The **Low FIO_2** control is used to set the low FIO_2 alarm limit value. See *Low FIO2* in Chapter 8 – Alarms for detailed alarm information.

Range**:** **18** through **95%** in increments of 1, or **"- -"** (off)

To Set the Low FIO_2 Alarm:

When the FIO_2 Sensor option is enabled, use the three step "Select, Change and Confirm" method to set the low FIO_2 alarm (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Low Min. Vol. (Low Exhaled Minimum Volume)

The **Low Min. Vol.** (Low Minimum Volume) control is used to set the low exhaled minimum volume alarm limit value. See *Low Exhaled Minute Volume* in Chapter 8 – Alarms for detailed alarm information.

Range**:** **0.1** through **99 L**, or **"- -"** (off)

To Set the Low Minimum Volume Alarm:

Use the three step "Select, Change and Confirm" method to set the low minimum volume alarm (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

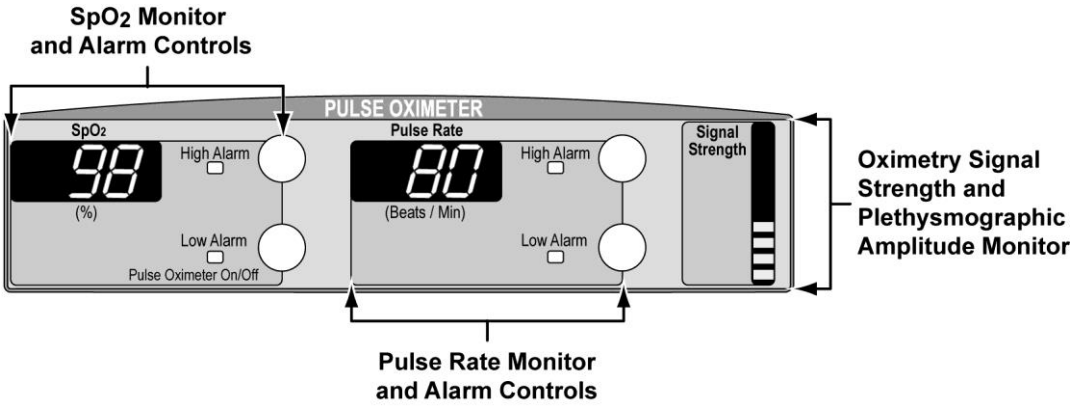
Front Panel, Pulse Oximeter

The Pulse Oximeter panel controls are used to enable/disable patient SpO_2, Pulse Rate and Oximetry Signal Strength monitoring, and to set their associated high and low alarm limits.

- See *Pulse Oximetry (SpO2)* in Chapter 2 – Installation and Setup for additional information

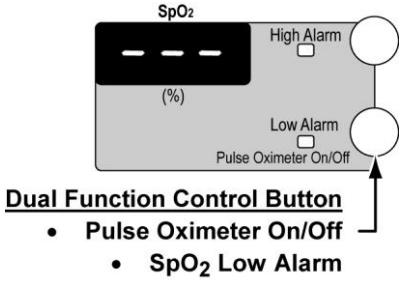
Pulse Oximetry average interval and pulse tone volume configuration values are set using the Extended Features menus.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Pulse Ox (Pulse Oximetry)* in Chapter 10 – Extended Features for additional information



Pulse Oximeter On/Off

The **Pulse Oximeter On/Off** control is a dual function control (also used for SpO_2 monitor low alarm limit setting) and for the purpose of these instructions is used to enable/disable patient SpO_2, Pulse Rate and Oximetry Signal Strength monitoring and their associated alarm limit controls.



To turn Pulse Oximetry on:

Push the **Pulse Oximeter On/Off** button.

- When pulse oximetry is enabled (on), the SpO_2, Pulse Rate, and Signal Strength display windows are illuminated and after a short delay will display the applicable monitored data

> **NOTE**
> If a SpO_2 sensor is not on a patient and properly connected to a SpO_2 module and the ventilator when Pulse Oximetry is enabled, a pulse oximetry alarm(s) will be activated.

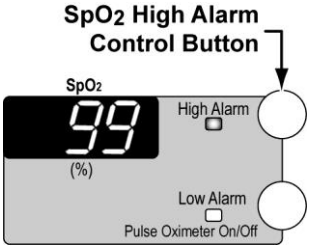
To turn Pulse Oximetry off:

Push and hold the **Pulse Oximeter On/Off** button for 3 seconds. A Vent Inop alarm occurs and the **Vent Inop** LED is illuminated.

NOTE

Pulse oximetry alarm limits (SpO_2 and Pulse Rate, high and low alarm limits) are set and changed in a manner similar to the way all other front panel adjustable controls are changed ("Select, Change, and Confirm"), except that pulse oximetry must first be enabled by pushing the dual function **Pulse Oximeter On/Off** control button as previously described.

High Alarm (SpO_2)



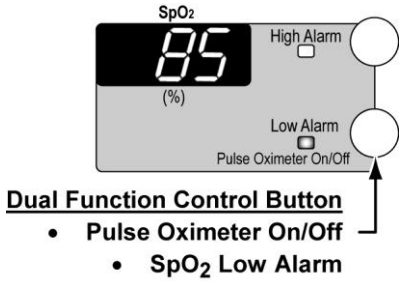
The SpO_2 monitor **High Alarm** control is used to set the SpO_2 high alarm limit value.

Range**:** **80** through **99%**, or **"- -"** (off)

To Set the SpO_2 Monitor High Alarm:

Once pulse oximetry is enabled, use the three step "Select, Change and Confirm" method to set the SpO_2 high alarm limit value (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Low Alarm (SpO_2)



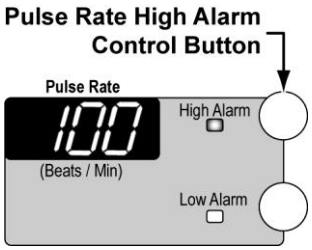
The SpO_2 monitor **Low Alarm** control is a dual function control (also used for enabling/disabling the Pulse Oximeter monitors) and for the purpose of these instructions is used to set the SpO_2 low alarm limit value.

Range**:** **60** through **99%**, or **"- -"** (off)

To Set the SpO_2 Monitor Low Alarm:

Once pulse oximetry is enabled, use the three step "Select, Change and Confirm" method to set the SpO_2 low alarm limit value (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

High Alarm (Pulse Rate)



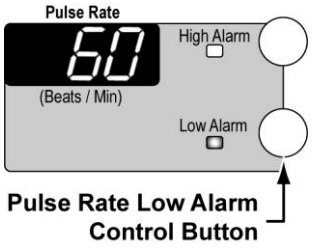
The Pulse Rate monitor **High Alarm** control is used to set the pulse rate high alarm limit value.

Range**:** **18** through **299 (Beats / Min.)**, or **"- -"** (off)

To Set the Pulse Rate Monitor High Alarm:

Once pulse oximetry is enabled, use the three step "Select, Change and Confirm" method to set the pulse rate high alarm limit value (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Low Alarm (Pulse Rate)



The Pulse Rate monitor **Low Alarm** control is used to set the pulse rate low alarm limit value.

Range**:** **19** through **300 (Beats / Min.)**, or **"- -"** (off)

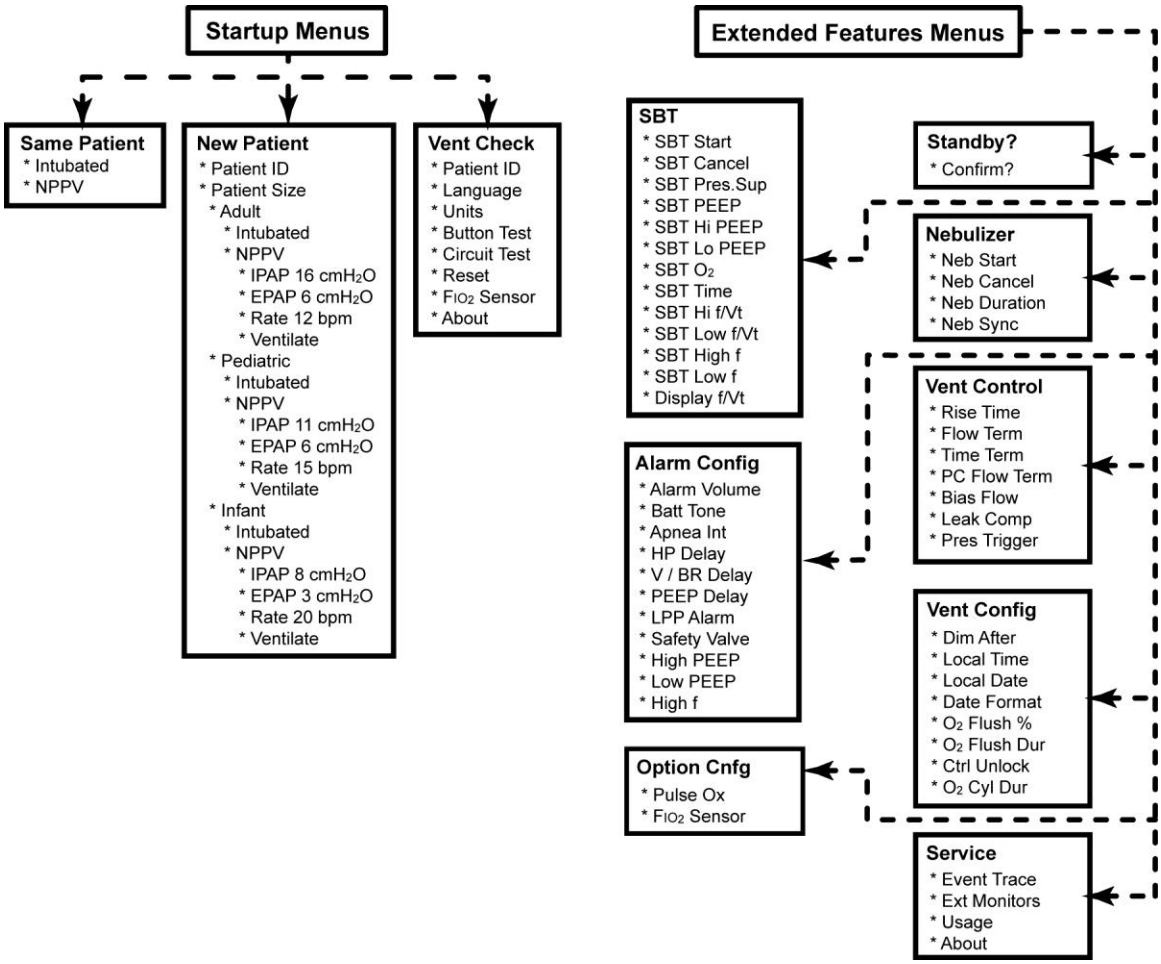
To Set the Pulse Rate Monitor Low Alarm:

Once pulse oximetry is enabled, use the three step "Select, Change and Confirm" method to set the pulse rate low alarm limit value (see *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator for detailed instructions).

Startup and Extended Features, Controls

Additional adjustable controls not directly represented on the front or lower interface panels are accessed, configured and set using the Startup and Extended Features menus.

- See *Navigating Startup and Extended Features Menus* and *Startup Mode and Menus* in Chapter 3 – Using the Ventilator, and *Extended Features Menus* in Chapter 10 – Extended Features for information regarding additional controls, available features and option



NOTE

Startup menus are only displayed and accessed when the ventilator is initially turned on and the ventilator is in Startup mode.

Extended Features menus are only displayed and accessed while the ventilator is in a normal ventilation mode. Extended Features menus cannot be accessed when the front panel controls are locked.

Fixed Controls

Safety Valve

The ventilator has a safety valve that automatically opens during the following conditions:

- During all ventilator operating states *other* than normal ventilation (e. g., Off, POST, Startup)
- During a sub-ambient relief condition (see below)
- To provide over-pressure relief during a sustained high pressure condition (see *High Airway Pressure* in Chapter 8 – Ventilator Alarms*)*
- To provide backup over pressure relief in conjunction with the High Airway Pressure alarm setting and the Delta Pressure setting (see *Safety Valve High Pressure Relief* in Chapter 8 –Ventilator Alarms)

Sub-Ambient (Anti-Asphyxia) Relief

The safety valve provides sub-ambient relief when the airway pressure is -10 to -5 cmH_2O.

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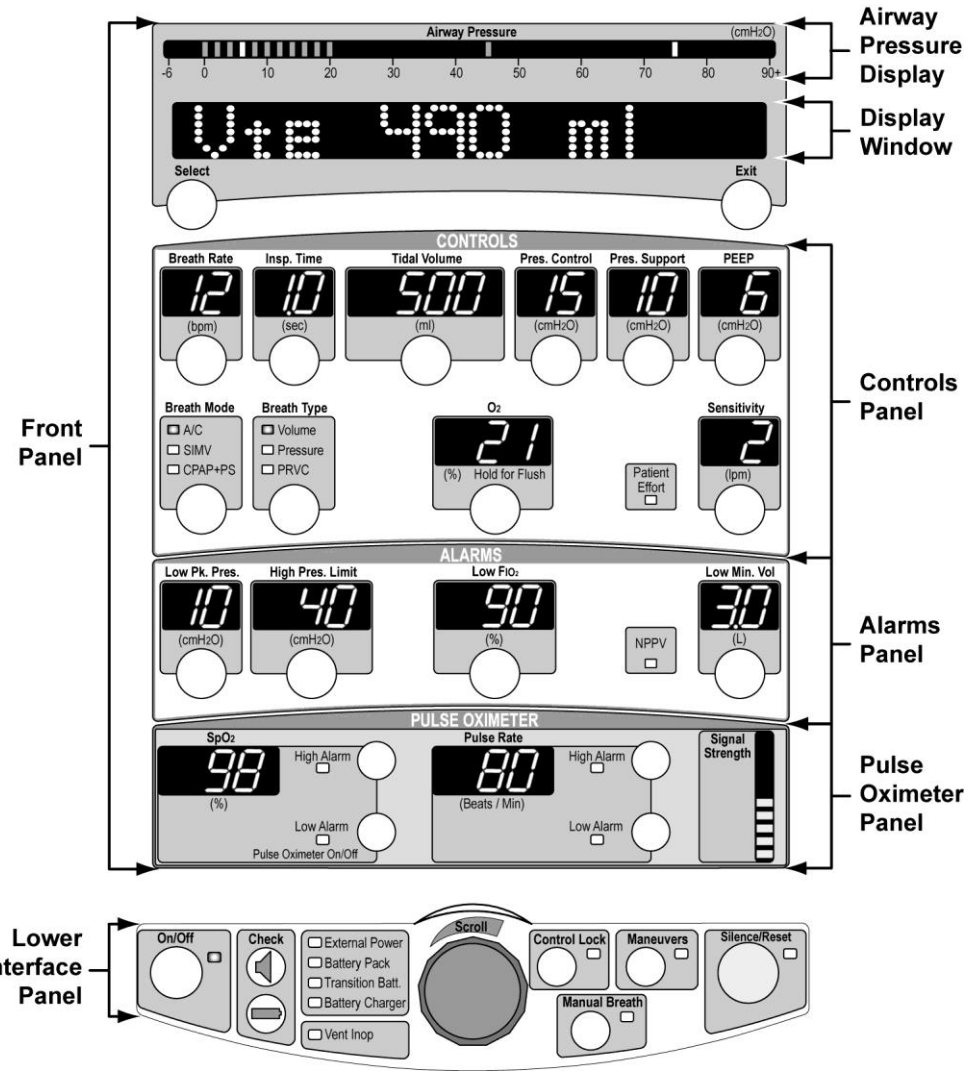
Chapter 6 - DISPLAYS AND INDICATORS

This chapter describes the displays and indicators on the ReVel ventilator front and lower interface panels.

- Front Panel
  - Airway Pressure Display (Manometer)
  - Display Window
  - Controls Panel
  - Alarms Panel
  - Pulse Oximeter Panel
- Lower Interface Panel



See *Display Characteristics* in Chapter 3 – Using the Ventilator for additional information.

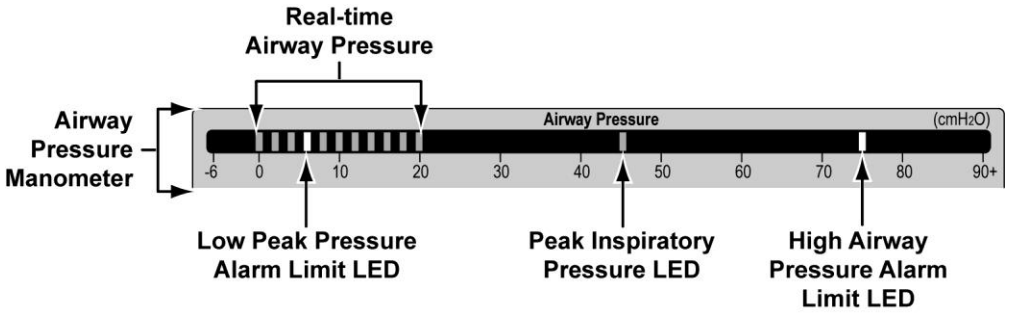
Front Panel Displays and Indicators

Airway Pressure Manometer

The Airway Pressure Manometer at the top of the front panel displays a bar of bi-color LEDs which are illuminated to display the real-time, breath by breath Airway Pressure.

The display includes the following elements:

- **Display Range** — **-6 cmH_2O** through **90+ cmH_2O**
  Each illuminated LED represents a pressure increment of 2 cmH_2O, except for **90+** which represents air pressure of 90 cmH_2O or higher
- **Low Peak Pressure Limit** — A single amber LED at the set Low Peak Pressure (**Low Pk. Pres**.) alarm limit value
- **Airway Pressure** — A continuous bar of green LEDs that display the real-time breath by breath Airway Pressure
- **Peak Inspiratory Pressure** — A single green LED which remains illuminated at the Peak Inspiratory Pressure (**PIP**) value until the start of the next breath
- **High Airway Pressure Limit** — A single amber LED at the set High Airway Pressure (**High Pres. Limit**) alarm limit value



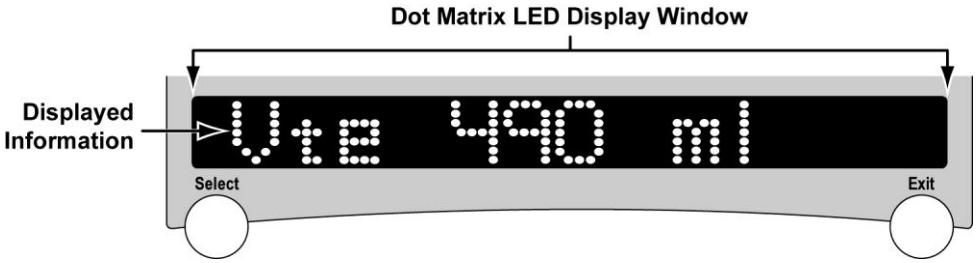
See the following chapters/sections for additional information concerning these displays and indicators:

- *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator
- *Front Panel, Alarms* in Chapter 5 – Controls
- *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms

Display Window

The display window near the top of the front panel is an alpha/numeric, 12 character, dot matrix LED array which displays a variety of types of information, in a prioritized (highest to lowest) sequence, as follows:

- Alarm Messages
- Battery/Power Check Information
- Test Results
- Startup and Extended Features Menus
- Alert Messages
- Monitored Data (automatic scrolling or paused)



The display window may appear in the following LED illumination states;

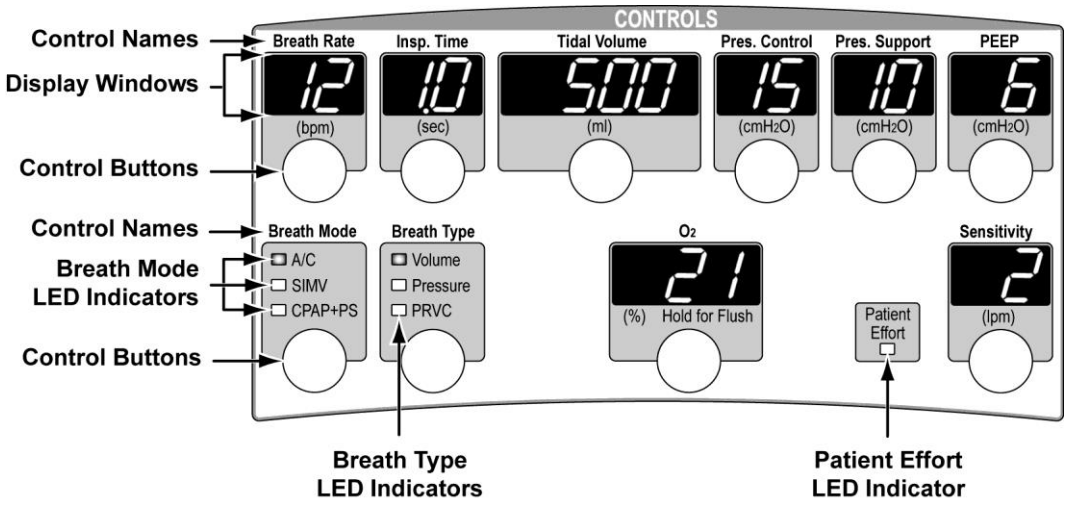
- **Bright** The entire display is at full intensity to indicate a control value is active
- **Dim** The entire display is at half intensity to indicate a control value is inactive
- **Blanked** The display is not illuminated to save battery power
- **Flashing** The display alternates between bright and blanked for alarm messages
- **Selected** A portion of the display is bright with all other characters are dimmed to indicate the location of a value to be changed

See the following chapters/sections for additional information concerning the display window:

- *Automatic or Manual Data Display Scrolling* and *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator
- *Front Panel, Display Window* in Chapter 5 – Controls
- *Front Panel Display Window* in Chapter 7 – Monitored Data
- *Visual Alarm Displays* and *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms
- *Dim After* in Chapter 10 – Extended Features

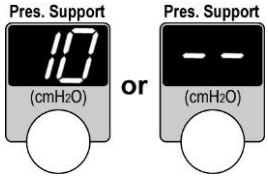
Controls Panel

The Controls panel contains various ventilation controls and associated push buttons with seven segment LED display windows or LED indicators, and the Patient Effort LED indicator.



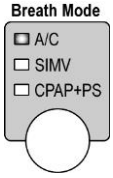
Seven Segment LED Display Windows

The seven segment LED display window is used to display either the particular ventilation control's set or selected value (active or not), including off ("**- -**").



Breath Mode or Type LED Indicators

When illuminated, the Breath Mode or Type LED indicators indicator which particular ventilation breath mode and type are set or selected.



Patient Effort LED Indicator

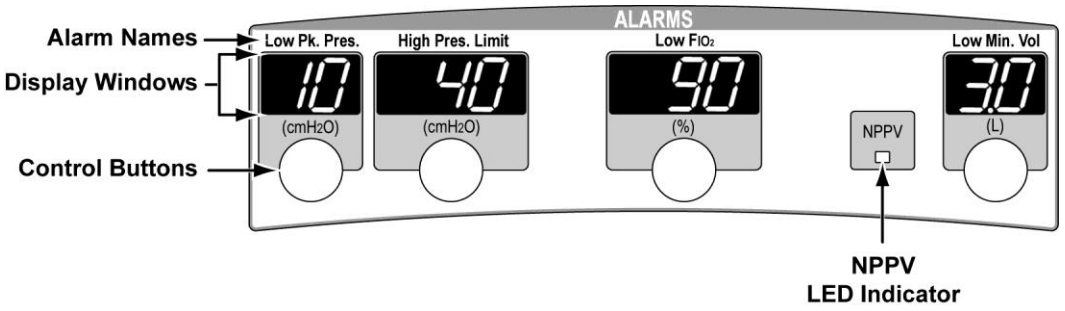
The Patient Effort LED indicator is illuminated (green) briefly each time a patient triggers a breath.

See the following chapters/sections for additional information concerning these displays and indicators:

- *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator
- *Front Panel, Controls* in Chapter 5 – Controls

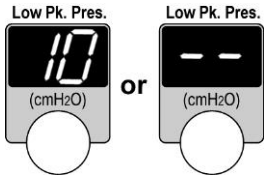
Alarms Panel

The Alarms panel contains various ventilation alarm controls and associated push buttons with seven segment LED display windows, and the NPPV LED indicator.



Seven Segment LED Display Windows

The seven segment LED display window is used to display either the particular alarm control's set or selected value (active or not), including off ("**- -**").



NPPV LED Indicator

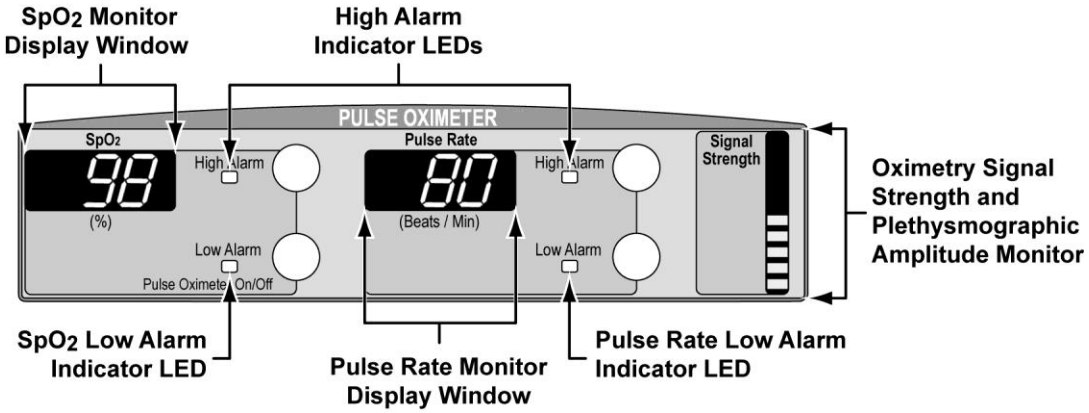
The **NPPV** LED indicator LED is illuminated (red) when an NPPV ventilation mode is active.

See the following chapters/sections for additional information concerning these displays and indicators:

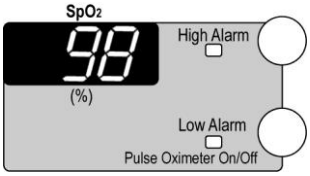
- *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator
- *Front Panel, Alarms* in Chapter 5 – Controls
- *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms

Pulse Oximeter Panel

The Pulse Oximeter panel contains the SpO_2, Pulse Rate, and Oximetry Signal Strength monitors, the SpO_2 and Pulse Rate High and Low Alarm controls and associated push buttons and LED indicators.

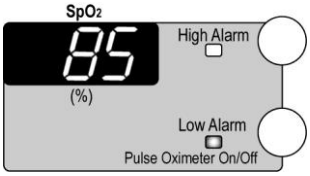


Seven Segment LED Display Windows



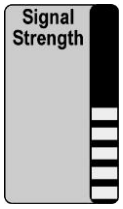
When Pulse Oximetry is enabled and a SpO_2 module and sensor are properly attached to the ventilator and patient, the SpO_2 and Pulse Rate seven segment LED display windows are used to display the associated SpO_2 and Pulse Rate monitored values and the set (when selected) High and Low alarm limit values.

High and Low Alarm LED Indicators



When an SpO_2 or Pulse Rate, High or Low Alarm LED indicator is illuminated, the associated seven segment LED display window is used to display the alarm's set limit value (including off ("- - -")).

Oximetry Signal Strength Display



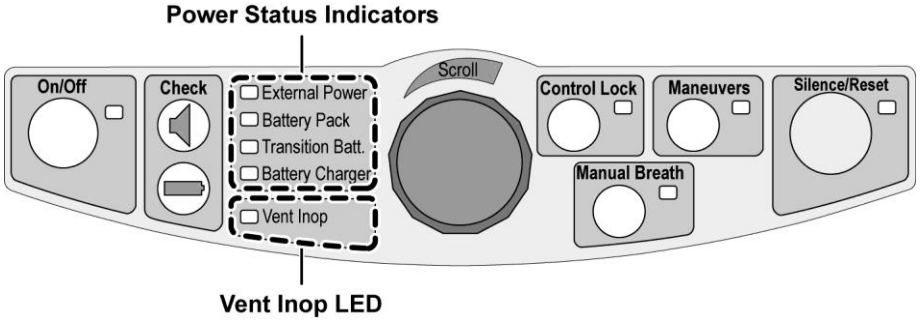
LEDs within the oximetry Signal Strength display window are illuminated (green, amber, or red) to indicate the strength of the signal being received from the external oximetry module. Additionally, the height to which the LEDs are illuminated fluctuates in unison with the Plethysmographic amplitude.

See the following chapters/sections for additional information concerning these displays and indicators:

- *Pulse Oximetry (SpO2)* in Chapter 2 – Installation and Setup
- *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* and *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator
- *Front Panel, Pulse Oximeter* in Chapter 5 – Controls
- *Pulse Oximetry Signal Strength* and *Pulse Rate* in Chapter 7 – Monitored Data
- *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms
- *Pulse Ox (Pulse Oximetry)* in Chapter 10 – Extended Features

Lower Interface Panel Indicators

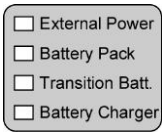
The following section describes the purpose of the LED indicators on the lower interface panel that do not have associated controls.



Power Status LEDs

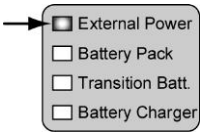
The Power Status LEDs indicate the active power source and battery charging status.

- External Power
- Battery Pack
- Transition Batt.
- Battery Charger



External Power

The **External Power** LED indicates the status of external sources of power for the ventilator (external DC (side) port and the Docking Station port), whether the ventilator is on or off.



When the **External Power** indicator LED is:

Off	The ventilator is not connected to usable external power
Green	The ventilator is connected to a usable external source of power that is adequate to properly run the ventilator
Amber	The ventilator is connected to an external power source with low voltage • The External Power Low **(Ext Pwr Low)** alarm is active
Flashing Red	The ventilator is connected to an external source of power that is faulted • The External Power Fault (**ExtPwrFault**) alarm is active

⚠ WARNING

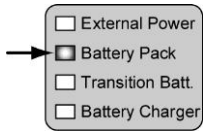
Flashing Red External Power LED - A flashing red **External Power** LED indicates that the external source of power connected to the ventilator is not usable and should be serviced. The ventilator will automatically switch to the Removable Battery Pack if present, or the Transition Battery. Insert a charged Removable Battery Pack or connect the ventilator to a Vyaire approved alternate source of power.

NOTE

The **External Power** LED is also illuminated when the Display/Alarm **Check** button is pushed (to check the status of the displays), even when the ventilator is not being powered by external power.

Battery Pack

The **Battery Pack** LED indicates the status of the Removable Battery Pack installed in the ventilator. When the **Battery Pack** indicator LED is:



Off	The ventilator is not operating on power from a Removable Battery Pack
Green	The ventilator is operating on power from a Removable Battery Pack with a charge level greater than 25% capacity
Amber	The ventilator is operating on power from a Removable Battery Pack with a charge level greater than 5% and equal to or less than 25% capacity. • The Battery Low (**Bat Low**) alarm is active
Red	The ventilator is operating on power from a Removable Battery Pack with a charge level equal to or less than 5% capacity. • The Battery Empty (**Bat Empty**) alarm is active
Flashing Red	The currently installed Removable Battery Pack is not usable. • The Battery Fault (**Bat Fault**) alarm or the Insert Battery (**Insert Batt**) alarm is active

⚠ WARNING

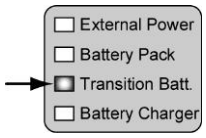
Flashing Red Battery Pack LED - A flashing red **Battery Pack** LED indicates that the currently installed Removable Battery Pack is not usable. Insert a different, charged Removable Battery Pack or connect the ventilator to a Vyaire approved alternate source of power.

NOTE

The **Battery Pack** LED is also illuminated when the Battery/Power **Check** button is pushed (to check the status of power), or when the Display/Alarm **Check** button is pushed (to check the status of the displays), even when the ventilator is not being powered by the battery.

Transition Battery

The **Transition Batt.** LED indicates the status of the Transition Battery installed in the ventilator.



NOTE

The internal Transition Battery is only intended for use as a short duration source of power for the ventilator when changing depleted Removable Battery Packs, or switching the ventilator to, or between, external sources of power. Do not operate the ventilator using the Transition Battery as the source of power for more than one (1) minute.

When the **Transition Batt.** indicator LED is:

Off — The ventilator is not operating on power from the Transition Battery.

Green — The ventilator is operating on power from the Transition Battery which has a normal charge level.

- The Transition Battery Use (**T-Bat Use**) alarm is active

Red — The ventilator is operating on power from the Transition Battery which has a low charge level.

- The Transition Battery Use (**T-Bat Use**) alarm is active

Flashing Red — The ventilator is operating on power from a Transition Battery which may be unreliable.

- The Transition Battery Fault (**T-Bat Fault**) alarm is active

⚠ WARNING

Transition Battery Use Alarm - A Transition Battery Use alarm indicates the ventilator is only being powered by the Transition Battery and will shut down soon. Immediately insert a charged Removable Battery Pack or connect the ventilator to an external source of power. As the Transition battery is depleted the audible and visual Transition Battery Use alarms will continue to be displayed/sounded. However, the LED indicator may transition from Green to Off.

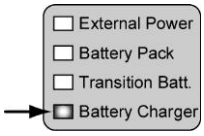
Flashing Red Transition Battery LED - A flashing red **Transition Batt** LED indicates that the ventilator's internal Transition Battery may be unreliable. Discontinue use of the ventilator and contact Vyaire or a service technician certified by Vyaire.

NOTE

The **Transition Batt.** LED is also illuminated when the Battery/Power **Check** button is pushed (to check the status of power), or when the Display/Alarm **Check** button is pushed (to check the status of the displays), even when the ventilator is not being powered by the battery.

Battery Charger

The **Battery Charger** LED indicates the charging status of the Removable Battery Pack and the Transition Battery installed in the ventilator.



When the **Battery Charger** indicator LED is:

Off	The battery charger is not charging a Removable Battery Pack or the Transition Battery (no external power connected, or charging is completed)
Green	The Transition Battery is fully charged or faulted and the battery charger is charging a Removable Battery Pack with constant voltage (nearing end of charge cycle)
Amber	The Transition Battery has been fully charged or faulted and the battery charger is charging a Removable Battery Pack with constant current (in bulk charge portion of charge cycle)
Flashing Amber	The battery charger is charging the Transition Battery

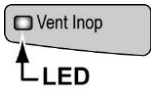
NOTE

When both the Transition Battery and the Removable Battery Pack require charging, and the ventilator is connected to a valid external DC power source, the battery charger will charge the Transition Battery to full capacity or “Faulted” status before charging the Removable Battery Pack.

To avoid depleting the Removable Battery Pack, when the ventilator is being powered by the Removable Battery Pack, it will only partially charge a depleted Transition Battery.

Vent Inop LED

The **Vent Inop** LED indicates the operational status of the ventilator.



When the **Vent Inop** LED is:

Off The ventilator is in the Off, POST, Startup, or Normal state

Flashing Red The ventilator is inoperative, or in the process of shutting down

- The flashing LED is accompanied by Vent Inop alarm tone until both are disabled by pushing the **Silence/Reset** button

⚠ WARNING

Vent Inop Alarm - If a Vent Inop alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a service technician certified by Vyaire

Alternative Ventilation – Vyaire recommends that an alternate means of ventilation be available and the procedures to be followed if the ventilator ceases to function properly.

NOTE

If not cleared by pushing the **Silence/Reset** button, the **Vent Inop** LED will remain illuminated for a minimum of 5 minutes after the ventilator is shut off.

The ventilator enters an inoperative state when:

- The ventilator is powered off by pushing the **On/Off** button for 3 seconds
- All ventilator power sources are insufficient to operate the ventilator
- The ventilator detects any condition that is deemed to make the ventilator unsafe

NOTE

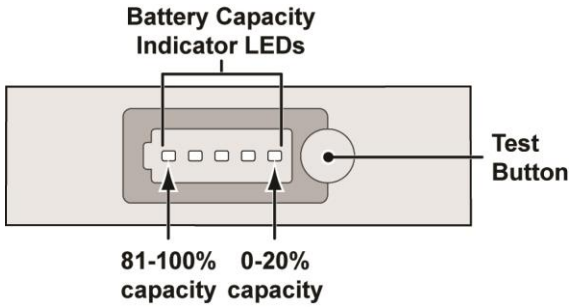
While in the Vent Inop state, the ventilator is set to a condition which allows the patient to breathe spontaneously from room air.

Removable Battery Pack LED Indicators

A button on the Removable Battery Pack, linked to a series of five LEDs, allows you to check the percentage of charge remaining regardless of whether the Removable Battery Pack is installed in the ventilator.

Each LED increments approximately 20% as follows:

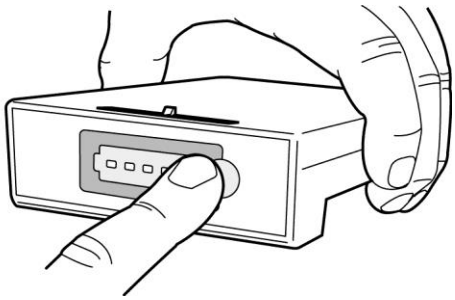
LEDs Illuminated	Approximate Charge Level
1	0-20%
2	21-40%
3	41-60%
4	61-80%
5	81-100%



If the battery is being charged, the LED that is representative of the of the battery's current charge level flashes while the test button is being pushed.

> **NOTE**
>
> **Battery Replacement** - Capacity is measured as a percentage of the battery's capacity when it was new. When a fully-charged battery does not display at least 50% capacity, the battery has reached the end of its useful life and it is time to replace that battery.

To check the battery charge, push and hold the Test button as shown.



Chapter 7 - MONITORED DATA

General Information

The ReVel ventilator monitors, updates and displays the following patient and device related data:

Monitored Patient Data

- Airway Pressure
- Exhaled Minute Volume (VE)
- Exhaled Tidal Volume (Vte)
- Fraction of Inspired Oxygen (FIO_2)
- I:E Ratio, Calculated (I:Ecalc)
- I:E Ratio, Measured (I:E)
- Mean Airway Pressure (MAP)
- Nebulizer Time Remaining (Neb)
- O_2 Flush level and Time Remaining (O_2+)
- Oxygen Saturation (SpO_2)
- Peak Inspiratory Flow Rate (Vpeak)
- Peak Inspiratory Flow, Calculated (Vcalc)
- Peak Inspiratory Pressure (PIP)
- Positive End Expiratory Pressure (PEEP)
- Pulse Oximetry Signal Strength (Signal Strength) and Plethysmographic Amplitude
- Pulse Rate (Pulse Rate)
- SBT Breath Rate (SBT f)
- SBT f/Vt
- SBT Time Remaining (SBT)
- Spontaneous Breath Rate (Sp f)
- Spontaneous Exhaled Tidal Volume (SpVte)
- Total Breath Rate (f)
- Trend Log (not displayed by the ventilator)

Monitored Device Data

- Leak, Measured (Leak)
- O_2 Source Pressure (O_2)
- Peak Expiratory Flow Rate, Measured (Vepk)
- Power Status
- Removable Battery Fuel Gauge
- Vent Usage Meter, Non-Resettable (Total Hrs)
- Vent Usage Meter, Resettable (Trip Hrs)

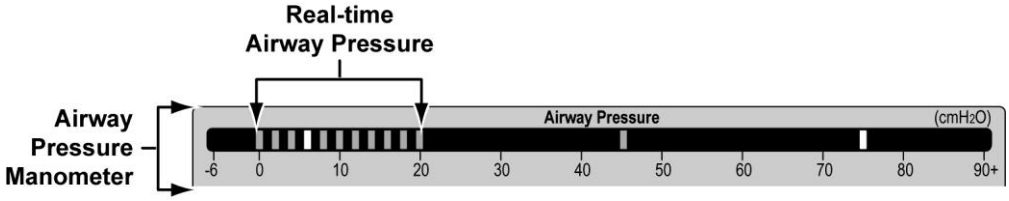
NOTE

When using the ventilator in transport situations, excessive movement may cause variations in monitored values. Values will self-recover once disturbance has been removed.

Front Panel Airway Pressure Manometer

Airway pressure is continuously displayed in the Airway Pressure segmented bar display at the top of the front panel.

- See *Airway Pressure Manometer* in Chapter 6 – Displays and Indicators for additional information

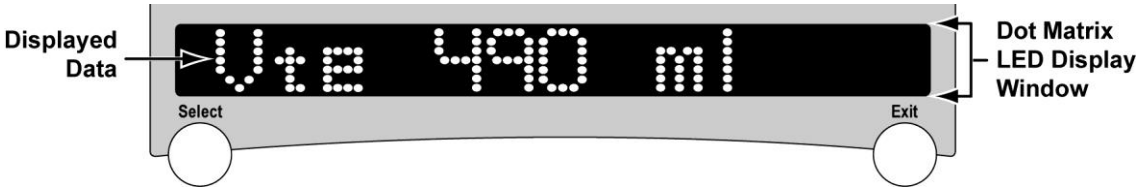


Front Panel Display Window

Monitored data is automatically scrolled continuously in the front panel display window during normal ventilation mode. The display is actively updated whenever alarms and/or extended features are not displayed. Each value is displayed for three seconds and is updated in real time.

To pause the display of data and/or manually scroll the display, see *Automatic or Manual Data Display Scrolling* in Chapter 3 – Using the Ventilator for detail instructions. For additional information, see:

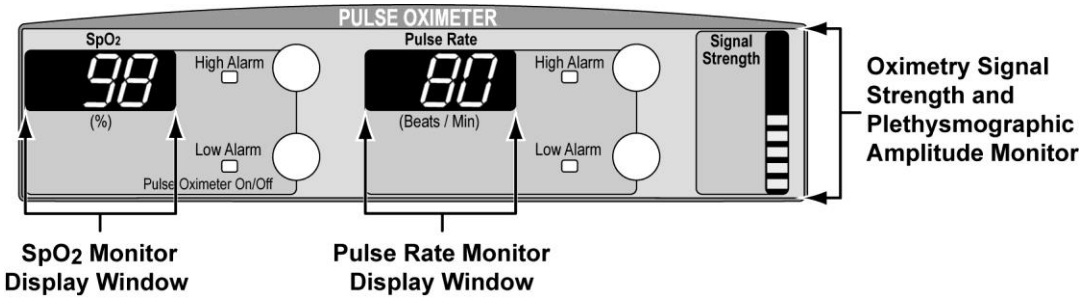
- *Front Panel, Display Window* in Chapter 5 – Controls
- *Display Window* in Chapter 6 – Displays and Indicators



Pulse Oximeter Panel

SpO_2, Pulse Rate, Oximetry Signal Strength and Plethysmographic Amplitude monitored data are displayed on the Pulse Oximeter Panel. For additional information, see:

- *Front Panel, Pulse Oximeter* in Chapter 5 – Controls
- *Pulse Oximeter Panel* in Chapter 6 – Displays and Indicators



Monitored Patient Data

Except for those data displayed in the Airway Pressure Manometer and on the Pulse Oximeter panel, monitored patient data is displayed in the front panel display window.

- LPPS / LMV alarm status messages, when applicable, are displayed in the front panel display window along with monitored data. See *Alerts, LPPS / LMV Status Messages* in Chapter 8 – Ventilator Alarms for detailed information.

Airway Pressure

Airway Pressure is continuously measured at the patient Wye and displayed real time, on the Airway Pressure manometer segmented bar display at the top of the front panel.

Range **-6** through **90+ (cmH_2O)**

Exhaled Minute Volume (VE)

Exhaled Minute Volume is calculated from the average Tidal Volume for the last eight (8) breaths times the Total Breath Rate. When less than eight breaths are available, only the available breaths are used.

Range: **VE 0** through **99.9 L**

Exhaled Tidal Volume (Vte)

Exhaled Tidal Volume is calculated by integrating the flow from the patient through the patient circuit Wye during the exhalation phase of the breath. Tidal volumes are displayed as BTPS (Body Temperature Pressure Saturated) compensated, however it does not compensate for circuit compliance.

Flows of less than 2 lpm (Adult/Ped/Infant) are not included in the integration.

Range: **Vte 0** through **4000 ml**

Fraction of Inspired Oxygen (FIO_2)

The FIO_2 monitored data is only visible when an optional FIO_2 Sensor is correctly installed, calibrated and FIO_2 monitoring is enabled .

Range: **FIO_2 12** through **103 %**

> **NOTE**
>
> To ensure accurate FIO_2 measurements, the FIO_2 Sensor must be calibrated to the ventilator upon initial ventilation of a new patient and if FIO_2 measurements become inaccurate based on the **O_2** ventilator setting.

I:E Ratio, Calculated (I:Ecalc)

Calculated I:E Ratio is the calculated inspiratory time divided by the expiratory time, based solely on the **Insp**. **Time** and **Breath Rate** settings.

Range: **I:Ecalc 1:99** through **4.0:1**

I:E Ratio, Measured (I:E)

Measured I:E Ratio is the measured inspiratory time divided by the measured exhalation time.

Range: **I:E 1:99** through **45:1**

Mean Airway Pressure (MAP)

Mean Airway Pressure is calculated as a running average of the airway pressure for the last 60 seconds. When less than 60 seconds of data is available, the running average of the available data is used.

The Mean Airway Pressure monitor is updated at least every 10 seconds.

Range: **MAP 0** through **99 cmH_2O**

Nebulizer Time Remaining (Neb)

When a Nebulizer procedure is started, the remaining time for the procedure, beginning at the set duration time (**Neb Duration**) and reducing every second and minute until no time is left, is displayed.

Range: **Neb 00:00** through **Neb 30:00**

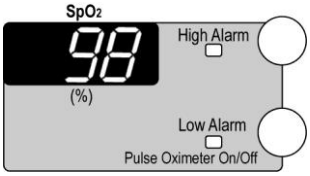
O_2 Flush Level and Time Remaining (O_2+)

When an O_2 Flush procedure is started, the percentage of O_2 increased (**O_2 Flush %**) and the remaining time for the procedure, beginning at the set duration time (**O_2 Flush Dur**) and reducing every second and minute until no time is left, is displayed.

Range: **O_2+0** through **79% 02:00** through **03:00** (MM:SS)

Oxygen Saturation (SpO_2)

The SpO_2 monitor (located on the Pulse Oximeter panel) displays an estimate of the patient's functional oxygen saturation of arterial oxyhemoglobin saturation, measured by the external Oximetry Module, when installed and enabled.



Range**:** **0** through **100** (%)

Peak Inspiratory Flow Rate (Vpeak)

Peak Inspiratory Flow Rate is the peak inspiratory flow of the previous breath, measured at the patient Wye.

Range: **Vpeak 3** through **190 lpm**

Peak Inspiratory Flow, Calculated (Vcalc)

Peak Inspiratory Flow is calculated from the **Tidal Volume** and **Insp. Time** settings for Volume breaths.

Range: **Vcalc 10** through **120 lpm**

> **NOTE**
> Calculated Peak Inspiratory Flow (**Vcalc**) is only displayed when Volume modes are selected.

Peak Inspiratory Pressure (PIP)

Peak Inspiratory Pressure is the greatest airway pressure measured during the inspiratory phase and minimum exhalation time of the exhalation phase.

Range: **PIP 0** through **120 cmH_2O**

Positive End-Expiratory Pressure (PEEP)

Positive End Expiratory Pressure is the pressure in the airway circuit at the end of exhalation.

Range: **PEEP 0** through **99 cmH_2O**

Pulse Oximetry Signal Strength

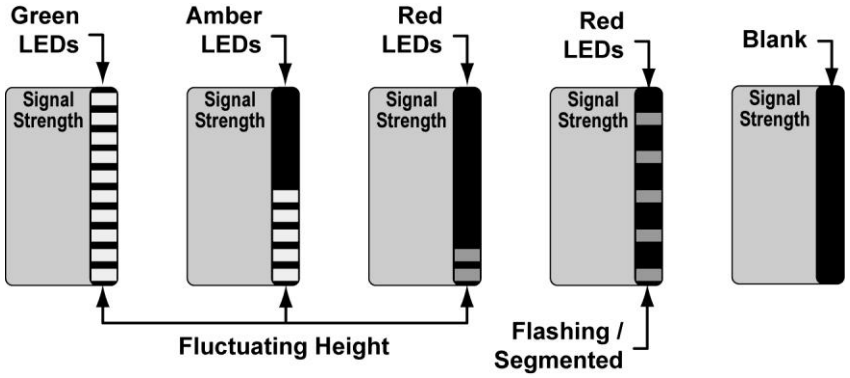
LEDs within the pulse oximetry **Signal Strength** monitor display window (located on the Pulse Oximeter panel) are illuminated to indicate the strength of the signal being received from an external oximetry module, when installed and enabled.

- The height to which the LEDs are illuminated fluctuates in unison with the Plethysmographic amplitude.

Range: **Green**, **Amber**, or **Red**

Indications:

- **Green** LEDs, fluctuating height — Maximum strength signal
- **Amber** LEDs, fluctuating height — Medium strength signal
- **Red** LEDs, fluctuating height — Minimum strength signal
- **Red** LEDs, flashing/segmented — ARTF or OOT condition occurring
- **Blank** — No signal being received



NOTE

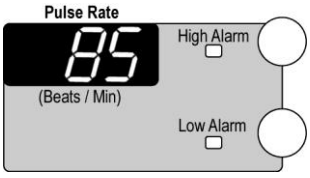
ARTF (Artifact) – A detected pulse beat didn't match the current pulse interval (typically additional/erroneous signal(s).

OOT (Out of Track) – An absence of consecutive good pulse signals.

Both are caused by variations in/of the signal(s) from the SpO_2 module and are typically caused by patient/finger movement. Neither is an indication of a faulty or defective SpO_2 module.

Pulse Rate

The Pulse Rate monitor (located on the Pulse Oximeter panel) displays the patients' heart rate, as measured by the external Oximetry module, when installed and enabled.



Range: Blank (off), "- - -" (no data), or **18** through **300** (Beats / Min)

SBT Breath Rate (SBT f)

SBT Breath Rate is the Total Breath Rate during an SBT procedure.

Range: **SBT f 1** through **120 bpm**

SBT f/Vt

When an SBT procedure is being performed, SBT f/Vt is the calculated value f/Vt, where f is the monitored SBT Breath Rate and Vt is the average Exhaled Tidal Volume in liters.

The SBT f/Vt monitor updates when the Breath Rate or Exhaled Minute Volume changes during the SBT period and the displayed data values remain visible during the SBT period and for five minutes after it has been completed.

Range: **0** through **998 bpm/L**, or **"- -"** (no data)

SBT Time Remaining (SBT)

When an SBT procedure is started, the remaining time for the procedure, beginning at the set **SBT Time** and reducing every second and minute until no time is left, is displayed.

Range**:** **SBT 00:00** (mm:ss) through **SBT 02:00:00** (hh:mm:ss)

Spontaneous Breath Rate (Sp f)

Spontaneous Breath Rate is the rate per minute of Spontaneous and Support breaths, based on the last eight (8) breath periods. When fewer than eight Spontaneous or Support breaths have occurred, the available number of breaths is used.

Range: **Sp f 0** through **120 bpm**

Spontaneous Exhaled Tidal Volume (SpVte)

The Spontaneous Exhaled Tidal Volume monitor displays the Exhaled Tidal Volume of Spontaneous and Support breaths. '----' is displayed if none of the last eight breaths were patient triggered. The Spontaneous Exhaled Tidal Volume monitor is updated at the end of the exhalation phase of Spontaneous breaths. Tidal volumes are displayed as BTPS (Body Temperature Pressure Saturated) compensated, however it does not compensate for circuit compliance.

Range: **SpVte 0** through **4000 ml**

Total Breath Rate (f)

Total Breath Rate is the patient breath rate, based on the last eight (8) breath periods. When fewer than 8 breaths have occurred, the available number of breaths is used. All breath types are included in the computation.

Range: **f 0** through **120 bpm**

Trend Log

Twenty-four (24) hours of monitored data can be stored in the ventilator's Trend Log (not displayed by the ventilator). Data values are entered into the Trend Log once per minute. The value entered is the average for the previous minute. Data older than 24 hours is discarded.

When the Patient Circuit Fault (**Pat Circuit**) alarm is active, or when no data is available (e.g. ventilator is not ventilating or feature is disabled) no data is entered in the Trend Log.

- When the ventilator is docked onto a PTV Series Docking Station with a CompactFlash™ Memory card installed, all data in the Trend Log is automatically copied onto the memory card. See the PTV Series Docking Station Operator's Manual, P/N 33870-001 for detailed information

- Auto PEEP
- Delta Pressure
- Exhaled Minute Volume
- Exhaled Tidal Volume
- Expiratory Pressure
- Fraction of Inspired Oxygen
- Mean Airway Pressure
- Measured Leak
- Oxygen Saturation
- Peak Expiratory Flow
- Peak Inspiratory Flow
- Peak Inspiratory Pressure
- Plateau Pressure
- Positive End-Expiratory Pressure
- Pulse Rate
- SBT Breath Rate
- SBT f/Vt
- Spontaneous Breath Rate
- Spontaneous Tidal Volume
- Static Compliance
- Total Breath Rate

Monitored Device Data

Except for the battery capacity indicator LEDs on the Removable Battery Pack itself, monitored device data is displayed in the front panel display window using the Extended Features menus. For additional information, see:

- *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator
- *Extended Features Menus* in Chapter 10 – Extended Features

Leak, Measured (Leak)

Measured Leak is a measure of the steady state flow through the patient circuit Wye toward the patient during exhalation, as determined by the Leak Compensation function.

- To view Measured Leak data, see *Ext Monitors (Extended Monitors)* in the Extended Features, Service menus in Chapter 10 – Extended Features for additional information

Range: **Leak 0.0** through **30.0 lpm**

NOTE

- **Values Not Reported** - The Measured Leak monitor reports no value during a patient circuit disconnect condition that lasts longer than 60 seconds or whenever a stable leak cannot be detected for 60 seconds or more.
- **Limitation of Compensation** - The limitation of compensation is determined by the range and accuracy of the Leak monitor and the set Bias Flow.

O_2 Source Pressure (O_2)

O_2 Source Pressure is the pressure measured at the O_2 Inlet.

- To view O_2 Source Pressure data, see *Ext Monitors (Extended Monitors)* in the Extended Features, Service menus in Chapter 10 – Extended Features for additional information

Range: **O_2 2.0** through **99.9 PSI**

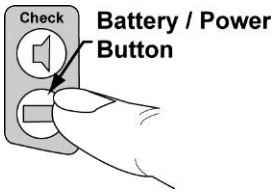
Peak Expiratory Flow Rate, Measured (Vepk)

Measured Peak Expiratory Flow Rate is the Peak Expiratory Flow of the previous breath, measured at the patient Wye.

- To view Peak Expiratory Flow Rate data, see *Ext Monitors (Extended Monitors)* in the Extended Features, Service menus in Chapter 10 – Extended Features for additional information

Range: **Vepk 0** through **190 lpm**

Power Status



The status of any power supply connected to the ventilator is monitored and relevant data displayed in the front panel display window when the Battery/Power **Check** button is pushed on the lower interface panel. For additional information, see:

- *Battery/Power* in Chapter 5 – Controls
- *Lower Interface Panel Indicators* in Chapter 6 – Displays and Indicators
- *Chapter 12 - Power Supplies and Batteries*

	Power Source			
	Removable Battery Pack	External DC Power	Docking Station	Transition Battery
Possible Status Messages Displayed	**Batt xxx%**	**Ext OK**	**Dock OK**	**T-Bat OK**
	Batt Removed	**Ext Low**	**Dock Low**	**T-Bat Low**
	Batt Fault	**Ext Removed**	**Dock Removed**	**T-Bat Remove**
		Ext Fault	**Dock Fault**	**T-Bat Chrg**
				T-Bat Fault

NOTE

Batt xxx% indicates the remaining percentage capacity of the Removable Battery Pack (**xxx** is the numeric percentage).

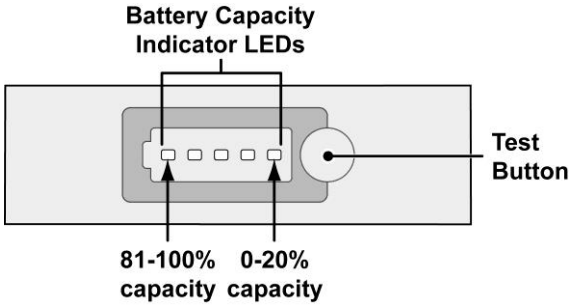
If any fault message (**xxxxx Fault**) is displayed, it is an indication that the displayed source of power (**Batt, Ext, Dock** or **T-Bat**) has been detected and is not adequate to power the ventilator.

Removable Battery Fuel Gauge

The status of the Removable Battery Pack is also displayed on the end of the Removable Battery Pack when the battery's **Test** button is pushed. For additional information, see:

- *Removable Battery Pack* in the Chapter 12– Power Supplies and Batteries

Range: **0-20%** through **81-100%**



LEDs Lit	Approximate Charge Level
1	**0-20%**
2	**21-40%**
3	**41-60%**
4	**61-80%**
5	**81-100%**

Vent Usage Meter, Non-Resettable (Total Hrs)

The Non-Resettable Usage monitor displays the total number of hours of ventilator operation and is updated every 0.1 hours.

- See *Usage* in the Extended Features, Service menus in Chapter 10 – Extended Features for additional information

Range: **0.0** through **500000.0 hrs**

Vent Usage Meter, Resettable (Trip Hrs)

The Resettable Usage monitor tracks and displays the number of hours of ventilator usage since the last time the monitor was reset by an operator.

- See *Usage* in the Extended Features, Service menus in Chapter 10 – Extended Features for additional information

Range: **0.0** through **500000.0 hrs**

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Chapter 8 - VENTILATOR ALARMS

General Information

When the ventilator detects a condition which may require action by the user, it initiates an alarm. The ventilator has both fixed and adjustable alarms. The following sections describe the alarms, what causes them, how to reset them, and how to configure them.

Some alarms can be delayed for a set number of breaths. For instance, a High Airway Pressure alarm (**High Pres**) can be delayed for one or two breaths to prevent activation during patient coughing. See *HP Delay (High Pressure Delay)* in the Alarm Configuration menus in Chapter 10 – Extended Features for detailed information.

NOTE

For optimal awareness of an alarm state, the ideal operator position is one meter in front of the ventilator

⚠ WARNING

Vent Inop Alarm - If a Vent Inop alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a service technician certified by Vyaire.

Patient Monitoring – Failure to identify and respond to alarm conditions may result in patient injury or death. Ventilator dependent patients should be constantly monitored by personnel trained to address circumstances where equipment becomes inoperative.

Patient Disconnection - The Low Exhaled Minute Volume (**Low Min. Vol.)** and Low Peak Pressure (**Low Pk. Pres.)** alarms must be appropriately set in order to detect disconnection of the patient from the patient circuit.

Check Alarms – Alarm function should be tested periodically to ensure proper operation (see *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning, and *Display/Alarm Test* in Chapter 2- Installation and Setup). If any alarm malfunctions, contact Vyaire or a service technician certified by Vyaire. Failure to immediately identify and correct alarm situations may result in serious patient injury or death.

Alarm Priorities

There are multiple priority levels for audible and visual signals generated by the ventilator, depending on the urgency of the condition.

When more than one alarm is activated, the alarm messages will be displayed in the front panel display window in the order of the priority sequence, with active alarms displayed first.

Audible and Visual Elements

Sound Types, Patterns and Volumes

The ReVel ventilator generates several unique types of audible alarm and signal notification sound patterns. The volume at which these are generated depends upon on the type of sound and the set audible volume level.

Operators and caregivers should be trained to recognize and respond appropriately to each type of audible alarm or signal sound pattern.

Alarm/Signal Sound Type	**Sound Pattern**	**Audible Volume Level**
Vent Inop alarm	A continuously repeated group of 8, pulsed tones	Sounds at fixed volume of 80 ± 5 dBA
High Priority alarm	Continuously repeated groups of 10, pulsed tones (3-2-3-2)[28]	Sounds between >45 dBa and 80 ± 5 dBA, and is automatically adjusted to a higher audible volume level than that of Low Priority alarms[29]
Medium Priority alarm	A continuously repeated group of 3, pulsed tones	
Low Priority alarm	A continuously repeated group of 2, pulsed tones	Sounds between >45 dBa and <80 ± 5 dBA, and is automatically adjusted to a lower audible volume level than that of High and Medium Priority alarms[29]
Accessory Attach signal	A group of 2, ascending pitch, pulsed tones	
Key Click signal	A single medium frequency note	
Battery Use alarm	A periodic audible tone, once per minute	Sounds at set Battery Use Tone volume
SpO_2 Pulse Tone signal	A single audible tone, repeated for each pulse detected	Sounds at set Pulse Tone volume

To set the audible volume levels for the High, Medium and Low priority alarms, the Battery Use alarm tone and/or the SpO_2 Pulse Tone signal, see *Alarm Config (Alarm Configuration)* and *Option Cnfg (Option Configuration)* in Chapter 10 – Extended Features for detailed instructions.

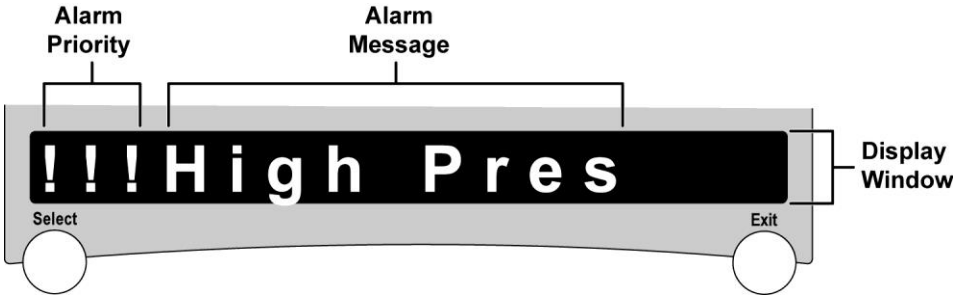
[28] Alarm tones Patterns are per ISO 9703-2

[29] Allows operators to differentiate between High/Medium and Low Priority alarm audible volume levels.

Visual Alarm Displays

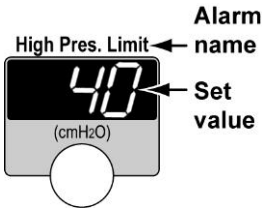
There are multiple components to the visual display portion of an alarm condition.

1) Alarm messages are displayed flashing off and on in the Display Window near the top of the front panel.
    - When multiple alarms are occurring, only the alarm with highest priority is displayed until it has been resolved and/or reset. Once the highest priority alarm has been resolved, the others are displayed in order of importance



2) To help identify alarm priorities, active high priority alarm messages displayed are preceded by three (3) exclamation points (!!!), active Medium priority alarm messages are preceded by two (2) exclamation points (!!), and active Low priority alarm messages are preceded by one (1) exclamation point.

3) The set/displayed values of associated front panel adjustable alarm or ventilation controls (if any) flash. See *Display Characteristics* in Chapter 3 – Using the Ventilator for additional information.



When an Alarm Occurs

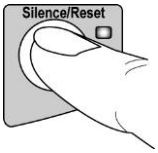
For most alarm conditions, the following happens when an alarm is activated:

- Alarm message(s) are displayed (see *Visual Alarm Displays* in this chapter)
- An audible alarm sounds (see *Sound Types, Patterns and Volumes* in this chapter)
- Associated front panel adjustable alarm or ventilation control displays (if any) flash (see *Visual Alarm Displays* in this chapter)
- Depending on which alarms were generated, the ventilator may also initiate other actions, such as terminating inspiration and opening the exhalation valve

Exceptions to the above, are as follows:

- The Battery Use alarm has no accompanying displayed message; see *Battery Use* in this chapter for additional information
- The Vent Inop alarm sounds an audible tone and flashes the **Vent Inop** LED; see *Vent Inop* in this chapter for additional information

To Silence an Active Alarm



Push the **Silence/Reset** button on the lower interface panel once to silence an active audible alarm for 60 seconds. Pushing the **Silence/Reset** button a second time cancels the 60 second silence period.

- See *Silence/Reset* in Chapter 5 - Controls for additional detailed information

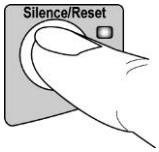
Alarm Recovery

When the conditions that generated an alarm no longer exist and the alarm has not yet been reset, the audible alarm is silenced.

- See *Silence/Reset* in Chapter 5 – Controls for additional information

To Reset Alarms

To reset alarms (silence the alarm sounder and clear the alarm message(s)), push the **Silence/Reset** button on the lower interface panel. A second push removes the visible (highest priority) flashing alarm message, and subsequent lower priority alarms (if actively occurring) are displayed.



> **⚠ WARNING**
>
> **Resetting Alarms** - Before resetting/removing alarm messages from the display window, operators should review each alarm message displayed and be fully aware of its meaning and applicability to the patient. When necessary, refer to the *Alarms, Detailed Descriptions* section located later in this chapter for an alphabetical listing of all alarms with detailed explanations of each alarm.

Each subsequent push removes the next visible alarm message in order of priority (see *Alarm Priorities* in Chapter 8 – Ventilator Alarms). Additionally, the following alarm messages are also reset/removed, even if they are active.

- Apnea (**Apnea**)
- Button Stuck (**ButtonStuck**)
- Configuration Reset (**ConfigReset**)
- Docking Station Disconnect (**Dock Discon**)
- External Power Lost (**ExtPwr Lost**)
- External Power Low (**Ext Pwr Low**)
- FiO_2 Sensor Fault (**FIO_2 Fault**)
- Insert Battery (**Insert Batt**) (reoccurs after 60 sec.)
- Preventive Maintenance Required (**P Maint xxx**)
- Removable Battery Low (**Bat Low**)
- Remove Patient (**Remove Ptnt**)
- SBT Off (**SBT Off**)
- SBT Time (**SBT Time**)
- Schedule Service (**SchedSvcxxx**)
- Transition Battery Use (**T-Bat Use**) (one time only, 60 sec.)
- Ventilator Reset (**Vent Reset**)

Adjustable Alarms

The ReVel ventilator has Front Panel and Extended Features accessible adjustable alarms. The adjustable alarm limit values are at factory-set values when the ventilator is manufactured.

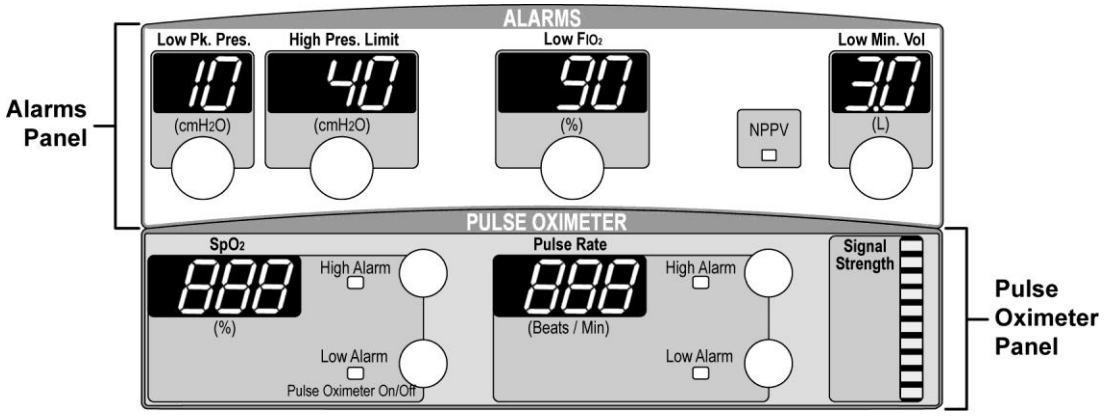
- See *Factory Settings* in Appendix C - Reference Information for a list of factory-set alarm values

> **⚠ WARNING**
>
> **Alarm Values** - To avoid patient injury, always check the alarm limits of all adjustable alarms for appropriateness prior to using the ventilator on a patient.

Front Panel Adjustable Alarms

The following adjustable alarm limits are set using the Alarms and Pulse Oximeter front panel controls:

- Low Peak Pressure (**Low Pk. Pres**)
- High Pressure (**High Pres. Limit**)
- Low F_{IO_2}
- Low Minute Volume (**Low Min. Vol.**)
- SpO_2 High and Low Alarms
- Pulse Rate High and Low Alarms



To Set Front Panel Adjustable Alarms

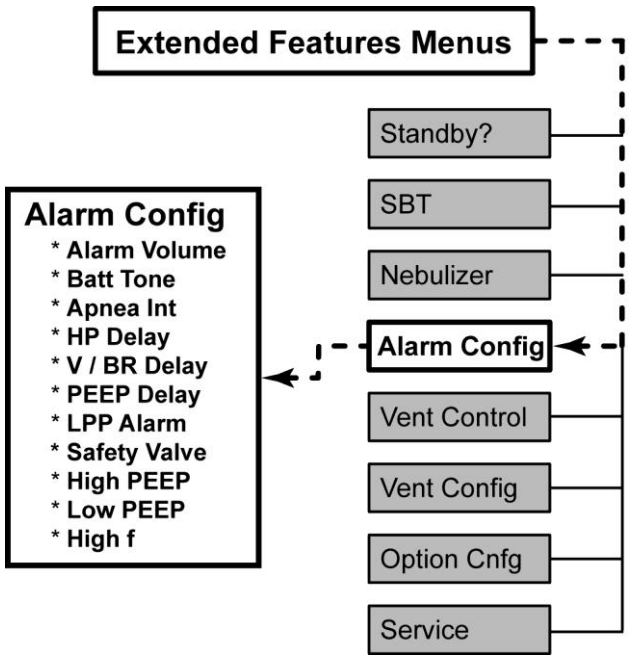
Use the three step “Select, Change and Confirm” method to set the front panel adjustable alarm limits. For additional information and detailed instructions, see:

- *Front Panel Ventilation and Alarm Controls* and *Setting Adjustable Front Panel Ventilation Controls and Alarm Limits* in Chapter 3 – Using the Ventilator
- *Front Panel, Alarms* and *Front Panel, Pulse Oximeter* in Chapter 5 - Controls

Extended Features Adjustable Alarms

The following adjustable alarm limits are set using the Extended Features, Alarm Configuration (**Alarm Config**) menus:

- High Positive End Expiratory Pressure (**High PEEP**)
- Low Positive End Expiratory Pressure (**Low PEEP**)
- High Breath Rate (**High f**)



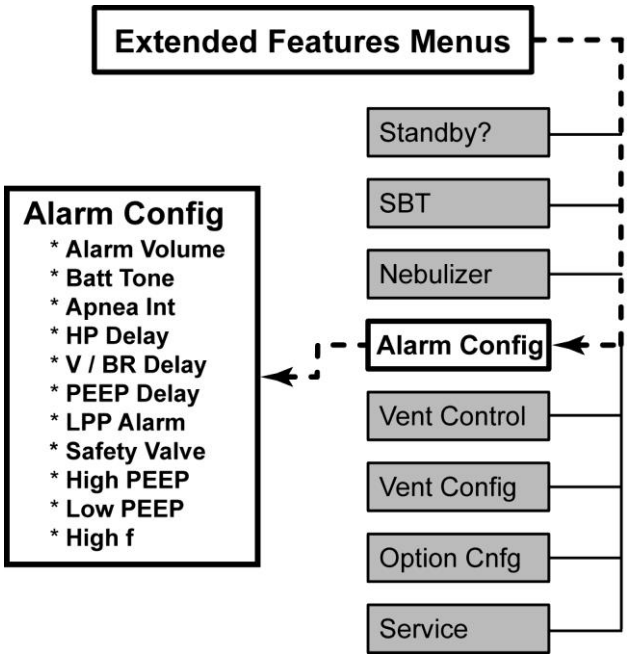
To Set Extended Features Adjustable Alarms

See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Alarm Config (Alarm Configuration)* in Chapter 10 - Extended Features for additional information and detailed instructions for setting Extended Features adjustable alarm limits.

Alarm Configuration in Extended Features

The Extended Features, Alarm Configuration (**Alarm Config**) menus are used to set alarm configuration parameters:

- Alarm Volume
- Battery Use Tone (**Batt Tone**)
- Apnea Interval (**Apnea Int**)
- High Pressure Delay (**HP Delay**)
- Minute Volume/Breath Rate Alarm Delay (**V/BR Delay**)
- Positive End Expiratory Pressure Delay (**PEEP Delay**)
- Low Peak Pressure Alarm (**LPP Alarm**)
- Safety Valve



To Set Alarms Configuration Parameters

See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Alarm Config (Alarm Configuration)* in Chapter 10 - Extended Features for additional information and detailed instructions for the configuration of alarm parameters.

Alarms, Detailed Descriptions

Apnea

The Apnea alarm (a user adjustable alarm) is generated when the time since the start of the last breath is greater than the set **Apnea Interval**.

Range**:** **10** through **60 sec** in increments of 10

When an Apnea alarm occurs:

- The **ApneaBackup** alarm message is displayed
- A high priority audible alarm sounds
- The displays for controls active in Apnea Backup mode are illuminated and all other control displays are dimmed
- The ventilator initiates Apnea Backup ventilation delivered in Assist/Control mode, per the set control values
- The breath period is reset

While in Apnea Backup mode, the alarm continues to sound and the **ApneaBackup** alarm message continues to flash until the operator resets the alarm or the patient triggers two (2) consecutive breaths.

When the Apnea alarm is reset by two consecutive breaths:

- Apnea Backup Ventilation terminates and the ventilator returns to the previous mode
- An **Apnea** alarm message is displayed and remains flashing
- The audible alarm is silenced
- Control displays return to normal ventilation mode

Pushing the **Silence/Reset** button clears the **Apnea** message.

Apnea Interval

To set the Apnea Interval:

The Apnea Interval is set using Extended Features menus. See *Apnea Int (Apnea Interval)* in the Extended Features, Alarm Configuration menus in Chapter 10 – Extended Features.

For additional information concerning Apnea Backup ventilation, see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes.

Battery Empty (Bat Empty)

A Battery Empty alarm (a fixed alarm) is generated when the ventilator is operating from the Removable Battery Pack and the battery charge level falls below the 5% charge threshold.

> **⚠ WARNING**
>
> **Battery Empty Alarm** - A Battery Empty alarm indicates the Removable Battery Pack is almost depleted. To avoid possible Vent Inop immediately insert a charged Removable Battery Pack or connect the ventilator to an external source of power.

When a Battery Empty alarm occurs:

- The **Batt Empty** alarm message is displayed
- A high priority audible alarm sounds
- The **Battery Pack** LED on the lower interface panel is illuminated red

Battery Fault (Bat Fault)

A Battery Fault alarm (a fixed alarm) is generated when the Removable Battery Pack is installed in the ventilator and any of the following conditions exist:

- Unable to charge the Removable Battery Pack
- Removable Battery Pack is unable to be used to power the ventilator for reasons other than the battery being depleted

> **⚠ WARNING**
>
> **Battery Fault Alarm** - Repeated or continuous Battery Fault alarms indicate that the currently installed Removable Battery Pack may be unreliable. Insert a reliable, charged Removable Battery Pack or connect the ventilator to an external source of power.

When a Battery Fault alarm occurs:

- The **Bat Fault** alarm message is displayed
- A medium priority audible alarm sounds
- The **Battery Pack** LED on the lower interface panel is illuminated flashing red

Battery Low (Bat Low)

A Battery Low alarm (a fixed alarm) is generated when the ventilator is operating from the Removable Battery Pack and the battery charge level falls below the 25% charge level threshold.

> **⚠ WARNING**
>
> **Battery Low Alarm** - A Battery Low alarm indicates the Removable Battery Pack is approaching depletion. Be prepared to insert a fully charged Removable Battery Pack or connect the ventilator to an external source of power.

When a Battery Low alarm occurs:

- The **Bat Low** alarm message is displayed
- A medium priority audible alarm sounds
- The **Battery Pack** LED on the Lower Interface Panel is illuminated amber

Battery Temperature Fault (RBatTempFlt)

The Battery Temperature Fault alarm (a fixed alarm) is generated when the Removable Battery Pack is the only power source available and:

- The temperature of the Removable Battery Pack is greater than 60° C
- The temperature of the Removable Battery Pack is less than -20° C

> **⚠ WARNING**
>
> **Battery Temperature Fault Alarm** – The Battery Temperature Fault alarm indicates that the ventilator's Removable Battery Pack is excessively hot or cold. When this alarm occurs, the ventilator shuts down and gas is not delivered to the patient. To avoid patient harm, disconnect the patient and ventilate using an alternate method until the cause of the Battery Temperature Fault alarm condition has been eliminated. See *Chapter 13 - Troubleshooting* for additional information.

When a Battery Temperature Fault alarm occurs:

- The **RBatTempFlt** alarm message is displayed
- A high priority audible alarm sounds
- The **Battery Pack** LED on the lower interface panel flashes red
- The ventilator stops delivering mandatory machine breaths and shuts down

Battery Use

The Battery Use alarm (a fixed alarm) is generated when the ventilator begins operating on power from a charged Removable Battery Pack.

When a Battery Use alarm occurs:

- An audible alarm sounds

Although the Battery Use alarm cannot be reset when the ventilator is operating from the Removable Battery Pack, the Battery Use tone volume level can be set within a range of **Off**, or **1** through **3**, using the Extended Features, Alarm Configuration (**Alarm Config**) menus.

- See *Batt Tone (Battery Use Tone)* in Chapter 10 – Extended Features for additional information and detailed instructions

Blower Demand Exceeded (Blwr Demand)

The Blower Demand Exceeded alarm (a fixed alarm) is generated when the average current demand of the ActiveCore™ blower exceeds a predetermined limit.

> **⚠ WARNING**
>
> **Blower Demand Exceeded Alarm** – During a sustained Blower Demand Exceeded alarm condition, the ventilator blower is stopped and gas is not delivered to the patient. To avoid patient harm, disconnect the patient and ventilate using an alternate method until the cause of the Blower Demand Exceeded alarm condition has been eliminated. See *Chapter 13 - Troubleshooting* for additional information.

When a Blower Demand Exceeded alarm occurs:

- The **Blwr Demand** alarm message is displayed
- A high priority audible alarm sounds
- The ventilator stops delivering mandatory machine breaths

Button Stuck (ButtonStuck)

A Button Stuck alarm (a fixed alarm) is generated when the ventilator detects pressure on any front or lower interface panel button, other than the **On/Off** control button, for more than 60 seconds.

> **⚠ WARNING**
>
> **Button Stuck Alarm -** If this alarm occurs without external stimulus, it indicates that the ventilator may not be working properly. Disconnect the patient from the ventilator, provide an alternative method of ventilation and contact Vyaire or a service technician certified by Vyaire.

When a Button Stuck alarm occurs:

- The **ButtonStuck** alarm message is displayed
- A medium priority audible alarm sounds

Remove any objects that may be applying pressure to the ventilator's front panels and see *Button Test* in Chapter 2 – Installation and Setup for instructions to perform the Button Test.

Configuration Reset (ConfigReset)

The ventilator is delivered with Controls, Alarms and Configuration settings set to factory values. When changes are made to any of the adjustable settings, the ventilator stores the new values in non-volatile memory[30].

During POST (Power On Self Test), the ventilator checks all stored configuration values. If an invalid value is detected, the Configuration Reset alarm (a fixed alarm) is generated.

When a Configuration Reset alarm occurs:

- The **ConfigReset** alarm message is displayed
- A high priority audible alarm sounds
- All adjustable Controls, Alarms or Configuration settings are reset to their original factory values

> **⚠ WARNING**
>
> **Check Settings** – Check all ventilator settings after a Configuration Reset alarm and modify them as necessary for your patient. Settings may no longer be appropriate.
>
> **Multiple Reset Alarms** - Repeated Configuration Reset alarms may indicate a problem with the ventilator's non-volatile memory. Immediately provide alternative ventilation for your patient and contact Vyaire or a service technician certified by Vyaire.

> **NOTE**
>
> A Configuration Reset alarm is not generated if the ventilator configuration has been manually reset to factory settings using the **Reset** menu in Startup mode.

[30] Non-volatile memory is memory that is not erased when the ventilator is turned off or disconnected.

Dock Disconnect (Dock Discon)

The Dock Disconnect alarm (a fixed alarm) is generated when the ventilator detects power and communications from a Docking Station are lost (such as occurs when undocking the ventilator).

When a Dock Disconnect alarm occurs:

- The **Dock Discon** alarm message is displayed
- A medium priority audible alarm sounds

Docking Station Fault (Dock Fault)

The Docking Station Fault alarm (a fixed alarm) is generated when the ventilator is receiving power from the Docking Station and detects corrupted or no communications; or when the ventilator is receiving communications from the Docking Station and is not receiving power.

When a Docking Station Fault alarm occurs:

- The **Dock Fault** alarm message is displayed
- A medium priority audible alarm sounds

External Power Fault (ExtPwrFault)

The External Power Fault alarm (a fixed alarm) is generated when the ventilator is operating on external power (from side power port or Docking Station) that has too high of a source impedance to properly power the ventilator.

> **⚠ WARNING**
>
> **External Power Fault Alarm** - Repeated External Power Fault alarms indicate that the ventilator's external power source may be unreliable. Provide an alternate power source for the ventilator.

When an External Power Fault alarm occurs:

- The **ExtPwrFault** alarm message is displayed
- A medium priority audible alarm sounds
- The **External Power** LED on the lower interface panel is illuminated flashing red
- Either the **Battery Pack** or **Transition Batt**. LED on the lower interface panel illuminates (depending on which is powering the ventilator)

External Power Lost (ExtPwr Lost)

The External Power Lost alarm (a fixed alarm) is generated when the ventilator is turned on and its external power source is disconnected or drops below the required minimum voltage.

> **⚠ WARNING**
>
> **External Power Lost Alarm** - An External Power Lost alarm indicates the ventilator is no longer operating from external power. Insert a charged Battery Pack or connect the ventilator to alternative external power.

When an External Power Lost alarm occurs:

- The **ExtPwr Lost** alarm message is displayed
- A medium priority audible alarm sounds
- The **External Power** LED on the lower interface panel is off
- Either the **Battery Pack** or **Transition Batt**. LED on the lower interface panel illuminates (depending on which is powering the ventilator)

External Power Low (Ext Pwr Low)

The External Power Low alarm (a fixed alarm) is generated when the ventilator is using external DC power and the voltage is equal to or less than the External Power Low Limit.

> **⚠ WARNING**
>
> **External Power Low Alarm** - Indicates that the external power voltage is low. Be prepared to provide an alternate power source for the ventilator.

When an External Power Low alarm occurs:

- The **Ext Pwr Low** alarm message is displayed
- A medium priority audible alarm sounds
- The **External Power** LED on the lower interface panel is illuminated amber

FIO_2 Sensor Fault (FIO_2 Fault)

The FiO_2 Sensor Fault alarm (a fixed alarm) is generated when FIO_2 has been enabled (in Startup mode) and the ventilator detects a FIO_2 Sensor failure.

> **⚠ CAUTION**
>
> **FIO_2 Sensor Fault Alarm** – This alarm indicates that the FIO_2 Sensor in use may not be working properly with the ventilator. Replace the FIO_2 Sensor.

When an FIO_2 Sensor Fault alarm occurs:

- The **FIO_2 Fault** alarm message is displayed
- A medium priority audible alarm sounds

Hardware Fault (HW Faultxxx)

The Hardware Fault alarm (a fixed alarm) is generated when the ventilator detects an internal failure condition that requires immediate operator attention.

> **⚠ WARNING**
>
> **Hardware Fault Alarm** - Operating the ReVel ventilator with an active Hardware Fault alarm may result in inaccurate measurements or ventilation. If this occurs, disconnect the patient from the ventilator and provide alternative ventilation. Contact Vyaire or a service technician certified by Vyaire.

When a Hardware Fault alarm occurs:

- The **HW Faultxxx** alarm message is displayed showing a numeric code representing the error condition (record the **xxx** code to report when scheduling servicing)
- A high priority audible alarm sounds

To check the type of hardware fault detected, see *Event Trace* in Chapter 10 – Extended Features.

High Airway Pressure (High Pres)

The High Airway Pressure alarm (a user adjustable alarm) is generated when the monitored airway pressure exceeds the set High Airway Pressure (**High Pres**) alarm limit for the set number of High Pressure Delay breaths (**HP Delay**).

Range**:** **5** through **100 cmH_2O** in increments of 1

When a High Airway Pressure alarm occurs:

- The **High Pres** alarm message is displayed
- A high priority audible alarm sounds
- The **High Pres. Limit** alarm control display flashes
- Inspiration is terminated and the exhalation valve is opened to relieve pressure

> **⚠ WARNING**
>
> **Sustained High Airway Pressure** - During a sustained High Airway Pressure alarm condition, the ventilator blower is stopped and gas is not delivered to the patient. To avoid patient injury, disconnect the patient circuit, assess the patient's airway (ensure patency) and ventilate using an alternate method until the cause of the high pressure condition has been eliminated. See *Chapter 13 - Troubleshooting* and *Safety Valve High Pressure Relief (SVHP Relief)* in this chapter for additional information.

If the high pressure condition does not recover within 1.5 seconds or if Airway Pressure ≥ 110 cmH_2O, the following occurs:

- The blower is stopped, the safety valve is opened, the PEEP pilot pressure is vented to ambient and the nebulizer drive (optional) is turned off

After a sustained high pressure condition:

When the ventilator has recovered from the high pressure condition[31], if the circuit pressure exceeds the set **High Pres. Limit** setting again before another un-terminated breath occurs:

- The Blower is stopped, the Safety Valve is opened, the PEEP pilot pressure is vented to ambient and the nebulizer drive (optional) is turned off without requiring a 1.5 second persistence of the condition
- The audible alarm is sounded immediately regardless of the High Pressure Alarm Delay (**HP Delay**) setting

Recovery from the sustained high pressure condition requires either an alarm reset or 10 seconds to have elapsed.

[31] The blower is restarted, the safety valve is closed, the PEEP pilot pressure is restored and the nebulizer drive (optional) is turned back on.

To set the High Airway Pressure alarm limit:

To set the High Airway Pressure alarm, see *Front Panel, Alarms* in Chapter 5 – Controls for instructions.

To set delayed notification for the High Airway Pressure alarm:

To set a delay for High Airway Pressure alarms, see *HP Delay (High Pressure Delay)* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features. The audible alarm will sound whenever a high pressure condition persists which stops the Blower, regardless of the delay setting.

High Breath Rate (High f)

The High Breath Rate alarm (a user adjustable alarm) is generated when the monitored Total Breath Rate exceeds the set High Breath Rate (**High f**) alarm limit for the set Minute Volume/Breath Rate Delay (**V/BR Delay**), and at least eight (8) breaths have occurred since the last High Breath Rate alarm was reset.

Range**:** **1** through **120 bpm**, or "**- -**" (off)

When a High Breath Rate alarm occurs:

- The **High f** alarm message is displayed
- A medium priority audible alarm sounds
- The **Breath Rate** control display flashes

To set the High Breath rate alarm:

To set the High Breath Rate alarm value, see *High f (High Breath Rate)* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

To set delayed notification for the High Breath Rate alarm:

To set a delay for the Low Exhaled Minute Volume (**Low Min Vol**) and the High Breath Rate (**High f)** alarms, see *V/BR Delay (Minute Volume/Breath Rate Alarm Delay)* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features**.**

High O_2 Inlet Pressure (Hi O_2 Pres)

The High O_2 Inlet Pressure alarm (a fixed alarm) is generated when the monitored O_2 Inlet Pressure is:

- Greater than 11 PSI when the active[32] **O_2** control is set to **LPS** (Low Pressure Source),
- Greater than 67 PSI and the Nebulizer procedure is active
  or
- Greater than 89 PSI

When a High O_2 Inlet Pressure alarm occurs:

- The **Hi O_2 Pres** alarm message is displayed
- A medium priority audible alarm sounds
- If the set **O_2** control value is **LPS** (Low Pressure Source) and the O_2 Inlet pressure is set above 40 PSI, the ventilator automatically switches to High Pressure O_2 Source mode and changes the active[32] **O_2%** control value to **21**%

High PEEP

The High PEEP alarm (a user adjustable alarm) is generated when the monitored PEEP is greater than the High PEEP alarm setting[33].

> **NOTE**
> If the active PEEP control setting[33] is changed, the **High PEEP** alarm is delayed for 30 seconds to allow the PEEP to stabilize.

Once the alarm is cleared, it will remain cleared until at least eight (8) breaths have occurred since the alarm was cleared.

Range**:** **3** through **40 cmH_2O**, or "**- -**" (off)

When a High PEEP alarm occurs:

- The **High PEEP** alarm message is displayed
- A medium priority audible alarm sounds
- The **PEEP** control display flashes

To set the High PEEP alarm limit:

To set the High PEEP alarm limit, see *High PEEP* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

To set delayed notification for the PEEP alarms:

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[32] The "active" O_2 value is the **O_2** control setting during normal ventilation, the Extended Features **O_2 Flush %** setting during an O_2 Flush procedure, or the Extended Features **SBT O_2** setting during an SBT procedure.

[33] The "active" PEEP control setting is the **PEEP** control setting during normal ventilation, or the **SBT PEEP** control setting (in Extended Features) during an SBT procedure.

To set a delay for the High PEEP and Low PEEP alarms (**PEEP Delay**), see *PEEP Delay* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

High Pulse Rate (High Pulse)

The High Pulse Rate alarm (a user adjustable alarm) is generated when the monitored Pulse Rate exceeds the set **Pulse Rate, High Alarm** limit. The High Pulse Rate alarm is only active when the SpO_2 Module is connected, enabled and attached to a patient.

Range: **18** through **299 Beats/min**, or "**- -**" (off)

When a High Pulse Rate alarm occurs:

- The **High Pulse** alarm message is displayed
- A high priority audible alarm sounds
- The **Pulse Rate** display flashes

To set the High Pulse Rate alarm limit:

To set the High Pulse Rate alarm limit see *Front Panel, Pulse Oximeter* in Chapter 5 – Controls for instructions.

High SpO_2

The High SpO_2 alarm (a user adjustable alarm) is generated when the monitored SpO_2 exceeds the set **SpO_2, High Alarm** limit. The High SpO_2 alarm is only available when an Oximetry Module is connected, enabled and attached to a patient.

Range**:** **80** through **99%**, or "**- -**" (off)

When a High SpO_2 alarm occurs:

- The **High SpO_2** alarm message is displayed
- A high priority audible alarm sounds
- The **SpO_2** display flashes

To set the High SpO_2 alarm limit:

To set the High SpO_2 alarm limit see *Front Panel, Pulse Oximeter* in Chapter 5 – Controls for instructions.

Insert Battery (Insert Batt)

The Insert Battery alarm (a fixed alarm) is generated when the Removable Battery Pack is not detected.

When an Insert Battery alarm occurs:

- The **Insert Batt** alarm message is displayed
- A medium priority audible alarm sounds
- **Battery Pack** indicator on the lower interface panel flashes red

The Insert Battery alarm can be silenced for 60 seconds but will continue to re-activate until a battery is inserted.

Low Exhaled Minute Volume (Low Min Vol)

The Low Exhaled Minute Volume alarm (a user adjustable alarm) is generated when the monitored Exhaled Minute Volume (**VE**) is less than the **Low Min. Vol**. alarm limit setting for the set Minute Volume/Breath Rate Alarm Delay (**V/BR Delay)** (in seconds) and at least eight (8) breaths have occurred since the **Low Min. Vol**. alarm was last reset.

Range**:** **0.1** through **99 L** or "**- -**" (off)

⚠ WARNING

Low Minute Volume Control Values - The Low Exhaled Minute Volume limit should be set to its highest clinically appropriate value. If there is a need to set the Low Exhaled Minute Volume alarm to lower values or "- - -" (off), assess whether an alternative monitor (i.e. a Pulse Oximeter with an audible alarm, or a Cardio Respiratory Monitor) should be used.

NOTE

Activation of the Low Exhaled Minute Volume (**Low Min Vol**), Low Peak Pressure (**Low Pk Pres**), **Low PEEP** and/or Patient Circuit Fault (**Pat. Circuit**) alarms could indicate a patient circuit leak. Check patient circuit integrity if one or more of these alarms is repeatedly activated.

When a Low Exhaled Minute Volume alarm occurs:

- The **Low Min Vol** alarm message is displayed
- A high priority audible alarm sounds
- The **Low Min. Vol.** alarm control flashes

To set the Low Exhaled Minute Volume alarm limit:

To set the Low Exhaled Minute Volume alarm limit see *Front Panel, Alarms* in Chapter 5 – Controls for instructions.

- LPPS / LMV alarm status messages, when applicable, are displayed in the front panel display window along with monitored data. See *Alerts, LPPS / LMV Status Messages* later in this chapter for detailed information.

To set delayed notification for the Low Exhaled Minute Volume alarm:

To set a delay for the Low Exhaled Minute Volume (**Low Min Vol**) and the High Breath Rate (**High f)** alarms, see *V/BR Delay (Minute Volume/Breath Rate Alarm Delay)* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features**.**

Low FIO_2

The Low FIO_2 alarm (a user adjustable alarm) is generated when the monitored FIO_2 (Fraction of Inspired Oxygen) is equal to or less than the **Low FIO_2** alarm setting. The Low FIO_2 alarm is only available when an FIO_2 Sensor is installed in the patient circuit, connected to the ventilator and enabled.

Range**:** **18** through **95% O_2** or "**- -**" (off)

When a Low FIO_2 alarm occurs:

- The **Low FIO_2** alarm message is displayed
- A High priority audible alarm sounds
- The **Low FIO_2** alarm control display flashes

To set the Low FIO_2 alarm

To set the Low FIO_2 alarm, see *Front Panel, Alarms* in Chapter 5 – Controls for instructions.

See *Procedures* in Chapter 9 – Maneuvers and Procedures for additional information.

Low O_2 Inlet Pressure (Low O_2 Pres)

The Low O_2 Inlet Pressure alarm (a fixed alarm) message is generated when the monitored O_2 Inlet Pressure is less than 35 PSI and the active[34] **O_2%** control is set to more than 21%. The alarm may also be triggered when the **O_2%** is set to 21% if the **O_2 Flush** procedure or the **Nebulizer** procedure is active.

- The Low O_2 Inlet Pressure alarm is inactive when the **O_2** control is set to **LPS**

When a Low O_2 Inlet Pressure alarm occurs:

- The **Low O_2 Pres** alarm message is displayed
- A high priority audible alarm sounds

See *Procedures* in Chapter 9 – Maneuvers and Procedures for additional information.

[34] The "active" O_2 value is the **O_2** control setting during normal ventilation, the Extended Features **O_2 Flush %** setting during an O_2 Flush procedure, or the Extended Features **SBT O_2** setting during an SBT procedure.

Low Peak Pressure (Low Pk Pres)

The Low Peak Pressure alarm (a user adjustable alarm) is generated when the monitored Peak Inspiratory Pressure (**PIP**) for a selected breath is less than the set **Low Pk Pres** alarm limit.

Range**:** **1** through **60 cmH_2O**, or "**- -**" (off)

> ⚠ **WARNING**
>
> **Patient Circuit Accessories** - Accessories such as speaking valves, heat-moisture exchangers and filters create additional patient circuit resistance. In the event of a disconnection, this may compromise Low Peak Pressure alarm generation. Set the **Low Pk Pres** alarm limit high enough to detect a disconnect when using these accessories, or use an alternate method (e.g. Low Exhaled Minute Volume alarm) to ensure disconnect detection.

> **NOTE**
>
> Activation of the Low Peak Pressure (**Low Pk Pres**), Low Exhaled Minute Volume (**Low Min Vol**), **Low PEEP**, and/or Patient Circuit Fault (**Pat. Circuit**) alarms could indicate a patient circuit leak. Check the patient circuit and exhalation diaphragm integrity if one or more of these alarms is repeatedly activated.

When a Low Peak Pressure alarm occurs:

- The **Low Pk Pres** alarm message is displayed
- A high priority audible alarm sounds
- The **Low Pk Pres**. alarm control display flashes

To set the Low Peak Pressure alarm:

To set the Low Peak Pressure alarm, see *Front Panel, Alarms* in Chapter 5 – Controls for instructions.

To set the applicable breath type for the Low Peak Pressure alarm

The Low Peak Pressure alarm can be configured to apply to **All Breaths** or to **Control Only**. In SIMV mode, selecting **Control Only** allows the Low Peak Pressure alarm to apply to Machine breaths only. It has no effect in A/C or CPAP modes. See *LPP Alarm (Low Peak Pressure Alarm)* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features for detailed instructions.

- LPPS / LMV alarm status messages, when applicable, are displayed in the front panel display window along with monitored data. See *Alerts, LPPS / LMV Status Messages* later in this chapter for detailed information.

Low PEEP

The Low PEEP alarm (a user adjustable alarm) is generated when the monitored PEEP is less than the Low PEEP alarm setting[35].

Once the alarm is cleared, it will remain cleared until at least eight (8) breaths have occurred since the alarm was cleared.

Range: "- -" (off) or, **1** through **20 cm H_2O**

When a Low PEEP alarm occurs:

- The **Low PEEP** alarm message is displayed
- A high priority audible alarm sounds
- The **PEEP** control display flashes

NOTE

- If the active PEEP control setting[35] is changed, the Low PEEP (**Low PEEP**) alarm is delayed for 30 seconds to allow the PEEP to stabilize.
- Activation of the Low PEEP (**Low PEEP**), Low Peak Pressure (**Low Pk Pres**), Low Exhaled Minute Volume (**Low Min Vol**) and/or Patient Circuit Fault (**Pat. Circuit**) alarms could indicate a patient circuit leak. Check the patient circuit and exhalation diaphragm integrity if one or more of these alarms is repeatedly activated.

To set the Low PEEP alarm limit:

To set the Low PEEP alarm limit, see Low PEEP in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

To set delayed notification for the PEEP alarms:

To set a delay for the Low PEEP and High PEEP alarms (**PEEP Delay**), see *PEEP Delay* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

[35] The "active" PEEP control setting is the **PEEP** control setting during normal ventilation, or the **SBT PEEP** control setting (in Extended Features) during an SBT procedure.

Low Pulse Rate (Low Pulse)

The Low Pulse Rate alarm (a user adjustable alarm) is generated when the monitored pulse rate is less than the **Pulse Rate, Low Alarm** limit setting. The Low Pulse Rate alarm is only active when the SpO_2 Module is connected, enabled and attached to a patient.

Range: **19** through **300 Beats/min**, or "**- -**" (off),

When a Low Pulse Rate alarm occurs:

- The **Low Pulse** alarm message is displayed
- A high priority audible alarm sounds
- The **Pulse Rate** display flashes

To set the Low Pulse Rate alarm:

To set the Low Pulse Rate alarm limit, see *Front Panel, Pulse Oximeter* in Chapter 5 – Controls for instructions.

Low SpO_2

The Low SpO_2 alarm (a user adjustable alarm) is generated when the monitored SpO_2 is less than the **SpO_2**, **Low Alarm** limit setting. The Low SpO_2 alarm is only active when the SpO_2 module is connected, enabled and attached to a patient.

Range**:** **60** through **99 %**, or "**- -**" (off),

When a Low SpO_2 alarm occurs:

- The **Low SpO_2**alarm message is displayed
- A high priority audible alarm sounds
- The **SpO_2** display flashes

To set the Low SpO_2 alarm:

To set the Low SpO_2 alarm limit, see *Front Panel, Pulse Oximeter* in Chapter 5 – Controls for instructions.

Patient Circuit Fault (Pat. Circuit)

The Patient Circuit Fault alarm (a fixed alarm) is generated under many conditions in which the integrity of the breathing circuit is compromised. This may be due to, but not limited to, one of the following conditions:

- A Low or High Pressure Sense Line is disconnected or occluded
- Patient Circuit Wye, Patient Connection Port is disconnected from patient
- Patient Circuit Expiratory Limb is occluded
- Patient Circuit Inspiratory Limb is disconnected

> **⚠ WARNING**
>
> **Disconnection Beyond the Patient Circuit Wye** – The Patient Circuit Fault alarm may not activate if a disconnect or blockage occurs beyond the Patient Circuit Wye (in-between wye and connection to patient). Ensure that the High Airway Pressure (**High Pres**), Low Peak Pressure (**Low Pk Pres**), **Low PEEP** and Low Exhaled Minute Volume (**Low Min Vol**) alarms are set appropriately to prevent patient risk.

> **NOTE**
>
> - If a High Airway Pressure (**High Pres**) or Safety Valve High Pressure Relief (**SVHP Relief**) alarm occurs before the patient circuit fault detection of an occluded inspiratory or expiratory limb, the Patient Circuit Fault alarm may not occur.
> - When ventilating at settings likely to cause AutoPEEP, a Patient Circuit Fault alarm may occur. Adjust the **High PEEP** alarm appropriately.
> - Activation of the Patient Circuit Fault, Low Peak Pressure (**Low Pk Pres**), **Low PEEP** and/or Low Exhaled Minute Volume (**Low Min Vol**) alarms could indicate a patient circuit leak. Check the patient circuit and exhalation diaphragm integrity if one or more of these alarms is repeatedly activated.

When a Patient Circuit Fault alarm occurs:

- The **Pat. Circuit** alarm message is displayed
- A high priority audible alarm sounds

Depending on which condition(s) triggered the alarm, the ventilator also performs the following actions:

- When the alarm is triggered by an occluded or disconnected High Pressure Sense Line, or a disconnected Inspiratory Limb, the ventilator;
    - terminates the breath and exhalation begins
- While the alarm is triggered by disconnection of the Patient Connection Port from the patient tubing, or a disconnected Expiratory Limb, the ventilator;
    - terminates the breath and exhalation begins
    - closes the exhalation valve and delivers a constant inspiratory flow
    - stops delivering mandatory machine breaths
    - stops recognizing patient trigger efforts
    - stops delivering nebulizer flow
    - disables Apnea Backup alarm and apnea ventilation

- While the alarm is triggered by an occluded Expiratory Limb, the ventilator;
    - terminates the breath and exhalation begins
    - opens exhalation and safety valves
    - stops delivering mandatory machine breaths
    - stops recognizing patient trigger efforts (flow and pressure trigger)
    - stops delivery of all flows
    - disables Apnea Backup alarm and apnea ventilation

Preventive Maintenance Required (P Maint xxx)

The Preventive Maintenance Required alarm (a fixed alarm) is generated when any of the numerous internal mechanical actuators (monitored by the ventilator) approach the end of their expected useful life.

> ⚠ **CAUTION**
>
> **Preventive Maintenance Required Alarm** - A Preventive Maintenance Required alarm is an indication that the ventilator should be scheduled for preventive maintenance service. Contact Vyaire or a service technician certified by Vyaire.

When a Preventive Maintenance Required alarm occurs:

- The **P Maint xxx** alarm message is displayed, with a numeric reference code representing the specific condition that initiated the alarm (record **xxx** code to report when scheduling servicing)
- A low priority audible alarm sounds

Remove Patient (Remove Ptnt)

The Remove Patient alarm (a fixed alarm) is activated when the ventilator enters the Vent Check menu in the Startup mode of operation.

The alarm is generated to advise operators that ventilation may be compromised and to remove the patient from the ventilator before proceeding.

> **⚠ WARNING**
>
> **Remove Patient Alarm** – To prevent possible harm to the patient, if a **Remove Ptnt** alarm occurs during normal ventilation, immediately remove the patient and use an alternative method of ventilation.

> **NOTE**
>
> **The ventilator operates in Startup mode;**
>
> - When initially powered up
> - While patient type (**Same Patient** or **New Patient**), patient ID, patient size (**Adult**, **Pediatric** or **Infant**) and patient breathing circuit type selections (**Intubated** or **NPPV**) are being made
> - During NPPV **IPAP**, **EPAP**, and **Rate** control values selection
> - While ventilator configuration selections (**Language**, **Units** and **Reset**) are being made
> - While the Button and Circuit Tests are being performed (**Vent Check**)

When a Remove Patient alarm occurs:

- The **Remove Ptnt** alarm message flashes
- A high priority audible alarm sounds

To silence the Remove Patient alarm:

The alarm will be automatically reset when normal ventilation has begun.

1) Push the **Silence/Reset** button on the lower interface panel twice to silence the audible alarm and remove the visible flashing alarm message.

While the Remove Patient alarm is active, the **Remove Ptnt** alarm message and its audible tone will be reactivated after being reset by the **Silence/Reset** button and 120 seconds of user inactivity.

Safety Valve High Pressure Relief (SVHP Relief)

The Safety Valve High Pressure Relief Alarm is generated when:

- Airway Pressure[36] is ≥ 110 cmH_2O, or
- Airway Pressure[36] ≥ the High Airway Pressure alarm (**High Pres)** setting plus the Safety Valve Delta Pressure setting (see *Safety Valve* in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features)

When a Safety Valve High Pressure Relief alarm occurs:

- The **SVHP Relief** alarm message is displayed
- A high priority audible alarm sounds
- The breath is immediately cycled to exhalation
- The blower is stopped
- The nebulizer drive (optional) is turned off
- The safety valve opens to provide over-pressure relief
- The PEEP pilot pressure is vented to ambient

Many of the conditions which can cause a Safety Valve High Pressure alarm to initiate or to recur can be corrected by the user. Refer to *Chapter 13 - Troubleshooting* for detailed corrective actions.

SBT High Breath Rate (SBT > f)

The SBT High Breath Rate alarm (a user adjustable alarm) is generated when the monitored SBT breath rate (**SBT f**) exceeds the set SBT High Breath Rate alarm limit continuously for 30 seconds during a Spontaneous Breathing Trial.

Range**:** **15** through **80 bpm**, or **SBT Hi f Off**

When an SBT High Breath Rate alarm occurs:

- The **SBT > f** alarm message is displayed
- A medium priority audible alarm sounds
- The SBT procedure terminates if the alarm is active continuously for 5 minutes

To set the SBT High Breath Rate Alarm limit:

To set the SBT High Breath Rate alarm limit, see *SBT High f* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

[36] Blower Estimated Airway Pressure is a redundant measure of airway pressure based on the blower differential pressure transducer.

SBT High f/Vt (SBT > f/Vt)

The SBT High f/Vt alarm (a user adjustable alarm) is generated when the SBT f/Vt ratio is greater than the set SBT High f/Vt alarm limit continuously for 30 seconds during a Spontaneous Breathing Trial.

Range: **70** through **900 bpm/L**, or **Hi f/Vt Off**

When an SBT High f/Vt alarm occurs:

- The **SBT > f/Vt** alarm message is displayed
- A medium priority audible alarm sounds
- The SBT procedure terminates if the alarm is active continuously for 5 minutes

To set the SBT High f/Vt alarm limit:

To set the SBT High f/Vt alarm limit, see *SBT Hi f/Vt* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

SBT High PEEP

The SBT High PEEP alarm (a user adjustable alarm) is generated when the monitored PEEP is greater than the High PEEP control setting[37] during a Spontaneous Breathing Trial.

Once the alarm is cleared, it will remain cleared until at least eight (8) breaths have occurred since the alarm was cleared.

Range**:** **3** through **40 cmH_2O**, or "**- -**" (off)

When a SBT High PEEP alarm occurs:

- The **SBT Hi PEEP** alarm message is displayed
- A medium priority audible alarm sounds

To set the SBT High PEEP alarm limit:

To set the SBT High PEEP alarm limit, see *SBT Hi PEEP* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

To set delayed notification for the PEEP alarms:

To set a delay for the High PEEP and Low PEEP alarms (**PEEP Delay**), see PEEP Delay in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

[37] The "active" PEEP control setting is the **PEEP** control setting during normal ventilation, or the **SBT PEEP** control setting (in Extended Features) during an SBT procedure.

SBT Low Breath Rate (SBT < f)

The SBT Low Breath Rate alarm (a user adjustable alarm) is generated when the monitored SBT breath rate (**SBT f**) is less than the set SBT Low Breath Rate alarm limit continuously for 30 seconds during a Spontaneous Breathing Trial.

Range**:** **1** through **40 bpm**, or **SBT Lo f Off**

When an SBT Low Breath Rate alarm occurs:

- The **SBT < f** alarm message is displayed
- A medium priority audible alarm sounds
- The SBT procedure terminates if the alarm is active continuously for 5 minutes

To set the SBT Low Breath Rate alarm limit:

To set the SBT Low Breath Rate alarm limit, see *SBT Low f* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

SBT Low PEEP

The SBT Low PEEP alarm (a user adjustable alarm) is generated when the monitored PEEP is less than the Low PEEP control setting[38] during a Spontaneous Breathing Trial.

Once the alarm is cleared, it will remain cleared until at least eight (8) breaths have occurred since the alarm was cleared.

Range**:** "- -" (off), or **1** through **20 cmH_2O**

When a SBT Low PEEP alarm occurs:

- The **SBT Lo PEEP** alarm message is displayed
- A high priority audible alarm sounds

> **NOTE**
>
> Activation of the SBT Low PEEP (**SBT Lo PEEP)**, Low Peak Pressure (**Low Pk Pres**), Low Exhaled Minute Volume (**Low Min Vol**) and/or Patient Circuit Fault (**Pat. Circuit**) alarms could indicate a patient circuit leak. Check the patient circuit and exhalation diaphragm integrity if one or more of these alarms is repeatedly activated.

To set the SBT Low PEEP alarm limit:

To set the SBT Low PEEP alarm limit, see *SBT Lo PEEP* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

To set delayed notification for the PEEP alarms:

To set a delay for the High PEEP and Low PEEP alarms (**PEEP Delay**), see PEEP Delay in the Extended Features, Alarm Config menus in Chapter 10 – Extended Features.

[38] The "active" PEEP control setting is the **PEEP** control setting during normal ventilation, or the **SBT PEEP** control setting (in Extended Features) during an SBT procedure.

SBT Low f/Vt (SBT < f/Vt)

The SBT Low f/Vt alarm is generated (a user adjustable alarm) when the SBT f/Vt ratio is less than the set SBT Low f/Vt limit continuously for 30 seconds during a Spontaneous Breathing Trial.

Range: **5** through **90 bpm/L**, or **Lo f/Vt Off**

When an SBT Low f/Vt alarm occurs:

- The **SBT < f/Vt** alarm message is displayed
- A medium priority audible alarm sounds
- The SBT procedure terminates if the alarm is active continuously for 5 minutes

To set the SBT Low f/Vt Alarm limit:

To set the SBT Low f/Vt alarm limit, see *SBT Low f/Vt* in the Extended Features, SBT menus in Chapter 10 – Extended Features.

SBT Off

The SBT Off alarm (a fixed alarm) is generated when the Spontaneous Breathing Trial has completed.

When an SBT Off alarm occurs:

- The **SBT Off** alarm message is displayed
- A low priority audible alarm sounds
- The SBT procedure terminates

SBT Time

The SBT Time alarm (a fixed alarm) is generated when the Spontaneous Breathing Trial has two minutes left to run.

When an SBT Time alarm occurs:

- The **SBT Time** alarm message is displayed
- A low priority audible alarm sounds

Schedule Service (SchedSvcxxx)

The Schedule Service alarm (a fixed alarm) is generated when the ventilator detects a non-critical internal component failure or an invalid event log.

> **⚠ CAUTION**
>
> **Schedule Service Alarm** - Repeated or continuous Schedule Service alarms may indicate a problem with the ventilator that could prevent the ventilator from performing within its specifications. Discontinue use of the ventilator and contact Vyaire or a service technician certified by Vyaire.

When a Schedule Service alarm occurs:

- The **SchedSvcxxx** alarm message is displayed, with a numeric reference code (**xxx**) representing the specific condition that initiated the alarm (record the **xxx** code to report when scheduling servicing)
- A low priority audible alarm sounds

SpO_2 Check Sensor Placement (SpO_2 Sensor)

The SpO_2 Check Sensor Placement alarm (a fixed alarm) is generated when the SpO_2 Module reports that the sensor is providing unusable data for analysis and the Oximetry option is still enabled.

When an SpO_2 Check Sensor Placement alarm occurs:

- The **SpO_2 Sensor** alarm message is displayed
- A high priority audible alarm sounds

SpO_2 Low Signal (SpO_2 LowSig)

The SpO_2 Low Signal alarm (a fixed alarm) is generated when the SpO_2 Module detects that the signal from the SpO_2 Sensor is too low while the Pulse Oximetry option is enabled.

When an SpO_2 Low Signal alarm occurs:

- The **SpO_2 LowSig** alarm message is displayed
- A high priority audible alarm sounds

SpO_2 Module Fault (SpO_2 Module)

The SpO_2 Module Fault alarm (a fixed alarm) is generated when the ventilator cannot establish proper communication with the SpO_2 Module while the Pulse Oximetry option is enabled.

When an SpO_2 Module Fault alarm occurs:

- The **SpO_2 Module** alarm message is displayed
- A high priority audible alarm sounds

SpO_2 Sensor Disconnect (SpO_2 Discon)

The SpO_2 Sensor Disconnect alarm (a fixed alarm) is generated when the SpO_2 Module or Sensor is faulty while the Pulse Oximetry option is enabled.

When an SpO_2 Sensor Disconnect alarm occurs:

- The **SpO_2 Discon** alarm message is displayed
- A high priority audible alarm sounds

Transition Battery Fault (T-Bat Fault)

The Transition Battery Fault alarm (a fixed alarm) is generated when:

- The ventilator is unable to charge the internal Transition Battery
- The Transition Battery voltage is below the minimum usable voltage

> **⚠ WARNING**
>
> **Transition Battery Fault Alarm** - Transition Battery Fault alarms indicate that the ventilator's internal Transition Battery may be unreliable. Discontinue use of the ventilator and contact Vyaire or a service technician certified by Vyaire.

When a Transition Battery Fault alarm occurs:

- The **T-Bat Fault** alarm message is displayed
- A medium priority audible alarm sounds
- The **Transition Batt** LED on the lower interface panel flashes red

Transition Battery Temperature Fault (TBatTempFlt)

The Transition Battery Temperature Fault alarm (a fixed alarm) is generated when the Transition Battery is the only power source available and:

- The temperature of the Transition Battery is greater than 60° C
- The temperature of the Transition Battery is less than -20° C

> **⚠ WARNING**
>
> **Transition Battery Temperature Fault Alarm** – The Transition Battery Temperature Fault alarms indicate that the ventilator's internal Transition Battery is excessively hot or cold. When this alarm occurs, the ventilator shuts down and gas is not delivered to the patient. To avoid patient injury, disconnect the patient and ventilate using an alternate method until the cause of the Transition Battery Temperature Fault alarm condition has been eliminated. See *Chapter 13 - Troubleshooting* for additional information.

When a Transition Battery Temperature Fault alarm occurs:

- The **TBatTempFlt** alarm message is displayed
- A high priority audible alarm sounds
- The **Transition Batt.** LED on the lower interface panel flashes red
- The ventilator stops delivering mandatory machine breaths and shuts down

Transition Battery Use (T-Bat Use)

The Transition Battery Use alarm (a fixed alarm) is generated when the ventilator begins operating on the internal Transition Battery.

⚠ WARNING

Transition Battery Use Alarm - A Transition Battery Use alarm indicates the ventilator is only being powered by the Transition Battery and will shut down soon. Immediately insert a charged Removable Battery Pack or connect the ventilator to an external source of power. The internal Transition Battery is a short duration source of power for use only when changing depleted Removable Battery Packs or switching between external power sources. It is only intended to power the ventilator for up to one minute.

When a Transition Battery Use alarm occurs:

- The **T-Bat Use** alarm message is displayed
- A high priority audible alarm sounds
- The **Transition Batt.** LED on the lower interface panel illuminates

NOTE

The Transition Battery Use alarm can be silenced and reset only once for 60 seconds. If the condition is not resolved, the alarm will resume at maximum volume ((80 ± 5 dBA) and cannot be silenced again until another power source is connected.

Vent Inop

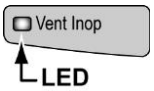
A Vent Inop alarm (a fixed alarm) is generated when:

- The ventilator is powered off by pushing the **On/Off** button
- The ventilator detects any condition that is deemed to make the ventilator unsafe
- The Transition Battery charge becomes completely depleted while in storage

> **⚠ WARNING**
>
> **Vent Inop Alarm** - If a Vent Inop alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a service technician certified by Vyaire.
>
> **Alternative Ventilation** - Vyaire recommends that an alternate means of ventilation be available and the procedures to be followed if the ventilator ceases to function properly.

When a Vent Inop alarm occurs:

- A Vent Inop audible alarm sounds
- The **Vent Inop** LED on the lower interface panel flashes red



> **NOTE**
>
> A **Vent Inop** alarm is normal when switching the ventilator off. It does not indicate a problem with the ventilator.

To silence the audible alarm and turn the **Vent Inop** LED off, push the **Silence/Reset** button.

Ventilator Reset (Vent Reset)

A Ventilator Reset alarm (a fixed alarm) is generated when the ventilator restarts following a condition other than being shut down by pushing the **On/Off** button.

The ventilator constantly runs a monitoring program to verify correct operation. If it detects a condition that makes safe operation uncertain, it reinitializes itself to perform the more sophisticated Power On Self Test (POST). If the POST does not detect any problems, the ventilator resumes normal operation and a Ventilator Reset alarm is generated. If the POST detects a problem that could cause unsafe operation, a **Vent Inop** alarm occurs.

> **⚠ CAUTION**
>
> **Repeated Occurrences** - Repeated occurrences of the Ventilator Reset alarm may indicate a problem with the ventilator's hardware. Remove the ventilator from service and contact Vyaire or a service technician certified by Vyaire.

When a Ventilator Reset alarm occurs:

- The **Vent Reset** alarm message is displayed
- A medium priority audible alarm sounds
- An error code is written to the Event Trace log indicating the type of problem
- The ventilator resets itself and performs the Power On Self Tests (POST)
- If no further problems are detected, the ventilator resumes operation

> **NOTE**
>
> **Restarting from the On/Off Button** - The ventilator will not generate a **Vent Reset** alarm if the restart is initiated from the **On/Off** button.

Volume Limited (Vol Limited)

The Volume Limited alarm (a fixed alarm) is generated when the active Breath Type is set to **PRVC** and the set **Tidal Volume** cannot be achieved without the Target Pressure exceeding the High Airway Pressure (**High Pres**) alarm setting minus 5 cmH_2O.

When a Volume Limited alarm occurs:

- The **Vol Limited** alarm message is displayed
- A medium priority audible alarm sounds

Alerts, Audible

Accessory Attach

The Accessory Attach alert is an audible confirmation signal indicating successful communication has been established between the ventilator and a newly attached accessory. The alert is generated each time any of the following occurs;

- A Removable Battery Pack is inserted into and recognized by the ventilator
- An external power source is connected to and qualified by the ventilator
- An external sensor is connected to and recognized by the ventilator
- The ventilator is attached to and communicating with a Docking Station
- An accessory (e.g. Patient Monitor System, Memory Card) is attached to the Docking Station when connected to the ventilator

NOTE

Qualification of an external power source normally occurs within 4 seconds of the source being applied.

SpO_2 Pulse Tone

The SpO_2 Pulse Tone is an informational audible signal which sounds with each detected heartbeat when a Pulse Oximetry module is connected to the ventilator, enabled and placed on a patient.

To set the SpO_2 Pulse Tone volume level:

To set the SpO2 Pulse Tone volume level, see *Pulse Tone* in the Extended Features, Option Cnfg menus in Chapter 10 – Extended Features.

Alerts, LPPS / LMV Status Messages

The ventilator generates the following Low Peak Pressure (**Low Pk Pres**) and Low Exhaled Minimum Volume (**Low Min Vol**) alarm status messages to alert the operator about disabled alarm settings:

- **LMV Off**
- **LMV On**
- **LMV/LPPS Off**
- **LPPS Off**

> **NOTE**
> These are informational messages only and are displayed (as applicable) whenever monitored data is being scrolled automatically or manually.

LMV Off

The **LMV Off** message is displayed when the Low Exhaled Minute Volume (**Low Min Vol**) alarm has been turned off by setting it to dashes ("- -") and the Low Peak Pressure (**LPP Alarm**) alarm configuration menu value has been set to **All Breaths.**

LMV On

The **LMV On** message is displayed when the Low Exhaled Minute Volume (**Low Min Vol**) alarm value is set to a numerical value (**1** through **60**) and the Low Peak Pressure (**LPP Alarm**) alarm configuration menu value has been set to **All Breaths.**

LMV/LPPS Off

The **LMV/LPPS Off** message is displayed when the Low Exhaled Minute Volume (**Low Min Vol**) alarm has been turned off by setting it to dashes ("- -") and the Low Peak Pressure (**LPP Alarm**) alarm configuration menu value has been set to **Control Only.**

LPPS Off

The **LPPS Off** message is displayed when the Low Exhaled Minute Volume (**Low Min Vol**) alarm value is set to a numerical value (**1** through **60**) and the Low Peak Pressure (**LPP Alarm**) alarm configuration menu value has been set to **Control Only**.

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Chapter 9 - MANEUVERS AND PROCEDURES

Maneuvers and Procedures General Information

Maneuvers and Procedures availability by Breath Mode and Type.

Breath Mode & Type	I-Hold	E-Hold	Nebulizer	SBT	O_2 Flush
A/C / Volume	Enabled	Enabled	Enabled	Enabled	Enabled
A/C / Pressure	Disabled	Enabled	Disabled	Enabled	Enabled
A/C / PRVC	Disabled	Enabled	Disabled	Enabled	Enabled
SIMV / Volume	Enabled	Enabled	Disabled	Enabled	Enabled
SIMV / Pressure	Disabled	Enabled	Disabled	Enabled	Enabled
SIMV / PRVC	Disabled	Enabled	Disabled	Enabled	Enabled
CPAP+PS / Volume	Disabled	Disabled	Disabled	Enabled	Enabled
CPAP+PS / Pressure	Disabled	Disabled	Disabled	Enabled	Enabled
CPAP+PS / PRVC	Disabled	Disabled	Disabled	Enabled	Enabled
NPPV Pressure	Disabled	Disabled	Disabled	Disabled	Enabled
NPPV CPAP+PS	Disabled	Disabled	Disabled	Disabled	Enabled

Maneuvers and Procedures combinations that the ReVel ventilator is capable of performing simultaneously.

Maneuver / Procedure	SBT	I-Hold	E-Hold	Nebulizer	O_2 Flush
SBT	N/A	No	No	No	No
I-Hold	No	N/A	No	Yes	No
E-Hold	No	No	N/A	Yes	No
Nebulizer	No	Yes	Yes	N/A	No
O_2 Flush	No	No	No	No	N/A

Maneuvers

The following maneuvers are available on the ReVel ventilator:

- Inspiratory Hold
- Expiratory Hold

NOTE

The Inspiratory and Expiratory Hold maneuvers cannot be performed simultaneously. The maneuvers are also disabled during **NPPV Pressure** or **NPPV CPAP+PS** ventilation Mode (Non-Invasive), and during an O_2 Flush, or SBT procedure.

Inspiratory Hold

During an Inspiratory Hold maneuver, the inspiratory phase of a breath is held for a period of time sufficient to determine and display Delta Pressure (**Δ Pres xx**), Plateau Pressure (**P Plat xx**) and Static Lung Compliance (**C Static xx**).

NOTE

Lung Compliance (**C Static xx**) calculation includes circuit compliance.

Expiratory Hold

During an Expiratory Hold maneuver, the ventilator monitors Expiratory Pressure (**P Exp x**), calculates the value for **AutoPEEP** and displays both.

NOTE

The E-Hold maneuver is disabled if the Nebulizer Synchronization menu (**Neb Sync**) selection is set to **Continuous** and the Nebulizer procedure has been activated.

Setting Up and Running I-Hold and E-Hold Maneuvers

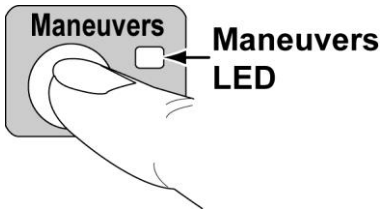
Setting up and running a maneuver is accomplished in the following stages:

- **Select**
- **Arm**
- **Run**

> **NOTE**
> Maneuvers are disabled when Extended Features are being accessed.

To Select the Maneuver

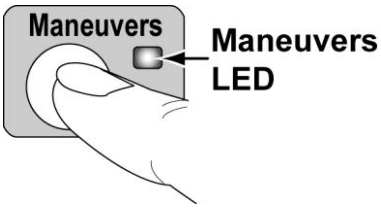
Push and release the **Maneuvers** button located on the lower interface panel. **I-Hold** is displayed in the front panel display window and the **Maneuvers** LED does not illuminate at this stage.



To perform an Inspiratory Hold, arm and run the maneuver as follows, or to perform an Expiratory Hold, rotate the **Scroll** knob until **E-Hold** appears in the display window, then proceed as follows.

To Arm the Maneuver

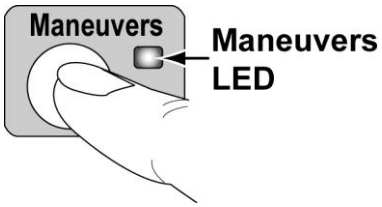
When the name of the desired maneuver is displayed, push and release the **Maneuvers** button again. The **Maneuvers** LED begins flashing to indicate that the displayed/selected maneuver is armed and ready to run.



Maneuver arming automatically terminates if 60 seconds elapse in the same phase of a maneuver without a button press.

To Run the Maneuver

To activate the maneuver, push and hold the **Maneuvers** button. The **Maneuvers** LED illuminates continuously and on the next appropriate breath the ventilator will initiate the “Hold”.

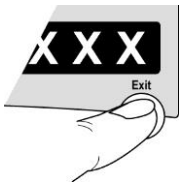


The maneuver will occur while the **Maneuvers** button is held for a maximum of six (6) seconds. If the button is released before the six seconds has expired, the maneuver will be terminated. In either case, the ventilator returns to normal ventilation immediately following termination of the maneuver.

NOTE

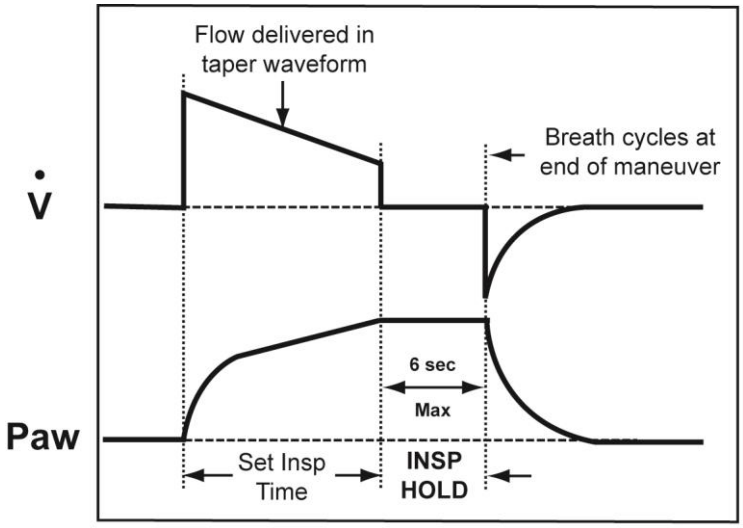
- If the **Maneuvers** button is released *before* the Hold maneuver has begun, the ventilator returns to the armed state.
- If the **Maneuvers** button is released *after* the maneuver has begun, the maneuver ends and the ventilator displays the maneuver results.

To clear scrolling maneuver data or exit a Maneuver at any time, push the **Exit** button on the front panel.



During an Inspiratory Hold:

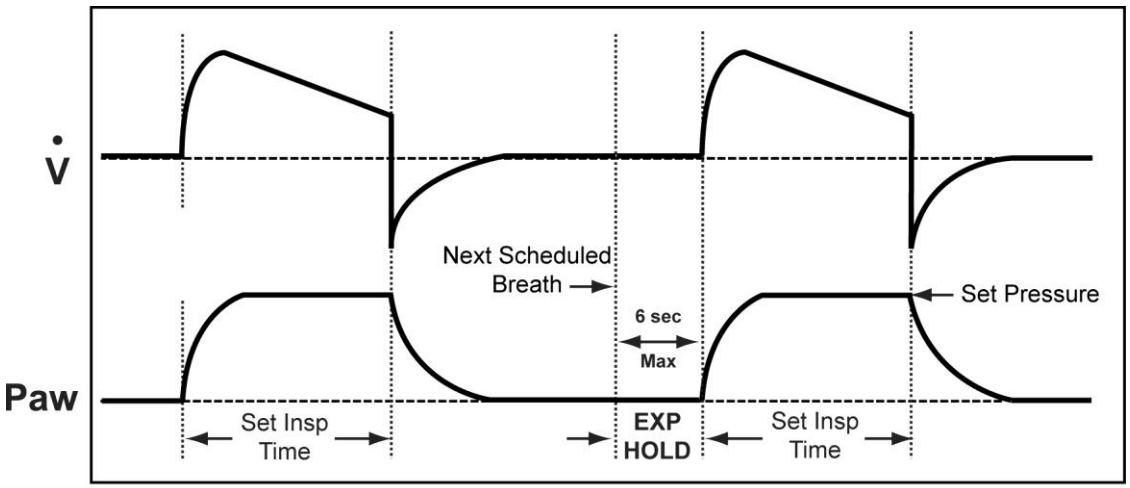
- The exhalation valve remains closed
- Flow is set to 0 lpm
- The breath remains in inspiration so no breath triggers are allowed
- The breath period timing and apnea timing are compensated for while the hold is performed
- If High Airway Pressure (**High Pres**) alarm occurs, the maneuver exits the hold phase but remains armed



Inspiratory Hold on Volume Control Breath

During an Expiratory Hold:

- The exhalation valve is closed
- Flow is set to 0 lpm
- The breath remains in exhalation phase
- The breath period timing and apnea timing are compensated for while the Hold is performed
- If a Patient Effort is detected, it is ignored
- If a High Airway Pressure (**High Pres**) alarm occurs, the maneuver exits the Hold state, remains armed, and the exhalation valve opens as normal



Expiratory Hold on Pressure Control Breath

Maneuver Results

Inspiratory Hold

When the Inspiratory Hold maneuver has completed successfully:

- The **Maneuver** LED is extinguished and the calculated data is displayed
- The exhalation valve is opened and exhalation begins
- The flow servo operates normally
- Breath starts and any Apnea alarms that were held off resume

The maneuver results are displayed in the front panel display window while the maneuver is in progress and cycled every two (2) seconds when completed for two (2) minutes unless the **Exit**, **Select** or **Maneuver** button is pushed:

- ∆ **Pres xxx** - where **xxx** is the final airway pressure minus PEEP from the previous breath
- **C Static xxx** - where **xxx** is the set Tidal Volume divided by Delta Pressure
- **P Plat xxx** - where **xxx** is the airway pressure at the end of the Hold

Expiratory Hold

When the Expiratory Hold maneuver has completed successfully:

- The **Maneuver** LED is extinguished and the calculated data is displayed
- The inspiration phase begins
- The flow servo operates normally

The maneuver results are displayed in the front panel display window while the maneuver is in progress and cycled every two (2) seconds when completed for two (2) minutes unless the **Exit**, **Select** or **Maneuver** button is pushed:

- **AutoPEEP xxx** is displayed, where **xxx** is Expiratory Pressure at the end of the Expiratory Hold maneuver minus the Expiratory Pressure measured immediately before closing the exhalation valve to start the maneuver
- **P Exp** is calculated as Expiratory Pressure measured at end of the Expiratory Hold maneuver

Procedures

The following procedures may be performed on the ReVel ventilator**:**

- O_2 Flush
- Nebulization
- Spontaneous Breathing Trial (SBT)

O_2 Flush

The O_2 Flush procedure allows you to deliver a pre-set elevated percentage of oxygen to the patient for a specified duration of time.

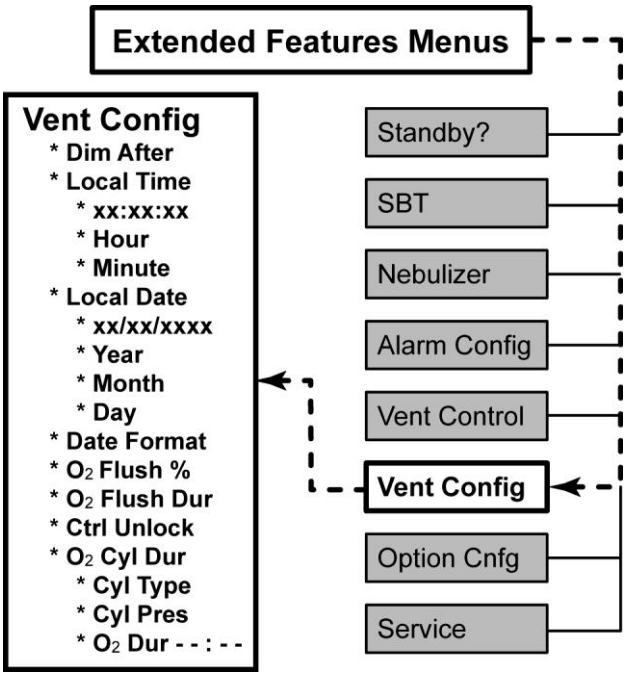
NOTE

- To perform this procedure, the ventilator must be connected to a high pressure oxygen source and **O_2%** set to ≥ 21%.
- The O_2 Flush, SBT and Nebulization procedures cannot be performed simultaneously. When one of these procedures is in-process, the other procedures are deactivated until the in-process procedure has been cancelled or completed.

To Configure the O_2 Flush Procedure:

The O_2 Flush procedure elevated percentage of oxygen delivered (**O_2 Flush %**) and for what duration of time (**O_2 Flush Dur**) is configured and set using the Extended Features menus.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *O2 Flush %* and *O2 Flush Dur (O2 Flush Duration)* in the Extended Features, Vent Config menus in Chapter 10 – Extended Features for detailed instructions



To Start the O_2 Flush Procedure:

The **O_2** control on the ventilator's front panel is a dual function control. Although primarily used to adjust the percentage of oxygen to be delivered through the ventilator's oxygen blending system, it is also used to initiate the O_2 Flush procedure.

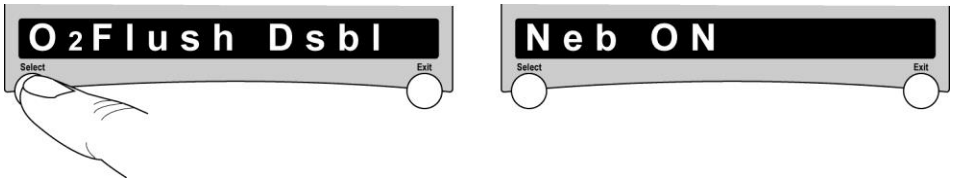
- See *O2 (Oxygen Percentage and Flush)* in Chapter 5 – Controls for additional information

To start the O_2 Flush procedure once the **O_2 Flush %** and **O_2 Flush Dur** Extended Features menus have been configured/set, push and hold the **O_2 (%)** control button on the front panel for ~3 seconds.

O_2 Flush Disabled Message

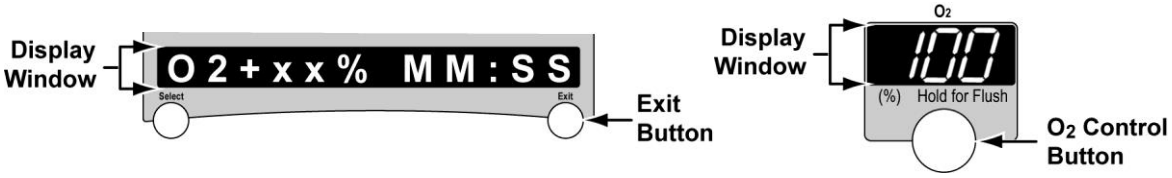
The **O_2 Flush Dsbl** message is displayed when the **O_2%** button is pushed and held for ~3 seconds and the current ventilator settings do not support an O_2 Flush procedure.

Push the **Select** button when **O_2 Flush Dsbl** is displayed to view the reason or reasons why the O_2 Flush is disabled. If more than one reason occurs, rotate the **Scroll Knob** to scroll through the reasons.



Displayed Message	Reason
Neb ON	A **Nebulizer** procedure is in Progress
SBT ON	An **SBT** procedure is in Progress
LPS Selected	**O_2** setting not set to ≥ 21%

When an O_2 Flush procedure is started, the percentage of O_2 increased and the remaining time for the procedure (beginning at the set duration of time and reducing every second and minute until no time is left), is added to the scrolling monitored values in the front panel display window. Additionally, the total percentage of oxygen being delivered to the patient will be flashed in the **O_2** control display window while the procedure is being performed.



To Cancel the O_2 Flush Procedure:

The delivery of the elevated level of oxygen will continue until the set duration of time expires, the **O_2** control button is pushed a second time, or the **Exit** button is pushed.

NOTE

When the O_2 Flush procedure ends, it may take the oxygen several seconds to flush out of the patient circuit and for the **O_2** monitors to return to set levels.

Nebulization

The Nebulization procedure can be performed on the ReVel ventilator during Volume breaths in Assist/Control mode only. When the Nebulizer is activated, a six (6) lpm nominal flow is delivered to the nebulizer drive port. This drives an aerosol nebulizer that doses medication into the patient circuit.

⚠ WARNING

Risk of Injury - If the nebulizer drive system fails, medication can be delivered at an incorrect rate. Monitor medication consumption rate and discontinue use if it does not meet patient needs.

If the nebulizer drive system fails, medication can be delivered during exhalation phase resulting in a release of medications into the room. Monitor medication consumption rate and discontinue use if rate is excessively high.

If the nebulizer drive line is connected to a gas supply/flow meter other than the ventilator's nebulizer drive port during a nebulization procedure, delivered volume to the patient may be higher than the ventilator's set **Tidal Volume** and the ventilator's Extended Features nebulization procedure control menus Start Nebulizer (**Neb Start**), Stop Nebulizer (**Neb Cancel**), Nebulizer Duration (**Neb Duration**) and Nebulizer Synchronization (**Neb Sync**) are circumvented. To avoid harm to the patient (e.g., Barotrauma), do not connect the nebulizer drive line to any gas supply/flow meter other than the ventilator's nebulizer drive port.

Inspiratory Pause - If an Inspiratory Pause is initiated during the Nebulization procedure, additional volume will be delivered to the patient.

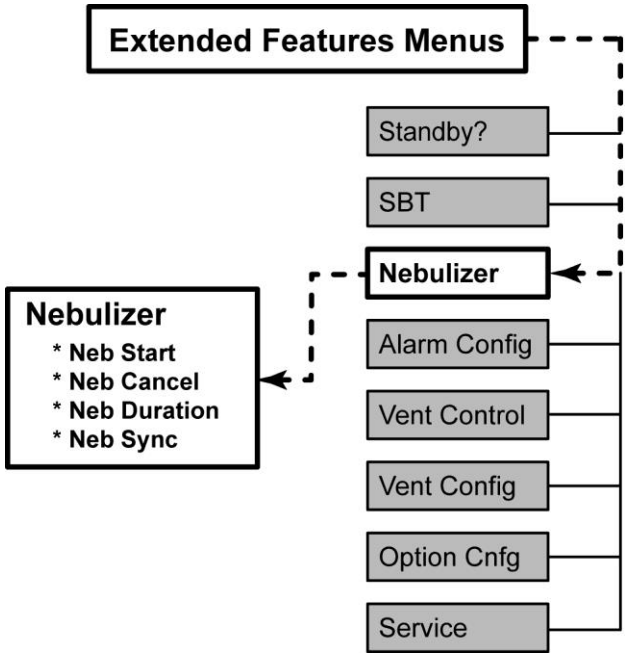
NOTE

- To perform the Nebulization procedure, the **Bias Flow** must be set to 10 lpm, the Breath Mode set to **A/C**, the Breath Type set to **Volume**, and the ventilator must be connected to a Nebulizer and a high pressure oxygen source connected with **O_2** set to ≥ 21%.
- The O_2 Flush, SBT and Nebulization procedures cannot be performed simultaneously. When one of these procedures is in-process, the other procedures are deactivated until the in-process procedure has been cancelled or completed.

To Configure the Nebulization Procedure:

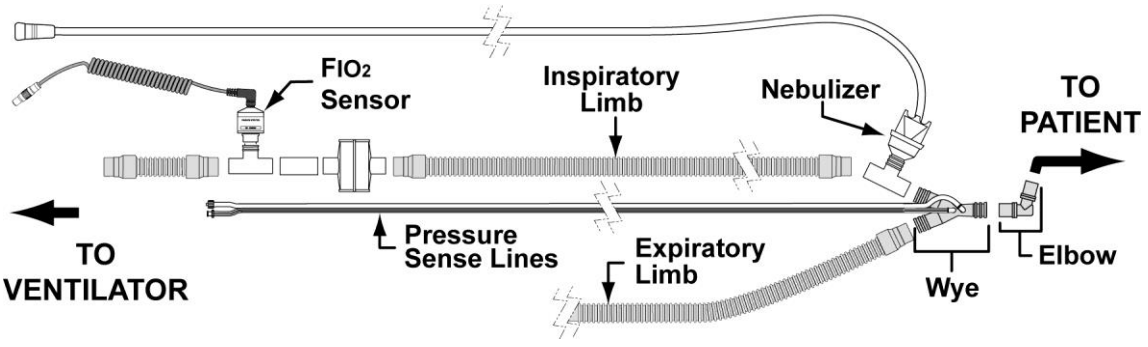
The total length of time that a Nebulizer treatment session is active and how it is synchronized with the patient's breath pattern is configured and set using the Extended Features menus.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *Neb Duration (Nebulizer Duration)* and *Neb Sync (Nebulizer Synchronization)* in the Extended Features, Nebulizer menus in Chapter 10 – Extended Features for detailed instructions



Automatic Adjustments During Nebulization

The nebulizer flow is 100% oxygen, delivered to the Nebulizer port from the high pressure O_2 inlet. During nebulization, the ventilator decreases the flow to its inspiratory limb to compensate for the addition of the nebulization flow at the patient Wye. However, because the nebulizer is driven by 100% oxygen, the percentage of oxygen in the patient airway increases during nebulizer treatments. The illustration below shows the relative positions of the F_{IO_2} Sensor and the Nebulizer in a typical patient circuit setup.

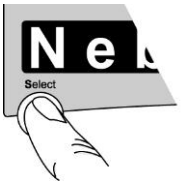


NOTE

Due to the relative positioning of the F_{IO_2} Sensor and the Nebulizer in a typical patient circuit setup (see diagram), the percentage of oxygen in the patient circuit cannot be accurately measured during nebulization.

The Nebulizer should be removed from the patient circuit and the ventilator when not in use.

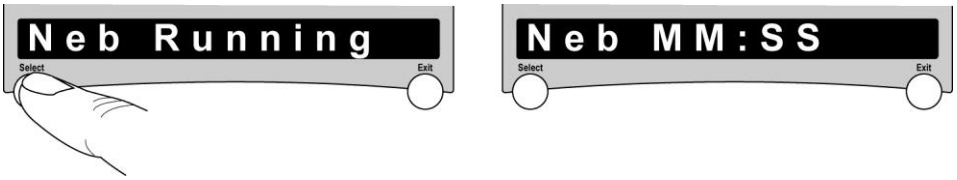
To Start the Nebulization Treatment



To start the nebulization treatment once the Nebulizer Duration (**Neb Dur**) and Nebulizer Synchronization (**Neb Sync**) Extended Features menus have been configured/set, push the **Select** button on the front panel when the Nebulization Start (**Neb Start**) menu is displayed.

- See *Neb Start (Nebulizer Start)* in Chapter 10 – Extended Features for detailed instructions

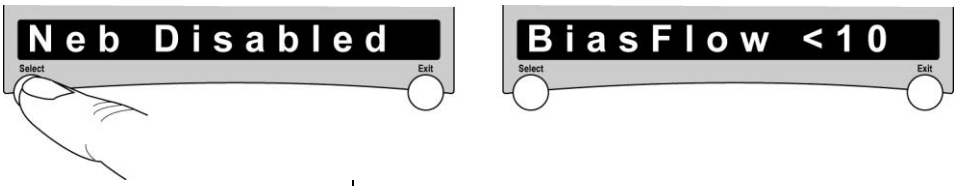
When a Nebulizer procedure is started, displayed monitored values will stop scrolling in the front panel display window and **Neb Running** is displayed. To view monitored data values during the Nebulizer procedure (including the minutes and seconds remaining for the Nebulization treatment (**Neb MM:SS**), push the **Exit** button on the front panel until **Neb MM:SS** is displayed. Data values are viewed by rotating the **Scroll Knob** or pushing the **Exit** button again for the data to automatically scroll.



Nebulizer Disabled Message

The **Neb Disabled** message is displayed when the **Select** button is pushed (when **Neb Start** is displayed) and the current ventilator settings do not support a nebulizer procedure.

Push the **Select** button when **Neb Disabled** is displayed to view the reason or reasons why the nebulizer is disabled. If more than one reason occurs, rotate the **Scroll Knob** to scroll through the reasons.



Displayed Message	Reason
O_2 Flush ON	An **O_2 Flush** procedure is in Progress
SBT ON	An **SBT** procedure is in Progress
NOT Vol A/C	Ventilator Breath Mode and Breath Type not set to **Volume A/C**
Bias Flow <10	**Bias Flow** is setting is less than 10 lpm
LPS Selected	**O_2** setting not set to ≥ 21%

To Cancel the Nebulization Procedure

The Nebulizer procedure will continue until the set duration of time expires, or the **Select** button on the front panel is pushed when the Nebulization Cancel (**Neb Cancel**) menu is displayed.

- See *Neb Cancel (Nebulizer Cancel)* in Chapter 10 – Extended Features for detailed instructions

SBT (Spontaneous Breathing Trial)

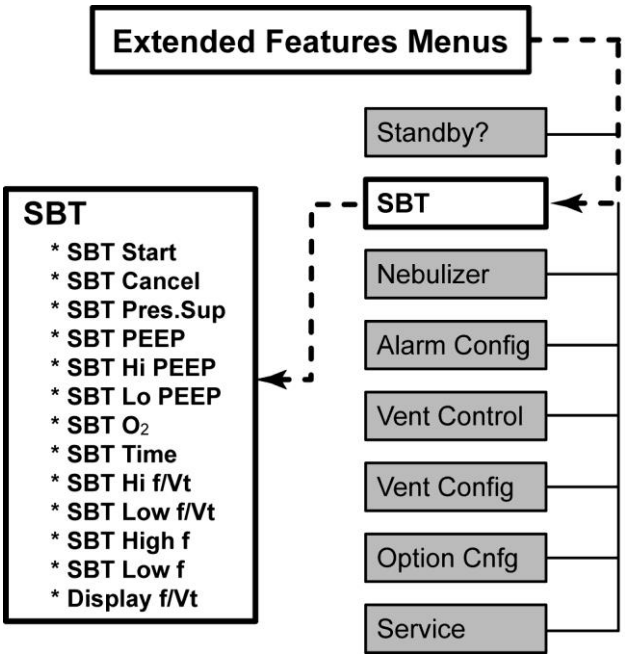
The Spontaneous Breathing Trial (SBT) procedure provides temporarily minimized ventilatory support so a clinician can perform clinical assessments of a patient's dependence on, or ability to be removed from positive pressure ventilation. SBT mode should be used only while attended by a Respiratory Therapist or other properly trained and qualified personnel.

- SBT can be performed with all patient types

To Configure the SBT Procedure:

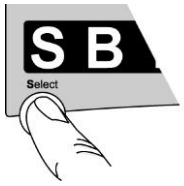
The SBT procedure controls (**SBT Pres. Sup, SBT PEEP, SBT O_2,** and **SBT Time**) and alarm limits (**SBT Hi f/Vt, SBT Low f/Vt, SBT High f** and **SBT Low f**) are configured and set using the Extended Features menus.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator and *SBT (Spontaneous Breathing Trial)* and *To Configure and Initiate the* SBT Procedure in the Extended Features, SBT menus in Chapter 10 – Extended Features for detailed instructions
- See *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms for detailed information about SBT related alarms



To Start the SBT Procedure:

To start the SBT procedure, configure/set the SBT related controls and alarm limits appropriate for the patient, and push the **Select** button on the front panel when the **SBT Start** menu is displayed.



- See *SBT Start* in Chapter 10 – Extended Features for detailed instructions

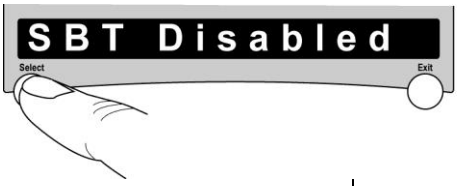
NOTE

You cannot perform SBT when the ventilator is performing an Increase O_2 or Nebulizer procedure, or operating in **NPPV Pressure** or **NPPV CPAP+PS** ventilation modes (Non-Invasive).

SBT Disabled Message

The **SBT Disabled** message is displayed when the **Select** button is pushed (when **SBT Start** is displayed) and the current ventilator settings do not support an SBT procedure.

Push the **Select** button when **SBT Disabled** is displayed to view the reason or reasons why the SBT is disabled. If more than one reason occurs, rotate the **Scroll Knob** to scroll through the reasons.

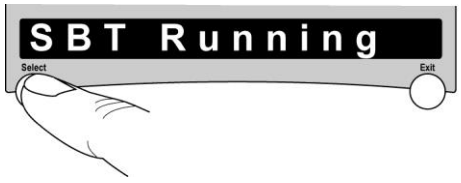


Displayed Message	Reason
Neb ON	A **Nebulizer** procedure is in Progress
O_2 Flush ON	An **O_2 Flush** procedure is in Progress
NIV/NPPV ON	**NPPV Pressure** or **NPPV CPAP+PS** mode running

When the SBT procedure is started, **SBT Running** is displayed in the front panel display window and the ventilator begins the SBT procedure functioning in the **CPAP+PS** mode using the current SBT menu settings (i.e., factory-set values, or previously reconfigured SBT ventilation control and alarm limit settings).

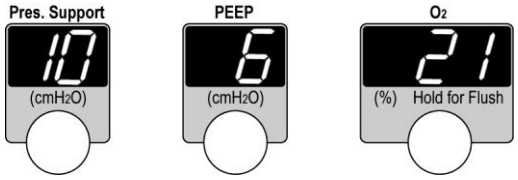
To view monitored data values (including the hours, minutes and seconds remaining for the SBT procedure, push the **Exit** button on the front panel until **SBT HH:MM:SS** (for ≥ 1 hour) or **SBT MM:SS** (for < 1 hour) is displayed. Data values are viewed by rotating the **Scroll Knob** or pushing the **Exit** button again for the data to automatically scroll.

- If the SBT menu item **Display f/Vt** is set to **On**, **SBT f/Vt** and **SBT f** monitored data is also displayed during an SBT procedure



When an SBT procedure is active, **SBT Pres. Sup**, **SBT PEEP** and **SBT O_2** monitored values are displayed in the front panel **Pres**. **Support, PEEP** and **O_2** control display windows, respectively.

- See *Monitored Patient Data* in Chapter 7 – Monitored Data for detailed information about SBT related monitored data displayed by the ventilator



The SBT trial ends when any of the following occur:

- The **SBT Cancel** menu is selected (in Extended Features)
- An **SBT Off** alarm occurs (indicating that SBT ran for the full set time duration)
- An **Apnea** or Patient Circuit Fault (**Pat. Circuit**) alarm occurs
- A High Airway Pressure alarm (**High Pres**) or Safety Valve High Pressure Relief alarm (**SVHP Relief**) condition persists for more than 1.5 seconds
- The SBT high / low breath rate alarms (**SBT High / Low f**), or SBT high / low f/Vt alarm
- Any ventilation or alarm control is selected and confirmed other than **Control Lock**, **Silence/Reset**, or the **SBT High/Low f** and **SBT Hi/Low f/Vt** alarms

When the SBT ends, the ventilator automatically reverts to the settings in use prior to initiating the SBT procedure.

To Cancel the SBT Procedure:

1) To cancel an in-process SBT procedure:
   - If **SBT Running** is displayed, push the **Exit** button and **SBT Start** is displayed.

   OR

   - If **SBT Running** is <u>not</u> displayed, navigate back to the **SBT** Extended Features menu, push **Select** and **SBT Start** is displayed.

2) Rotate the **Scroll** knob until **SBT Cancel** is displayed, push the **Select** button, the SBT procedure is terminated, normal ventilation resumes and **Cancelled** is displayed.
   - See *SBT Cancel* in Chapter 10 – Extended Features for detailed instructions

Chapter 10 - EXTENDED FEATURES

This chapter describes the controls, alarms, monitors, features and options that do not have dedicated front panel controls or displays and are accessed through the Extended Features menus.

Extended Features Menus

To access/enter Extended Features menus

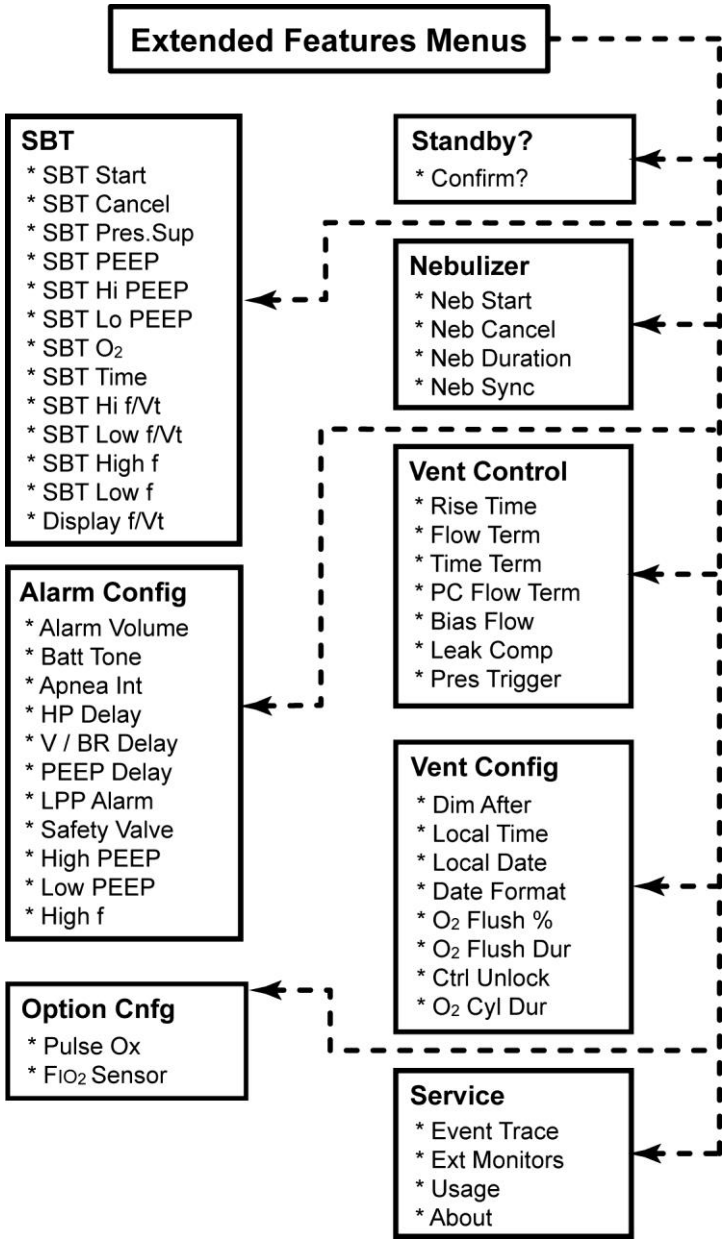
To access/enter Extended Features menus while the ventilator is in a normal ventilation mode, push and hold the **Select** control button on the front panel for three seconds.

- See *Navigating Startup and Extended Features Menus* in Chapter 3 – Using the Ventilator for detailed instructions

To exit Extended Features menus

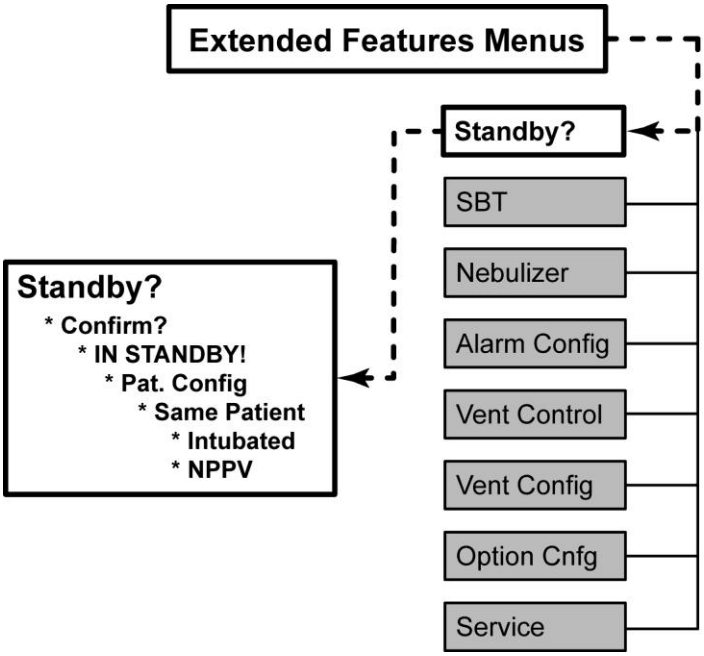
To exit specific Extended Features menus, push the **Exit** button on the front panel to exit the current/displayed menu and display the previous level menu (if any).

To exit all Extended Features menus, repeatedly push the **Exit** button until scrolling monitored data is displayed.



Standby? (Standby mode)

The **Standby?** menus are used by operators to initiate a temporary suspension of patient ventilation which can be used to accommodate changing or reconfiguration of accessories, gas delivery methods, patient movement or transport, and does not require changing ventilation settings or shutting down and restarting the ventilator.



When Standby mode is initiated/confirmed:

- Patient ventilation is suspended
- **Stopping** may be momentarily displayed, followed by **IN STANDBY!** flashing in the front panel display window
- Any in-process I-Hold or E-Hold maneuvers, or SBT, Nebulization, or O_2 Flush procedures are exited
- O_2 is set to 21% and the O_2 Flush Procedure is disabled
- PEEP pilot pressure is vented to ambient
- A constant two (2) lpm bias flow is delivered to the patient circuit
- Ventilation and clinical alarms are disabled
- The front panel ventilation and alarm controls are locked (**Control Lock** enabled, LED illuminated)

When Standby mode is exited:

- Patient ventilation can be resumed using the ventilation control and alarm configurations/limits settings that were in effect before Standby mode was initiated,

  OR

  If desired, the operator can change the type of patient circuit to patient interface configuration (**Intubated** versus **NPPV**) and then exit Standby mode and resume patient ventilation
- Disabled ventilation and clinical alarms are enabled
- The front panel ventilation and alarm controls are unlocked (**Control Lock** disabled, LED extinguished)

To Initiate Standby Mode

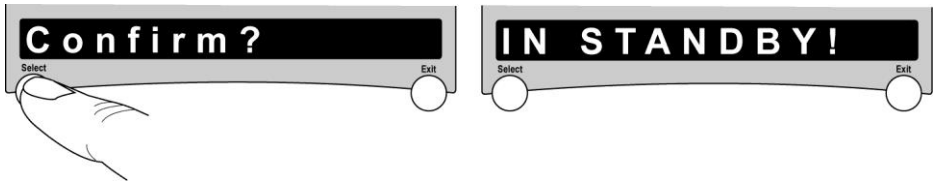
⚠ WARNING

Standby Mode – When Standby mode is initiated, patient ventilation is suspended until Standby mode is exited and normal ventilation is resumed. To avoid serious injury or death, disconnect the patient from the ventilator before initiating Standby and provide alternative ventilation until such time as a normal ventilation mode is resumed and the patient is reconnected to the ventilator.

1) Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Standby?** is displayed, push the **Select** button and **Confirm?** is displayed.

2) To suspend patient ventilation and initiate the Standby mode, push the **Select** button when **Confirm?** is displayed.

   Patient ventilation is suspended and **Stopping** is momentarily displayed, followed by **IN STANDBY!** flashing in the front panel display window.



NOTE

During Standby mode ventilation and clinical alarms are disabled (e.g. Low Minute Volume, High PEEP, etc.) however, alarms that would affect normal ventilation when resumed (e.g. hardware/software fault alarms, loss of power, etc.) remain enabled and are generated (visual and audible) whenever the associated alarm conditions arise.

3) If using a heated wire patient circuit, turn the humidifier off (source of power for the heated wire circuit) prior to leaving the ventilator in the Standby mode for an extended period of time.

⚠ CAUTION

Patient Circuit Overheating – To avoid damaging active heated wire patient breathing circuits during Standby mode, turn the humidifier off (source of power for the heated wire circuit).

To Exit Standby Mode

1) To change the type of patient circuit to patient interface configuration (**Intubated** versus **NPPV**) prior to exiting the Standby mode and resuming patient ventilation, continue; otherwise skip to the next step.

   While **IN STAND BY!** is displayed, push the **Select** button and **Pat. Config** is displayed. Push the **Select** button again and **Same Patient** is displayed. Push the **Select** button a third time and **Intubated** is displayed.

   To select an intubated type of patient circuit to patient interface, exit Standby mode and initiate ventilation, push the **Select** button.

   OR

   To select a non-invasive type of patient circuit to patient interface, exit Standby mode and initiate ventilation, rotate the **Scroll** knob until **NPPV** is displayed and push the **Select** button.

   When either **Intubated** or **NPPV** is selected (**Select** button pushed), Standby mode is exited and ventilation is resumed using the patient circuit to patient interface configuration selected.

   If using a heated wire patient circuit, turn the humidifier back on (source of power for the heated wire circuit).

> **NOTE**
>
> When the type of patient circuit to patient interface configuration (**Intubated** or **NPPV**) is changed before exiting Standby mode:
>
> - If the type of patient circuit to patient interface selected is **Intubated** and the previous setting was **NPPV**, the Breath Mode and Breath Type will be set to their last selected / preset intubated interface settings
> - If the type of patient circuit to patient interface selected is **NPPV** and the previous setting was **Intubated**, the Breath Mode will be set to **CPAP+PS** and the Breath Type will be set to **Pressure**

2) To exit the Standby mode and resume patient ventilation using the ventilation control and alarm configurations/limits settings that were in effect before Standby mode was initiated, push the **Exit** button.

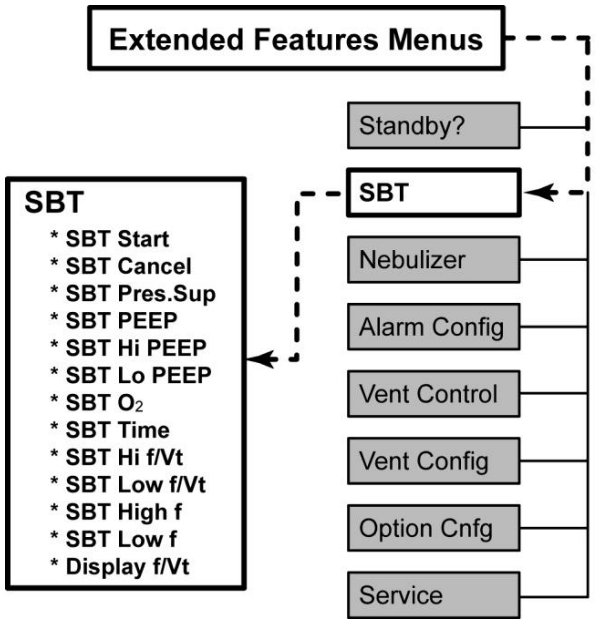
   When the **Exit** button is pushed, the Standby mode is exited and ventilation is resumed.

   If using a heated wire patient circuit, turn the humidifier back on (source of power for the heated wire circuit).

SBT (Spontaneous Breathing Trial)

The **SBT** (Spontaneous Breathing Trial) menus are used to configure SBT related ventilation controls and alarm limits, and initiate the SBT procedure.

- See *SBT (Spontaneous Breathing Trial)* in Chapter 9 – Maneuvers and Procedures for detailed information about the SBT procedure
- See *Monitored Patient Data* in Chapter 7 – Monitored Data for detailed information about SBT related monitored data displayed by the ventilator
- See *Alarms, Detailed Descriptions* in Chapter 8 – Ventilator Alarms for detailed information about SBT related alarms



NOTE

You cannot perform SBT when the ventilator is performing an Increase O_2 or Nebulizer procedure, or operating in **NPPV Pressure** or **NPPV CPAP+PS** ventilation modes (Non-Invasive).

The Spontaneous Breathing Trial (SBT) procedure provides temporarily minimized ventilatory support so a clinician can perform clinical assessments of a patient's dependence on, or ability to be removed from positive pressure ventilation. SBT mode should be used only while attended by a Respiratory Therapist or other properly trained and qualified personnel.

- SBT can be performed with all patient types

To Configure and Initiate the SBT Procedure

Factory-set or reset SBT menu configuration values are retained and used by the ventilator (through shut downs and power ups) until re-set by an operator. Accordingly, all SBT menu settings should be reviewed for appropriateness and/or reset as necessary, prior to initiating an SBT procedure.

1) Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **SBT** is displayed, push the **Select** button and **SBT Start** is displayed.

SBT Start

The **SBT Start** menu is used to initiate an SBT procedure.

1) Rotate the **Scroll** knob until **SBT Start** is displayed.
2) Push the **Select** button**, Running** is displayed and the ventilator begins the SBT procedure using the current SBT menu settings (i.e., factory-set values, or previously reconfigured SBT ventilation settings).

SBT Cancel

The **SBT Cancel** menu is used to cancel/end an in-process SBT procedure.

1) When the ventilator is performing an SBT procedure, push the **Exit** button while **Running** or **SBT xx:xx** is displayed and **SBT Start** is displayed.
2) Rotate the **Scroll** knob until **SBT Cancel** is displayed, push the **Select** button. The SBT procedure is terminated, normal ventilation resumes and **Cancelled** is displayed.

SBT Pres.Sup (SBT Pressure Support)

The **SBT Pres.Sup** (SBT Pressure Support) menu is used to set the target pressure above set **SBT PEEP** for SBT patient breaths. During the SBT procedure, this control is disabled.

1) Rotate the **Scroll** knob until **SBT Pres.Sup** is displayed, push the **Select** button and the set SBT Pressure Support value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Pressure Support value is set and **SBT Pres.Sup** is displayed.

   Range: **1** through **20 cmH_2O** in increments of 1

SBT PEEP

The **SBT PEEP** menu is used to set the level of PEEP to be in effect during a Spontaneous Breath Trial procedure. During the SBT procedure, this control is disabled.

1) Rotate the **Scroll** knob until **SBT PEEP** is displayed, push the **Select** button and the set SBT PEEP value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT PEEP value is set and **SBT PEEP** is displayed.

   Range: **0** through **20 cmH_2O** in increments of 1, or **"- -"** (off)

SBT Hi PEEP

The **SBT Hi PEEP** menu is used to set the upper limit of the SBT Hi PEEP alarm.

1) Rotate the **Scroll** knob until **SBT Hi PEEP** is displayed, push the **Select** button and the set SBT Hi PEEP value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Hi PEEP value is set and **SBT Hi PEEP** is displayed.

   Range: **3** through **40 cmH_2O** in increments of 1, or "- -" (off)

SBT Lo PEEP

The **SBT Lo PEEP** menu is used to set the lower limit of the SBT Lo PEEP alarm.

1) Rotate the **Scroll** knob until **SBT Lo PEEP** is displayed, push the **Select** button and the set SBT Lo PEEP value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Lo PEEP value is set and **SBT Lo PEEP** is displayed.

   Range: "- -" (off), or **1** through **20 cmH_2O** in increments of 1

SBT Low f/Vt

The **SBT Low f/Vt** menu is used to set the lower limit of the SBT Low f/Vt alarm.

1) Rotate the **Scroll** knob until **SBT Low f/Vt** is displayed, push the **Select** button and the set SBT Low f/Vt value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Low f/Vt value is set and **SBT Low F/Vt** is displayed.

   Range: **5** through **90 bpm/L** in increments of 5, or **Lo f/Vt Off**

SBT O_2

The **SBT O_2** menu is used to set the percentage of oxygen to be delivered in the gas flow during a Spontaneous Breath Trial procedure. During the SBT procedure, this control is disabled.

1) Rotate the **Scroll** knob until **SBT O_2** is displayed, push the **Select** button and the set SBT O_2 value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT O_2 value is set and **SBT O_2** is displayed.

   Range: **21** through **100%** in increments of 1, or **LPS**

SBT Time

The **SBT Time** menu is used to set the maximum run time of the SBT procedure. During the SBT procedure, this control is disabled.

1) Rotate the **Scroll** knob until **SBT Time** is displayed, push the **Select** button and the set SBT Time value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Time value is set and **SBT Time** is displayed.

   Range **15** through **120 min** in increments of 5

SBT Hi f/Vt

The **SBT Hi f/Vt** menu is used to set the upper limit of the SBT Hi f/Vt alarm.

1) Rotate the **Scroll** knob until **SBT Hi f/Vt** is displayed, push the **Select** button and the set SBT Hi f/Vt value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Hi f/Vt value is set and **SBT Hi F/Vt** is displayed.

   Range: **70** through **900 bpm/L** in increments of 5, or **Hi f/Vt Off**

SBT Low f/Vt

The **SBT Low f/Vt** menu is used to set the lower limit of the SBT Low f/Vt alarm.

1) Rotate the **Scroll** knob until **SBT Low f/Vt** is displayed, push the **Select** button and the set SBT Low f/Vt value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Low f/Vt value is set and **SBT Low F/Vt** is displayed.

   Range: **5** through **90 bpm/L** in increments of 5, or **Lo f/Vt Off**

SBT High f

The **SBT High f** menu is used to set the upper limit of the SBT High Breath Rate alarm.

1) Rotate the **Scroll** knob until **SBT High f** is displayed, push the **Select** button and the set SBT High f value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT High f value is set and **SBT High f** is displayed.

   Range: **15** through **80 bpm/L** in increments of 1, or **SBT Hi f Off**

SBT Low f

The **SBT Low f** menu is used to set the lower limit of the SBT Low Breath Rate alarm.

1) Rotate the **Scroll** knob until **SBT Low f** is displayed, push the **Select** button and the set SBT Low f value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new SBT Low f value is set and **SBT Low f** is displayed.

   Range: **1** through **40 bpm** in increments of 1, or **SBT Lo f Off**

Display f/Vt

The **Display f/Vt** menu is used to set the scrolling display (in the front panel display window) of the f/Vt (Rapid Shallow Breathing Index) monitor value on or off.

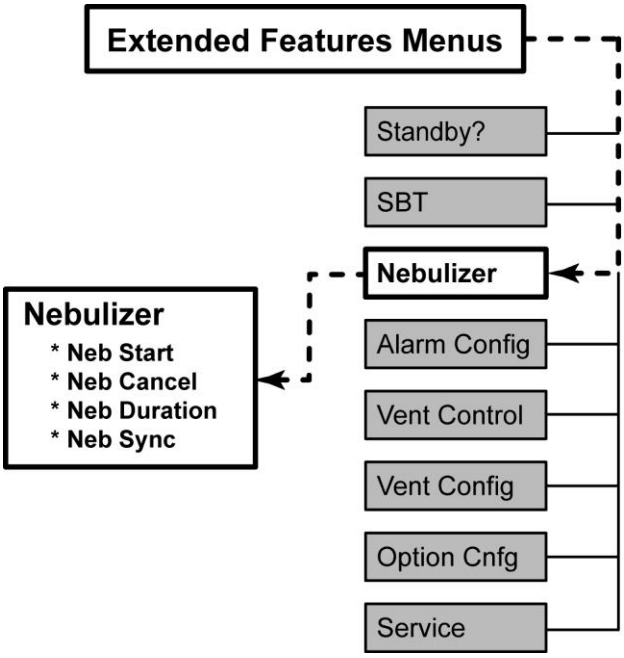
1) Rotate the **Scroll** knob until **Display f/Vt** is displayed, push the **Select** button and the set Display f/Vt value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Display f/Vt value is set and **Display f/Vt** is displayed.

   Range **On** or **Off**

Nebulizer

The **Nebulizer** menus are used to configure the ventilators nebulization treatment related controls, and initiate the Nebulization procedure.

- See *Nebulization* in Chapter 9 – Maneuvers and Procedures for detailed information about the Nebulization procedure



To Configure and Initiate the Nebulization Procedure

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Nebulizer** is displayed, push the **Select** button and **Neb Start** is displayed.

NOTE

- To perform the Nebulization procedure, the **Bias Flow** must be set to 10 lpm, the Breath Mode set to **A/C**, the Breath Type set to **Volume**, and the ventilator must be connected to a Nebulizer and a high pressure oxygen source connected with **O_2** set to ≥ 21%.
- The O_2 Flush, SBT and Nebulization procedures cannot be performed simultaneously. When either one of these procedures is in-process, the other procedure is deactivated until the in-process procedure has been cancelled or completed.

Neb Start (Nebulizer Start)

The **Neb Start** (Nebulizer Start) menu is used to initiate a Nebulization procedure.

1) Rotate the **Scroll** knob until **Neb Start** is displayed.
2) Push the **Select** button, **Neb Running** is displayed and the ventilator begins the Nebulization procedure using the current Nebulizer Duration (**Neb Dur**) and Nebulizer Synchronization (**Neb Sync**) menu settings (i.e., factory-set values, or previously reconfigured nebulization settings).

   Or

   If **Neb Start** is selected and **Neb Disabled** is displayed, the Nebulization procedure is not available because the ventilator is not operating in **Volume A/C** mode, the **Bias Flow** is not set to 10 lpm, and/or an **SBT** or **O_2 Flush** procedure is in progress.
   Push the **Select** button while **Neb Disabled** is displayed and rotate the scroll knob to view all applicable reasons why the nebulizer is disabled.

Neb Cancel (Nebulizer Cancel)

The **Neb Cancel** (Nebulizer Cancel) menu is used to cancel/end an in-process Nebulization procedure.

1) While **Neb Running** is displayed, rotate the **Scroll** knob until **Neb Cancel** is displayed and push the **Select** button. The Nebulization procedure is terminated, normal ventilation resumes and **Cancelled** is displayed.

Neb Duration (Nebulizer Duration)

The **Neb Duration** (Nebulizer Duration) menu is used to set the total length of time that a Nebulization procedure is active. During the Nebulization procedure, this control is disabled.

1) Rotate the **Scroll** knob until **Neb Duration** is displayed, push the **Select** button and the set nebulization time duration value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new nebulization time duration value is set and **Neb Duration** is displayed.

   Range **1**through **30 min** in increments of 1

Neb Sync (Nebulizer Synchronization)

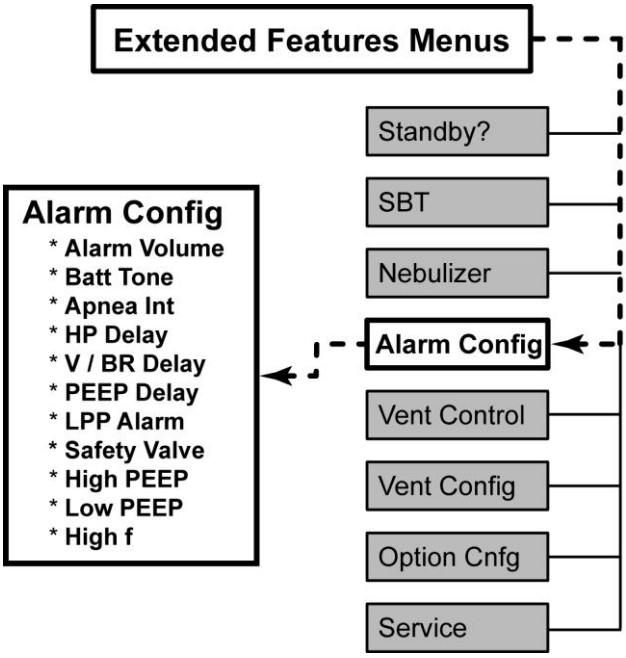
The **Neb Sync** (Nebulizer Synchronization) menu is used to set how the Nebulization procedure is synchronized with the patient's breath pattern. During the Nebulization procedure, this control is disabled.

1) Rotate the **Scroll** knob until **Neb Sync** is displayed, push the **Select** button and the set nebulizer synchronization value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new nebulizer synchronization value is set and **Neb Sync** is displayed.

   Range **Continuous** or **Insp Only**

Alarm Config (Alarm Configuration)

The **Alarm Config** (Alarm Configuration) menus are used to configure/set alarm features and limits that are not available on the front panel.



To Use the Alarm Config Menus

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Alarm Config** is displayed, push the **Select** button and **Alarm Volume** is displayed.

Alarm Volume

The **Alarm Volume** menu is used to set the audible volume at which the ventilator sounds alarms. For more information on the set volume versus the actual volume at which each priority of alarm sounds, see *Sound Types, Patterns and Volumes* in Chapter 8 - Ventilator Alarms.

1) Rotate the **Scroll** knob until **Alarm Volume** is displayed, push the **Select** button and the set alarm volume value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new alarm volume value is set and **Alarm Volume** is displayed.

   Range: **Vol 1** through **6**

Batt Tone (Battery Use Tone)

The **Batt Tone** (Battery Use Tone) menu is used to set the audible volume at which the ventilator sounds the Battery Use tone. For more information on the set volume versus the actual volume at which each priority of alarm sounds, see *Sound Types, Patterns and Volumes* in Chapter 8 - Ventilator Alarms.

1) Rotate the **Scroll** knob until **Batt Tone** is displayed, push the **Select** button and the set battery tone volume value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new a battery tone volume value is set and **Batt Tone** is displayed.

   Range: **Vol 1** through **3** in increments of 1, or **Off**

Apnea Int (Apnea Interval)

The **Apnea Int** (Apnea Interval) menu is used to set the maximum time allowed between the beginning of one breath and the beginning of the next breath, before initiating Apnea Backup ventilation and sounding the Apnea alarm.

1) Rotate the **Scroll** knob until **Apnea Int** is displayed, push the **Select** button and the set apnea interval is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new apnea interval value is set and **Apnea Int** is displayed.

   Range: **Apnea 10** through **Apnea 60 sec** in increments of 5

HP Delay (High Pressure Delay)

The **HP Delay** (High Pressure Delay) menu is used to set the delay (in number of consecutive breaths), that the ventilator will wait after the circuit pressure exceeds the set high pressure limit, before initiating a High Airway Pressure (**High Pres**) alarm condition.

- The High Pressure Delay setting does not affect the pressure limiting function of the High Airway Pressure alarm. For more information on the High Airway Pressure alarm, see *High Airway Pressure (High Pres)* in Chapter 8 – Ventilator Alarms

1) Rotate the **Scroll** knob until **HP Delay** is displayed, push the **Select** button and the set HP Delay value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new HP Delay value is set and **HP Delay** is displayed.

   Range: **Delay 0** through **Delay 2 Brth** in increments of 1

V/BR Delay (Minute Volume/Breath Rate Alarm Delay)

The **V/BR** (Minute Volume/Breath Rate Alarm Delay) menu is used to set the delayed notification (in seconds) for the Low Exhaled Minute Volume (**Low Min Vol**) and the High Breath Rate (**High f)** alarms.

1) Rotate the **Scroll** knob until **V/BR Delay** is displayed, push the **Select** button and the set V/BR Delay value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new V/BR Delay value is set and **V/BR Delay** is displayed.

   Range: **Delay 0** through **Delay 60 sec** in increments of 1

PEEP Delay

The **PEEP Delay** menu is used to set the delayed notification period (in seconds), for the high and low limits of the PEEP alarm.

1) Rotate the **Scroll** knob until **PEEP Delay** is displayed, push the **Select** button and the set PEEP Delay value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new PEEP Delay value is set and **PEEP Delay i**s displayed.

   Range: **Delay 0** through **Delay 60 sec** in increments of 1

LPP Alarm (Low Peak Pressure Alarm)

The **LPP Alarm** (Low Peak Pressure Alarm) menu is used to set the breath types for which the Low Peak Pressure (**Low Pk Pres**) alarm is applicable.

The LPP Alarm limit can be set to apply to all breaths (**All Breaths**), or only to Machine and Assist breaths in SIMV mode, and all breaths in A/C and CPAP+PS modes (**Control Only**).

- See *Low Peak Pressure (Low Pk Pres)* in Chapter 8 – Ventilator Alarms for more information about the Low Peak Pressure alarm
- LPPS / LMV alarm status messages, when applicable, are displayed in the front panel display window along with monitored data. See *Alerts, LPPS / LMV Status Messages* in Chapter 8 – Ventilator Alarms for detailed information.

NOTE

In CPAP+PS mode, all breaths are monitored for Low Peak Pressure.

1) Rotate the **Scroll** knob until **LPP Alarm** is displayed, push the **Select** button and the set LPP Alarm breath type is displayed.
2) Rotate the **Scroll** knob until the desired breath type is displayed, push the **Select** button, the new LPP Alarm breath type is set and **LPP Alarm** is displayed.

   Range: **All Breaths** or **Control Only**

Safety Valve

The **Safety Valve** menu is used to set the Safety Valve over-pressure (Delta Pressure) activation level. This setting, in conjunction with the High Airway Pressure (**High Pres**) alarm setting, determines the level at which the Safety Valve will open to provide high pressure relief in a high pressure condition.

- See *High Airway Pressure (High Pres)* and *Safety Valve High Pressure Relief (SVHP Relief)* in Chapter 8 - Ventilator Alarms for additional information

NOTE

It may be necessary to increase the Safety Valve setting when restrictive devices (e.g. dense filters) are used in the inspiratory limb of the patient circuit and the Safety Valve High Pressure (**SVHP**) alarm occurs. Otherwise, it is recommended to set this value at its factory-set value (10 cmH_2O) or lower.

1) Rotate the **Scroll** knob until **Safety Valve** is displayed, push the **Select** button and the set **Safety Valve** value is displayed.
2) Rotate the **Scroll** knob until the desired Safety Valve value is displayed, push the **Select** button, the new Safety Valve value is set and **Safety Valve** is displayed.

   Range: **5** through **30 cmH_2O** in increments of 5

High PEEP

The **High PEEP** menu is used to set the High PEEP alarm limit. See *High PEEP* in Chapter 8 – Ventilator Alarms for additional information.

1) Rotate the **Scroll** knob until **High PEEP** is displayed, push the **Select** button and the set High PEEP value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new High PEEP value is set and **High PEEP** is displayed.

   Range: **3** through **40 cmH_2O** in increments of 1, or "**- -**" (off)

Low PEEP

The **Low PEEP** menu is used to set the Low PEEP alarm limit. See *Low PEEP* in Chapter 8 – Ventilator Alarms for additional information.

1) Rotate the **Scroll** knob until **Low PEEP** is displayed, push the **Select** button and the set **Low PEEP** value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Low PEEP value is set and **Low PEEP** is displayed.

   Range: "**- -**" (off) or **1** through **20 cmH_2O** in increments of 1.

High f (High Breath Rate)

The **High f** (High Breath Rate) menu is used to set the High Breath Rate alarm limit. See *High Breath Rate (High f)* in Chapter 8 – Ventilator Alarms for additional information.

1) Rotate the **Scroll** knob until **High f** is displayed, push the **Select** button and the set High f value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new High f value is set and **High f** is displayed.

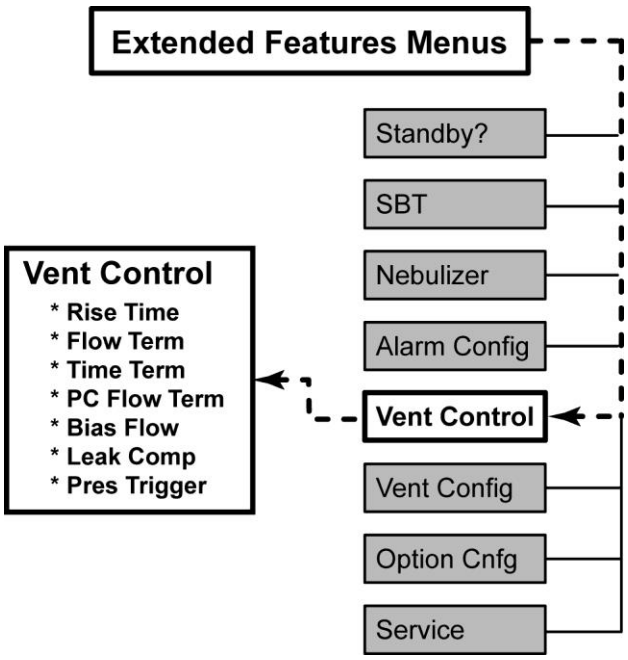
   Range: **1** through **120 bpm** in increments of 1, or "**- -**" (off

To set delayed notification for the High Breath Rate alarm:

To set a delay for the Low Exhaled Minute Volume (**Low Min Vol**) and the High Breath Rate (**High f)** alarms, see *V/BR Delay (Minute Volume/Breath Rate Alarm Delay)* in this chapter.

Vent Control (Ventilator Controls)

The **Vent Control** (Ventilator Controls) menus are used to set ventilator controls that are not available on the front panel.



To Use the Vent Control Menus

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Vent Control** is displayed, push the **Select** button and **Rise Time** is displayed.

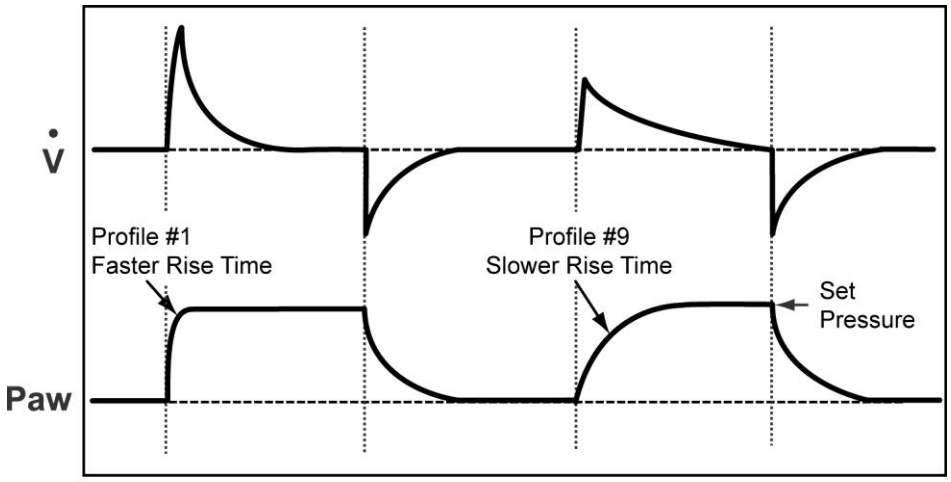
Rise Time

The **Rise Time** menu is used to select a rise time profile for Pressure Control, Pressure Support, Spontaneous, PRVC and Volume Targeted Pressure Support breaths.

The rise time profiles are numbered 1 through 9, where 1 is the fastest rise time and 9 is the slowest rise time. Starting with the fastest rise time (**Profile 1**), each increment in rise time is approximately 33% longer than the previous one. The rise time setting takes effect on the next Pressure Control or Pressure Support breath.

1) Rotate the **Scroll** knob until **Rise Time** is displayed, push the **Select** button and the current Rise Time profile is displayed.
2) Rotate the **Scroll** knob to until the desired profile is displayed, push the **Select** button, the new Rise Time profile is set and **Rise Time** is displayed.

   Range: **Profile 1** through **Profile 9** in increments of 1



Adjusting Rise Time on Pressure Control Breaths

NOTE

In **CPAP+PS (Pressure)** and **NPPV CPAP+PS** settings, the **Rise Time** control establishes the inspiratory rise time profile for Apnea Backup ventilation. Be sure to set it appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information).

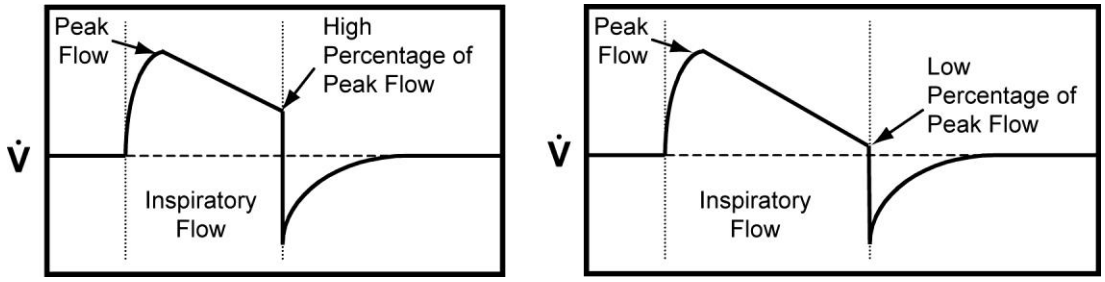
Flow Term (Flow Termination)

The **Flow Term** (Flow Termination) menu is used to set the percentage of Peak Flow at which Pressure Support, Spontaneous and Volume Targeted Pressure Support breaths are cycled. The breath is cycled from inspiration to exhalation when the flow is less than the set **Flow Term** setting. The breath also cycles when the flow is less than 2 lpm.

> **NOTE**
> Inspiration is also terminated if the inspiration time exceeds the Time Termination (**Time Term**) setting or two breath periods.

When Pressure Control Flow Termination (**PC Flow Term**) is on (**Term On**), the set Flow Termination percentage is used for flow termination of Pressure Control and Pressure Regulated Volume Control (PRVC) breaths as well.

- See *PC Flow Term (Pressure Control Flow Termination)* in this chapter and *Pres. Control (Pressure Control)* and *Pres. Support (Pressure Support)* in Chapter 5 - Controls for additional information regarding Flow Termination



1) Rotate the **Scroll** knob until **Flow Term** is displayed, push the **Select** button and the set Flow Term value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Flow Term value is set and **Flow Term** is displayed.

   Range: **Flow 10** through **Flow 40 %** in increments of 5

Time Term (Time Termination)

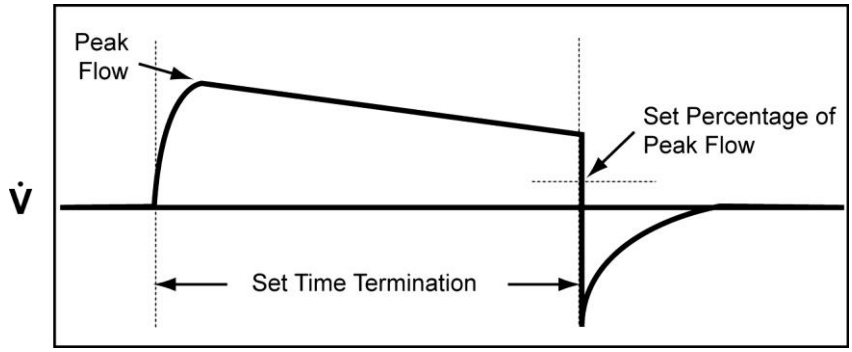
The **Time Term** (Time Termination) menu is used to set the maximum inspiratory time for terminating Pressure Support and Spontaneous breaths.

Breaths are time cycled from inspiration to exhalation if the set **Time Term** is reached before the flow reaches the set percentage of the peak flow for flow termination to take effect.

- See *Pres. Support (Pressure Support)* in Chapter 5 - Controls for additional information regarding Time Termination

NOTE

The Pressure Support display flashes briefly after each Time Terminated breath.



1) Rotate the **Scroll** knob until **Time Term** is displayed, push the **Select** button and the set Time Term value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Time Term value is set and **Time Term** is displayed.

   Range: **Term 0.3** through **Term 3.0 sec** in increments of 0.1

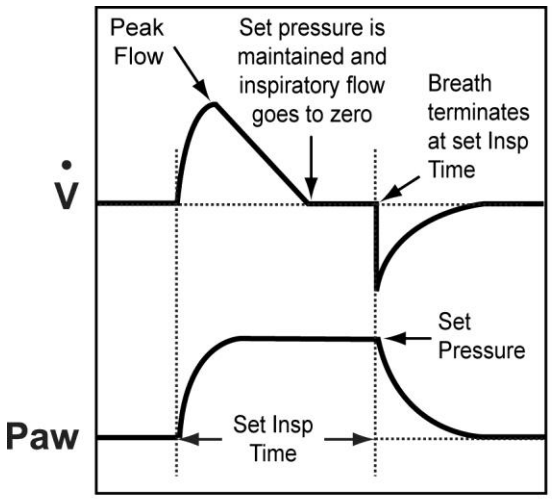
PC Flow Term (Pressure Control Flow Termination)

The **PC Flow Term** (Pressure Control Flow Termination) menu is used to enable or disable flow termination for Pressure Control and Pressure Regulated Volume Control (PRVC) breaths. The percentage of peak flow used for PC Flow Termination is set using the Flow Termination (**Flow Term**) menu.

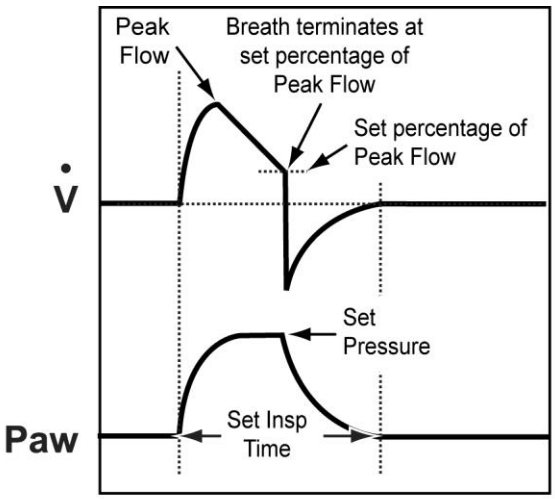
- See *Pres. Control (Pressure Control)* in Chapter 5 - Controls for additional information regarding Pressure Control Flow Termination

NOTE

When the Pressure Control Flow Termination option is Off (**Term Off)**, Pressure Control breaths are cycled when the set Inspiratory Time (**Insp. Time**) is reached.



PC Flow Term set to Off
Pressure Control breath terminates normally



PC Flow Term set to On
Pressure Control breath terminates at the same percentage of Peak Flow as Pressure Support breaths

NOTE

In **CPAP+PS (Pressure)** and **NPPV CPAP+PS** settings, the **PC Flow Term** control establishes the flow termination criteria for Apnea Backup ventilation. Be sure to set it appropriately (see *Apnea Backup Ventilation* in Chapter 4 – Breath Types and Modes for additional information).

1) Rotate the **Scroll** knob until **PC Flow Term** is displayed, push the **Select** button and the set PC Flow Termination value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new PC Flow Termination value is set and **PC Flow Term** is displayed.

   Range: **Term On** or **Term Off**

Bias Flow

The **Bias Flow** menu is used to provide a continuous flow through the patient circuit during the exhalation phase of breaths.

Bias Flow reduces the work of breathing by providing a flow source for flow triggering. Bias Flow not consumed by the patient exits the patient circuit through the exhalation valve.

1) Rotate the **Scroll** knob until **Bias Flow** is displayed, push the **Select** button and the set Bias Flow value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Bias Flow value is set and **Bias Flow** is displayed.

   Range: **Flow 3** through **Flow 10 lpm** in increments of 1

   The **Bias Flow** menu setting may be limited to less than its specified range; see *Control Limiting* in Chapter 5 – Controls for detailed information.

NOTE

- When Leak Compensation (**Leak Comp**) is enabled (**L. Comp On**), the Bias Flow is automatically increased by the amount of the measured leak.
- The Air/O_2 mix of the Bias flow is dependent on the set **O_2** control value and therefore affects oxygen consumption.

Leak Comp (Leak Compensation)

The **Leak Comp** (Leak Compensation) menu is used to enable or disable tracking steady state exhaled flow to improve monitored patient flow accuracy in the presence of a stable circuit leak.

1) Rotate the **Scroll** knob until **Leak Comp** is displayed, push the **Select** button and the set Leak Comp value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Leak Comp value is set and **Leak Comp** is displayed.

   Range: **L. Comp On** or **L. Comp Off**

NOTE

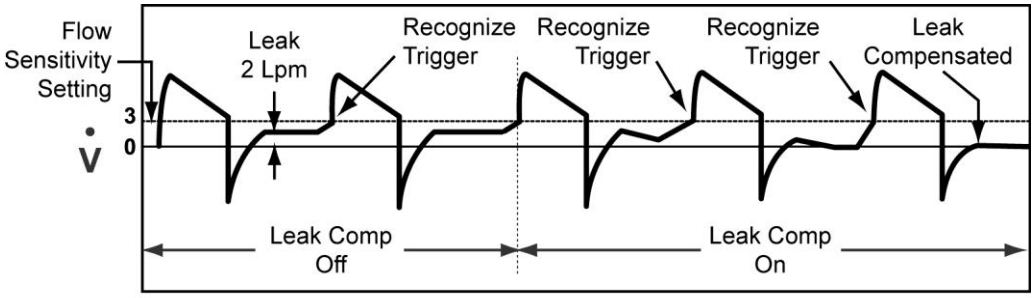
- **Leak Stability** - If a leak is unstable during exhalation, it will not be detected and will not be compensated for
- **Expiratory Limb Leak –** A leak on the expiratory limb may not be detected and may not be compensated for depending on the size of leak
- **Limitation of Compensation** - The limitation of compensation is determined by the range and accuracy of the Measured Leak (**Leak**) monitor and the set Bias Flow

When set to **L. Comp On**, the following measurements are compensated:

- Flow Triggering
- Exhaled Tidal Volume Monitor (**Vte**)
- Spontaneous Exhaled Tidal Volume Monitor (**SpVte**)
- Inspiratory Tidal Volume Monitor (**Vti**)
- Delivered Bias Flow (leaks up to 30 lpm)

If auto-cycling occurs, it may be helped by the following procedure:

1) Set flow **Sensitivity** to a value higher than the leak amount (see *Sensitivity* in Chapter 5 - Controls).
2) Set **Leak Comp** to **L. Comp On.**
3) Wait for a period of 10 through 15 breaths.
4) Reset flow **Sensitivity** to desired level.



Leak Compensation - Off to On

Pres Trigger (Pressure Trigger)

The **Pres Trigger** (Pressure Trigger) menu is used to set the pressure threshold level to allow the patient to trigger breaths.

A pressure trigger occurs when:

- The **Sensitivity** control is set to **P** (pressure triggering enabled)
- The ventilator is in exhalation phase
- The minimum exhalation time has expired, and
- The airway pressure drops below or is equal to the **Pres Trigger** setting

A backup breath is delivered when:

- The ventilator is in exhalation phase
- The minimum exhalation time has expired, and
- The airway pressure drops below -3 cmH_2O

NOTE

When a patient demand is detected, the **Patient Effort** indicator LED on the front panel is briefly illuminated.

1) Rotate the **Scroll** knob until **Pres Trigger** is displayed, push the **Select** button and the set Pres Trigger value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Pres Trigger value is set and **Pres Trigger** is displayed.

   Range: **1** through **20 cmH_2O** below PEEP in increments of 1

⚠ WARNING

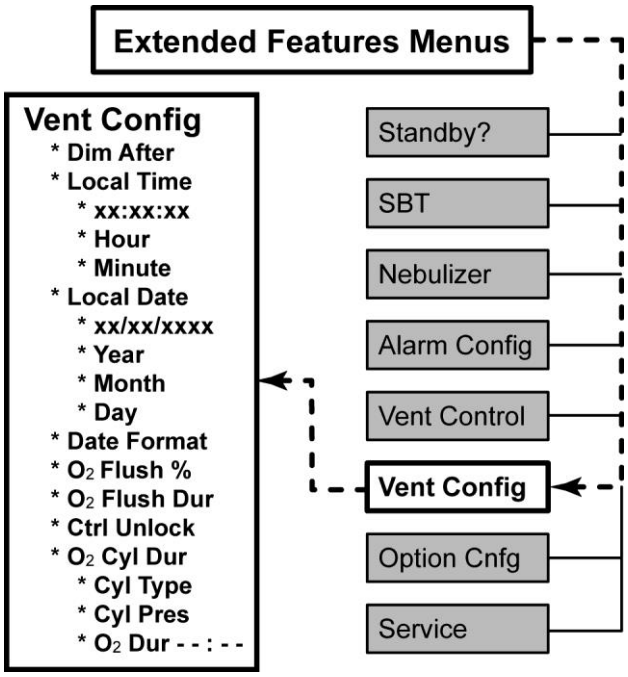
When using the ventilator in transport situations, excessive movement of the patient circuit may cause auto cycling. To reduce the possibility of auto cycling during transport, reduce the Sensitivity setting (by increasing Flow Trigger) or consider utilizing pressure triggering ("**P**").

NOTE

When pressure triggering is enabled, always set the **Low PEEP** alarm limit above the Pressure Trigger setting to ensure proper Low PEEP alarm functionality.

Vent Config (Ventilator Configuration)

The **Vent Config** (Ventilator Configuration) menus are used to configure ventilator controls that are not available on the front panel.



To Use the Vent Config Menus

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Vent Config** is displayed, push the **Select** button and **Dim After** is displayed.

Dim After

The **Dim After** menu is used to conserve battery power by allowing operators to disable or enable display dimming and to set the time after which the illuminated front panel displays will be automatically extinguished.

When the ventilator is operating on power from the Removable Battery Pack or Transition Battery and the set display dimming time expires, the illuminated displays and indicators are extinguished, with the following exceptions:

- All alarm messages
- **Airway Pressure** display
- **On/Off** indicator
- **Battery Pack** indicator (when applicable)
- **Battery Charge**r indicator (when applicable)
- **Transition Batt.** indicator (when applicable)

1) Rotate the **Scroll** knob until **Dim After** is displayed, push the **Select** button and the set Dim After value is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Dim After value is set and **Dim After** is displayed.

   Range: **Dim 1** through **Dim 60 min** in increments of 1, or **Never**

Pushing any control button, rotating the **Scroll** knob, or ventilator qualification of an external power source restarts the display dimming time period and returns the displays to their normal brightness.

Local Time

The **Local Time** menu is used to view or set the local time displayed by the ventilator.

To View the Local Time

Rotate the **Scroll** knob until **Local Time** is displayed, push the **Select** button and the local time is displayed **HH:MM:SS** (if previously set) or, **- - : - - : - -** (if not previously set).

> **NOTE**
>
> Until the Local Date and Local Time control values are set differently, the ventilator date-time tags and displays recordable events in the Events Log using factory-set date and time GMT[39] values (see *Event Trace* later in this chapter for additional information).
>
> - When the date and time control values are set to local date and time values, the Event Trace and Time Setting displays GMT values in the event log as a correction factor between the ventilator's internal clock and the user selected local time
> - The ventilator's internal clock does not automatically compensate for Daylight Savings Time (DST) and must be reset accordingly, if desired

[39] GMT – Greenwich Mean Time

To Change the Local Time Settings

1) Access the **Local Time** menu as described above.
2) When the local time is displayed, rotate the **Scroll** knob until **Hour** is displayed, push the **Select** button and the set Hour is displayed.
3) Rotate the **Scroll** knob until the desired Hour value is displayed, push the **Select** button, the new Hour value is set and **Hour** is displayed.

   Range: **0** through **23** in increments of 1
4) Rotate the **Scroll** knob until **Minute** is displayed, push the **Select** button and the set Minute value is displayed.
5) Rotate the **Scroll** knob until the desired Minute value is displayed, push the **Select** button, the new Minute value is set (seconds are automatically set to **00**) and **Minute** is displayed.

   Range: **0** through **59** in increments of 1

Local Date

The **Local Date** menu is used to view or set the local date displayed by the ventilator.

To View the Local Date

Rotate the **Scroll** knob until **Local Date** is displayed, push the **Select** button and the Local Date value is displayed in one of the following date formats:

MM/DD/YYYY, YYYY/MM/DD or **DD/MM/YYYY**

To Change the Local Date Settings

1) Access the **Local Date** menu as described above.
2) When the currently selected Local Date format is displayed, rotate the **Scroll** knob until **Year** is displayed, push the **Select** button and the set year is displayed.
3) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new year is set and **Year** is displayed.

   Range**:** **2004** through **2056** in increments of 1
4) Rotate the **Scroll** knob until **Month** is displayed, push the **Select** button and the set Month is displayed.
5) Rotate the **Scroll** knob until the desired Month is displayed, push the **Select** button, the new Month is set and **Month** is displayed.

   Range: 1 through 12 in increments of 1
6) Rotate the **Scroll** knob until **Day** is displayed, push the **Select** button and the set Day is displayed.
7) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new day is set and **Day** is displayed.

   Range: 1 through 31 in increments of 1

Date Format

The **Date Format** menu is used to view or set the display format for the current date.

To View the Date Format

Rotate the **Scroll** knob until **Date Format** is displayed, push the **Select** button and the set Date Format is displayed.

To Change the Date Format Settings

1) Rotate the **Scroll** knob until **Date Format** is displayed, push the **Select** button and the set Date Format is displayed.
2) Rotate the **Scroll** knob until the desired value is displayed, push the **Select** button, the new Date Format is set and **Date Format** is displayed.

   Range**:** **MM/DD/YYYY, YYYY/MM/DD** or **DD/MM/YYYY**

O_2 Flush % (O_2 Flush Percentage)

The **O_2 Flush %** menu is used to set the "increased" percentage of oxygen (above the current **O_2** control setting) to be delivered to the patient during the set duration of time when the O_2 Flush procedure is initiated. For example:

- A +50% **O_2 Flush %** menu setting combined with a 21% **O_2** control setting would result in 71% oxygen being delivered to the patient during the set duration of time
- A +50% **O_2 Flush %** control setting combined with a 40% **O_2** control setting would result in 90% oxygen being delivered to the patient during the set duration of time
- Any combination of **O_2 Flush %** and **O_2** control settings that exceed 100% would result in 100% oxygen being delivered to the patient during the set duration of time

See *O2 Flush* in Chapter 9 – Maneuvers and Procedures for detailed information about the O_2 Flush procedure.

1) Rotate the **Scroll** knob until **O_2 Flush %** is displayed, push **Selec**t and the set O_2 Flush % value is displayed.
2) Rotate the **Scroll** knob until the desired O_2 Flush % value is displayed, push the **Select** button, the new O_2 Flush % value is set and **O_2 Flush %** is displayed.

   Range: **+0** through **+79 %** in increments of 1

O_2 Flush Dur (O_2 Flush Duration)

The **O_2 Flush Dur** (O_2 Flush Duration) menu is used to set the duration of time for which an elevated percentage of oxygen is delivered to the patient when the O_2 Flush procedure is initiated. See *O2 Flush* in Chapter 9 – Maneuvers and Procedures for detailed information about the O_2 Flush procedure.

1) Rotate the **Scroll** knob until **O_2 Flush Dur** is displayed, push **Selec**t and the set O_2 Flush Dur value is displayed.
2) Rotate the **Scroll** knob until the desired O_2 Flush Dur value is displayed, push the **Select** button, the new O_2 Flush Dur value is set and **O_2 Flush Dur** is displayed.

   Range: **2** through **3 min** in increments of 1

Ctrl Unlock (Control Unlock)

The **Ctrl Unlock** (Control Unlock) menu is used to set the degree of difficulty for control unlocking*. See Control Lock* in Chapter 5 – Controls for additional information.

1) Rotate the **Scroll** knob until **Ctrl Unlock** is displayed, push the **Select** button and the set Ctrl Unlock value is displayed.
2) Rotate the **Scroll** knob until the desired Ctrl Unlock value is displayed, push the **Select** button, the new Ctrl Unlock value is set and **Ctrl Unlock** is displayed.

   Range: **Easy** or **Hard**

O_2 Cyl Dur (O_2 Cylinder Duration)

The **O_2 Cyl Dur** (O_2 Cylinder Duration) menus are used by an operator to enter data used by the ventilator to perform a calculation (based on current ventilation and O_2 settings) and display the approximate remaining usable time (in hours and minutes) of an external O_2 cylinder.

> **⚠ WARNING**
>
> **O_2 Cylinder Duration Accuracy** - The accuracy of the displayed useable amount of oxygen remaining in an external O_2 cylinder is dependent on the precision of the pressure gauge used on the O_2 cylinder and the accuracy of the information provided by the operator. The results of the calculation should be used for reference only.
>
> **Ventilation Variables and O_2 Consumption** - Variations in the patient's minute ventilation, I:E ratio and/or ventilator setting changes or equipment status (i.e. circuit leaks) affect the consumption rate of oxygen. When warranted by a patient's condition, a backup cylinder or alternative source of oxygen should be available at all times.

To Calculate the O_2 Cylinder Duration

1) Rotate the **Scroll** knob until **O_2 Cyl Dur** is displayed, push the **Select** button and **Cyl Type** is displayed.
2) Push the **Select** button while **Cyl Type** is displayed and the currently set cylinder type is displayed (in compressed liters, **xxxx L**).
3) Rotate the **Scroll** knob until the correct cylinder type is displayed (volume in compressed Liters), push the **Select** button, the new cylinder type is set and **Cyl Type** is displayed.

   Range: **75** through **9,900 L** in increments of 1

   This setting is retained by the ventilator (through shut downs and power ups) until re-set by an operator and used to calculate the remaining oxygen.
4) Rotate the **Scroll** knob until **Cyl Pres** is displayed, push the **Select** button and "**- - - -**" is displayed. Rotate the **Scroll** knob until the correct cylinder pressure is displayed, push the **Select** button, the new cylinder pressure value is set and **Cyl Pres** is displayed.

   Range: **100** through **2300 PSI** in increments of 25 (**5** through **150 BAR** or **500** through **15000 kPa**), or "**- -**" (off)

To View the Calculated O_2 Cylinder Duration

When the cylinder pressure is entered and set, the ventilator uses the current ventilation values and settings to calculate and display the remaining usable time of the external O_2 cylinder specified.

NOTE

To obtain an accurate duration time estimate, the current cylinder pressure must be entered prior to each calculation. The O_2 Cylinder Pressure (**Cyl Pres**) menu setting reverts to "**- - - -**" one minute after a value is entered.

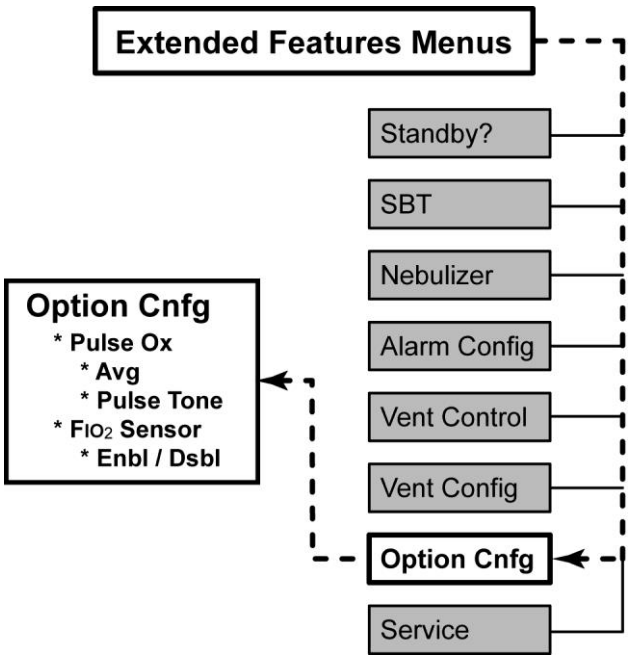
1) To view the calculated O_2 duration in hours and minutes, rotate the **Scroll** knob until **O_2 Dur HH:MM** is displayed. The calculated O_2 duration is displayed for 60 seconds, or until the message is acknowledged by pushing the **Select** or **Exit** button, or by rotating the **Scroll** knob on the lower interface panel.

   Range: **O_2 Dur 00:00** through **99:59 HH:MM**

   If the **Cyl Pres** setting has reverted to "- - - -", **O_2 Dur - - : - -** is displayed

Option Cnfg (Option Configuration)

The **Option Cnfg** (Option Configuration) menus are used to enable, disable, and configure control values for ventilator options that are not directly available on the front panel.



To Use the Option Cnfg Menus

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Option Cnfg** is displayed, push the **Select** button and **Pulse Ox** is displayed.

Pulse Ox (Pulse Oximetry)

The **Pulse Ox** (Pulse Oximetry) menus are used to set Pulse Oximetry monitoring averaging and pulse tone volume configuration values. See *Pulse Oximetry (SpO2)* in Chapter 2 – Installation and Setup for additional information

Avg (Average)

The **Avg** (Average) menu is used to set the averaging calculation used by the SpO_2 Module to display readings (i.e. display reading for each pulse beat, fast average, average of 4 pulse beats, or average of 8 pulse beats).

1) Push the **Select** button when **Pulse Ox** is displayed and **Avg** is displayed. Push the **Select** button again and the set Avg configuration is displayed.
2) Rotate the **Scroll** knob until the desired Avg configuration is displayed, push the **Select** button, the new Avg configuration is set and **Avg** is displayed.

   Range**:** **B-B**, **Fast**, **4-Beat**, or **8-Beat**

Pulse Tone

The Pulse Tone menu is used to set the audible volume level of the SpO_2 Pulse Tone. The tone is only active when a Pulse Oximetry Module is connected to the ventilator, enabled and a sensor is attached to a patient. The SpO_2 Pulse Tone is an informational only alert; see *Sound Types, Patterns and Volumes* and *Alerts, Audible* in Chapter 8 – Ventilator Alarms for additional information.

1) Push the **Select** button when **Pulse Ox** is displayed and **Avg** is displayed. Rotate the **Scroll** knob until **Pulse Tone** is displayed, push the **Select** button again and the set Pulse Tone value is displayed.
2) Rotate the **Scroll** knob until the desired Pulse Tone value is displayed, push the **Select** button, the new Pulse Tone value is set and **Pulse Tone** is displayed.

   Range**:** **Vol 1** or **Vol 2,** or **Off**

FIO_2 Sensor

The **FIO_2 Sensor** sub-menu **Enbl / Dsbl** (Enable / Disable) is used to enable or disable ventilator communication with an FIO_2 Sensor during normal ventilation modes (no need to disconnect the patient or restart the ventilator).

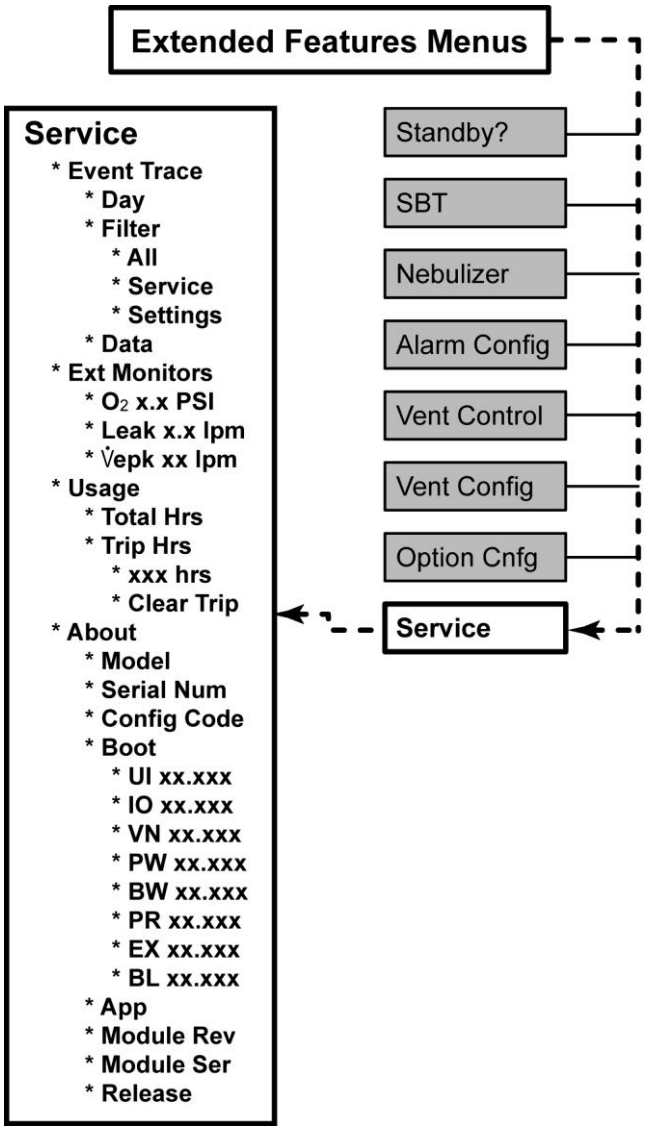
1) Rotate the **Scroll** knob until **FIO_2 Sensor** is displayed, push the **Select** button and **Enbl / Dsbl** is displayed.
2) Push the **Select** button again and the set Enbl / Dsbl status is displayed.
3) Rotate the **Scroll** knob until the desired Enbl / Dsbl status is displayed, push the **Select** button, the new Enbl / Dsbl status is set and **Enbl / Dsbl** is displayed.

   Range**:** **Enable** or **Disable**

To enable/disable or calibrate the FIO_2 sensor in Startup mode, Vent Check menus, see *FIO2 Sensor Configuration and Calibration* in Chapter 3 – Using the Ventilator.

Service

The **Service** menus are used to view various types of ventilator operation related information or data that is not directly available on the front panel.



To Use the Service Menus

Enter the Extended Features menus from a normal mode of ventilation; rotate the **Scroll** knob until **Service** is displayed, push the **Select** button and **Event Trace** is displayed. Rotate the **Scroll** Knob to the desired menu item and push the **Select** button.

Event Trace

The ReVel ventilator retains an Event Log in non-volatile memory. The Event Log is a list of events recorded by the ventilator. These events may be normal conditions, such as ventilation settings, turning the ventilator on or off, or alarm conditions such as Hardware Fault (**HW Faultxxx**) or High Airway Pressure (**High Pres**).

The Event Log is circular (i.e. the oldest record is displaced by the latest) and can contain at least 300,000 entries.

Types of events logged by the ventilator:

- Ventilator power on and software version
- Ventilator power off
- Preset menu selections
- Patient ID information
- Test execution and results
    - Circuit Test results
    - Button Test accessed
- F_{IO_2} calibration start and results
- Battery Check performed
- Display Alarm Check performed
- Ventilator configuration changes
- Ventilation control changes
- Alarm control changes
- Safety Valve activation / deactivation
- Alarm detections
- Alarm recoveries
- Alarm resets by user
- Alarm silence period activated / deactivated by user
- The start and end of any Maneuver or Procedure
- Manual Breaths initiated

Upon starting ventilation and every 24 hours of continuous operation the ventilator logs all control and alarm settings.

NOTE

Event log entries are only one of many diagnostic tools used to troubleshoot the ventilator. Additional information is often required to accurately identify the root cause of a problem. See *Chapter 13 - Troubleshooting* for more information.

The Event Trace data may be viewed by selecting the following options in the Event Trace menu:

- **Day** — Select a specific day to view the last event for the specified day and use the **Scroll** knob to view events that day and events leading up to that day
- **Filter** — Select **Service** to view events related to service / technical related events and conditions, alarms and alarm related events (e.g. hardware faults), and battery changes

  Select **Settings** to view events related to mode or breath rate changes, any settings changes, all settings upon completion of POST, and all settings logged every 24 hours of continuous operation

  Select **All** to view events including maneuvers, procedures, standby mode, service events, and settings events
- **Data** — Select **Data** to view the event trace information based on the **Day** and **Filter** settings

To view the Event Trace

1) Rotate the **Scroll** knob until **Event Trace** is displayed, push the **Select** button and **Day** is displayed.
2) Push the **Select** button and the current date is displayed, rotate the **Scroll** knob to the desired date and push **Select**. **Day** is displayed.
3) Rotate the **Scroll** knob until **Filter** is displayed, push the **Select** button and rotate the **Scroll** knob to the desired filter (**Service**, **Settings**, or **All**) and push the **Select** button. **Filter** is displayed.
4) Rotate the **Scroll** knob until **Data** is displayed and push the **Select** button. Event names are displayed in the Display Window. Event date/time of occurrence and the event number are displayed in the Controls Window.

NOTE

Until the Local Date and Local Time control values are set differently, the ventilator date-time tags and displays recordable events in the Events Log using factory-set date and time GMT[40] values (see *Local Time* and *Local Date* earlier in this chapter for additional information).

- When the date and time control values are set to local date and time values, the Event Trace and Time Setting displays GMT values in the event log as a correction factor between the ventilator's internal clock and the user selected local time

[40] GMT – Greenwich Mean Time

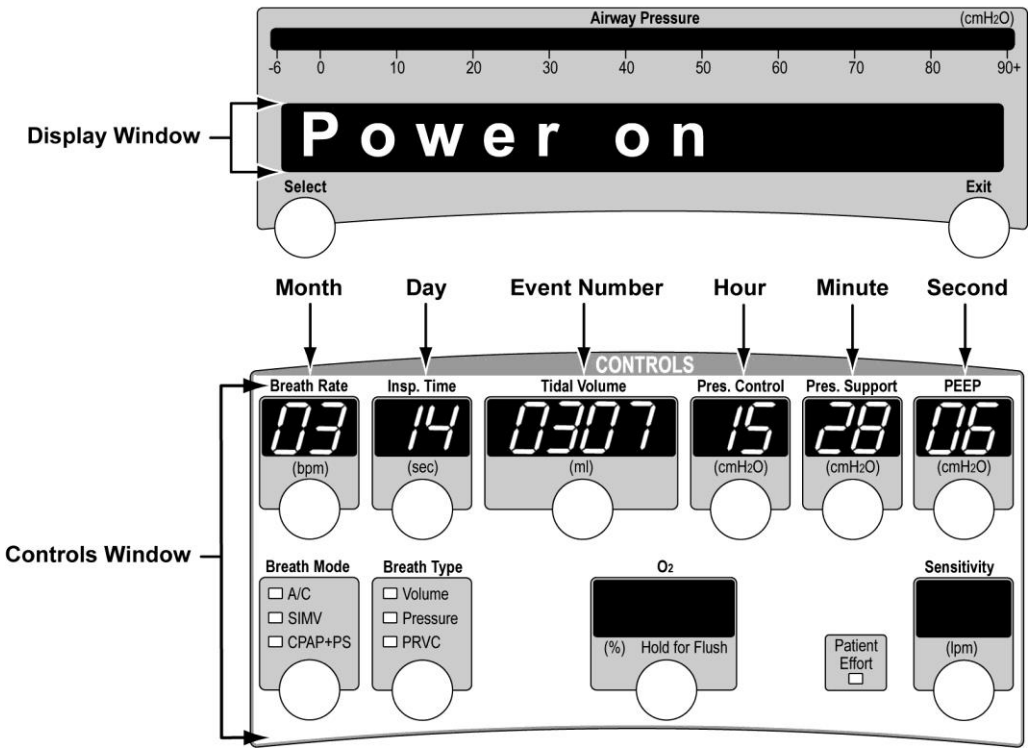
Event Trace data is displayed by the name of event, the date/time of occurrence, and the event number.

The event number (displayed in the Tidal Volume control window) is the event number of that day. Example: If the ventilator was powered off with 305 occurrences of events that day, the Power off event number would be logged as 0306. If the ventilator is turned on during the same day, the Power on Event Number would be logged as 0307 (the 307th event of that day).

Pushing the **Select** button while an Event is displayed will cycle each information window (Display Window and Controls Window) from dim to bright (inactive to active).

- When the text in the Display Window is bright and the numbers in the Controls Window are dim, rotate the **Scroll** knob to view additional event information in the Display Window (e.g. specific event settings, control values, etc.)
- When the text in the Display Window is dim and the numbers in the Controls Window are bright, rotate the **Scroll** knob to cycle through all events based on the **Filter** setting

Event Trace Display



NOTE

The **O_2** and **Sensitivity** control windows are blank when the event trace data is viewed.

Ext Monitors (Extended Monitors)

The **Ext Monitors** (Extended Monitors) menus are used to view O_2 Source Pressure, Measured Patient Circuit Leak, and Measured Peak Expiratory Flow monitored data.

Rotate the **Scroll** knob until **Ext Monitors** is displayed, push the **Select** button and rotate the **Scroll** knob to scroll through and display the available monitored data.

- **O_2 X.X PSI** O_2 Source Pressure measured at the O_2 Inlet
- **Leak XX.X lpm** Measured Leak is a measure of the steady state flow through the patient circuit Wye toward the patient during exhalation
- **Vepk XXX lpm** Peak Expiratory Flow of the previous breath, measured at the patient Wye

Usage

The **Usage** menus are used to:

- View the total hours the ventilator has been in use
- View the accumulated hours the ventilator has been in use since the last time the Usage data was cleared
- Clear (reset to 0.0 Hrs) the current **Trip Hours** reading

To View the Total or Trip Hours

1) Rotate the **Scroll** knob until **Usage** is displayed, push the **Select** button and **Total Hrs** is displayed.
2) Push the **Select** button to view the total hours the ventilator has been in use (**xxx hrs**)

   OR

   Rotate the **Scroll** knob until **Trip Hrs** is displayed and push the **Select** button to display the accumulated hours the ventilator has been in use since the last time the Usage data was cleared (**xxx hrs**).

To Clear the Trip Hours

1) Rotate the **Scroll** knob while viewing the Trip Hours data (**xxx hrs**) and **Clear Trip** is displayed.
2) Push the **Select** button, the accumulated Trip Hours data is reset (**0.0 hrs**) and **Cleared** is displayed.

About

The **About** menus are used to view specific ventilator configuration information, such as:

- Device Information (model name or part number, serial number, configuration code)
- Component(s) Information (name, boot and application software versions, hardware revisions, serial numbers)

To View the About Sub-Menus and Related Data

1) Rotate the **Scroll** knob until **About** is displayed, push the **Select** button and **Model** is displayed.
2) Push the **Select** button and the ventilator model name is displayed.
3) To view the remaining sub-menus and related data, push the **Exit** button to return to the previously displayed menu, rotate the **Scroll** knob until the desired sub-menu is displayed, push the **Select** button and the related data is displayed:
    - **Model**
    - **Serial Num**
    - **Config Code**
    - **App**
    - **Module Rev**
    - **Module Ser**
    - **Release**
4) Rotate the **Scroll** knob to view additional related data (if any) and push the **Exit** button to return to the previously displayed menu.
5) Continue using the **Scroll** knob, **Select** and **Exit** buttons to locate, view and exit the desired menus and related data.

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Chapter 11 - MAINTENANCE AND CLEANING

Maintenance Schedule

Routine Maintenance

The ReVel ventilator is designed to operate for extended periods of time with minimal routine maintenance. The following periodic maintenance is recommended:

Length of Service[41]	Maintenance Required
In storage	• Charge and remove the Removable Battery Pack from the ventilator prior to storage. For minimum aging of the Removable Battery Pack while in storage, store it with approximately 40% charge. Every six months, verify charge of Removable Battery is above 20% and recharge if necessary • Every two months, recharge the Transition Battery[42] by powering the ventilator from an AC power source for at least 5 hours
Prior to initial use	• Charge the Removable Battery Pack and Transition Battery by powering the ventilator from an AC power source for at least 13 hours • Setup the ventilator/accessories as shown in *Chapter 2 - Installation and Setup* • Check the ventilator for proper operation as detailed in *Ventilator* Testing in Chapter 2 – Installation and Setup
Daily	• Verify alarms are functioning properly • Check the Air Inlet Filter, replace if soiled • Check the Cooling Fan Filter, clean if necessary, replace if damaged or worn
When changing or reconfiguring the patient circuit	• Check the Exhalation Valve Diaphragm, clean if necessary, replace if damaged or worn • Perform the *Circuit Test* as detailed in Chapter 2 – Installation and Testing

If in use, a minimum of once a month	Perform the tests as detailed in *Ventilator* Testing in Chapter 2 – Installation and Setup.
	Alternatively, to retain patient settings, do the following:
	• While the ventilator is off patient, perform the:
	  • Button Test
	  • Vent Inop Alarm Test
	  • External power disconnect test
	  • Disconnect external power and Removable Battery Pack test
	• Verify the Vte or VE monitor
	• Verify the Airway Pressure or PIP monitor
	• Verify the delivered O_2 concentration, if not using an oxygen analyzer continuously

[41] To check the number of hours the ventilator has been in service, see *Usage* in Chapter 10 – Extended Features.
[42] The **Vent Inop** alarm will sound if the Transition Battery charge becomes completely depleted while in storage.

Extended Maintenance

Length of Service[43]	Maintenance Required
Every 15,000 hours or three years[44], whichever comes first	• Replace the Cooling Fan Filter • Replace the Air Inlet Filter and Screen • Replace the O_2 Inlet Filter • Replace the Blower Inlet Filter • Perform all Functional and Final Checkout Tests specified in the PTV Series Ventilators Service Manual
Every 30,000 hours or six years[44], whichever comes first	• Perform 15,000 hours / 3 years Extended Maintenance • Replace the Flow Sensor Filter • Replace the Transition Battery • Perform all Functional and Final Checkout Tests specified in the PTV Series Ventilators Service Manual

Extreme Environments

This schedule of maintenance is typical for most clinical or home settings. In some cases, however, environmental conditions may dictate that maintenance procedures are performed more frequently. Check with Vyaire if your ventilator is likely to be subject to extreme conditions.

Battery Maintenance

To ensure that the Removable Battery Pack and the Transition Battery used with the ventilator remain charged and conditioned when the ventilator is not in use, follow the recommended care and maintenance instructions (see *Chapter 12 - Power Supplies and Batteries)*.

[43] To check the number of hours the ventilator has been in service, see *Usage* in Chapter 10 – Extended Features.

[44] 15,000 hour, three year and/or 30,000 hour, six year Extended Maintenance and ventilator repair must be performed by a Vyaire trained service technician.

Cleaning the Ventilator

> ⚠ **CAUTION**
>
> **Equipment Damage** – To avoid irreparable damage to the ventilator, do not attempt to sterilize it.
>
> **Damage to the Device from Liquids** - Do not immerse the ventilator in liquids. Do not pour or spray cleaning agents directly onto any part of the ventilator. Do not allow liquids to pool on the ventilator. Damage to the device can occur if moisture enters the interior of the ventilator.
>
> **Damage to Plastic Components** - To avoid damaging the ventilator's plastic components and front panels, do not use cleaning agents containing ammonium chloride, other chloride compounds, more than 2% glutaraldehyde, phenols, or abrasive cleaners.

Surface Cleaning

Wipe the exterior surfaces of the ventilator with one of the following products using a clean, soft cloth. Never spray products directly onto the ventilator, only onto a cleaning cloth. Be sure to wipe away any residual cleaner.

Clean all ventilator external surfaces before and after each patient use, and as otherwise indicated.

Cleaning Product	Cleaning Method
Isopropyl alcohol	90% solution
White vinegar	Dilute to 50% with cold tap water
Control III™	As labeled by manufacturer, Maril Products, Inc.

Cleaning/Disinfecting/Sterilizing Reusable Patient Circuits

Before cleaning reusable patient circuits, detach the circuit from the ventilator (see *Patient Breathing Circuits* in Chapter 2 – Installation and Setup for detailed instructions) and disassemble all circuit components (see Instructions For Use provided with your circuit).

NOTE

Various optional accessories (humidifiers, water traps, etc.) are available from Vyaire for use with PTV Series patient circuits. For information refer to the manufacturer's instructions included with each accessory.

Detaching the Patient Circuit from the Ventilator

1) Hold the patient circuit hoses by the molded rubber end and pull straight out to detach, do not pull on the hoses.
2) Twist to detach the sense line Luer fittings at the ventilator.

Cleaning Patient Circuits

⚠ WARNING

Risk of Patient Infection – To avoid the risk of infection, reusable patient circuits and accessories should be cleaned before reuse. Refer to the detailed cleaning Instructions provided with your patient circuit. For humidifiers, filters or other patient circuit accessories, follow the manufacturer's recommended cleaning instructions.

In order to prevent cross-contamination, bacteria filters should be used between the patient and components in the pneumatic pathway that cannot be disinfected between patients (e.g. F_{iO_2} sensors).

To clean, disinfect or sterilize reusable patient circuits used with your ventilator, follow the detailed instructions included with your particular circuit type.

Reassembling the Patient Circuits

Reassemble the patient circuits per the exploded diagrams provided in the Instructions for Use included with your circuit. Install the patient Wye and proximal Sense Lines in the patient circuit so the proximal Sense Lines are oriented upwards while operating.

Filter Cleaning and Replacement

The Oxygen Inlet Filter

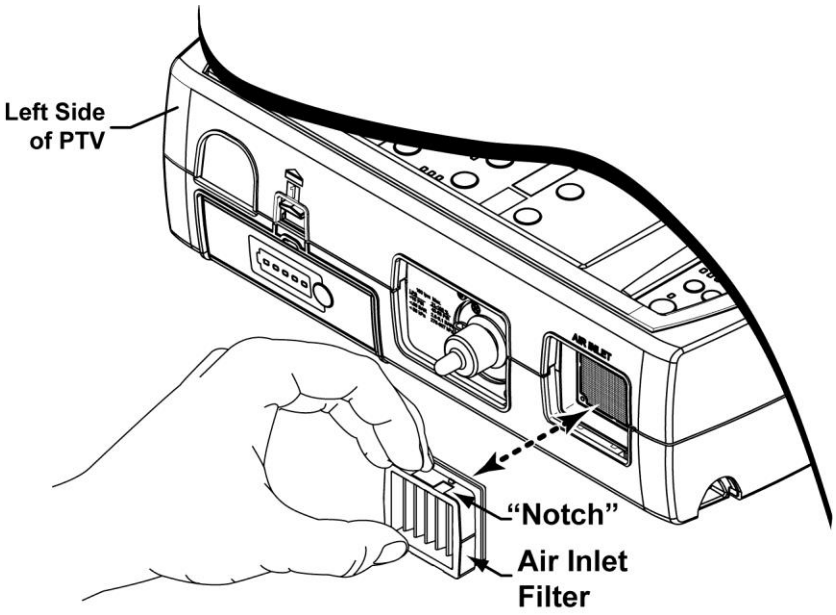
The ventilator has a small “cone” filter which is an integral part of the Oxygen inlet connector. This Oxygen Inlet Filter should be replaced by a service technician trained and certified by Vyaire as part of your regularly scheduled maintenance.

The Air Inlet Filter

Check the Air Inlet Filter daily and replace when soiled, worn or damaged. See in *Replacement Parts* in Appendix C – Reference Information for replacement part numbers and *Appendix A - Contact Information* for ordering information.

To Remove the Air Inlet Filter

1) Gently remove the worn or soiled filter as shown. Discard the old filter.



To Replace the Air Inlet Filter

Position the new Air Inlet Filter as shown in the illustration (notches in the filter frame oriented up/down and away from ventilator) and push it fully into the filter housing opening, up against the screen.

> **⚠ CAUTION**
>
> **Damaging the Air Inlet Filter** – To avoid damaging the Air Inlet Filter, hold and install it by grasping the outer rubber frame. Do not push on the pleated filter material.

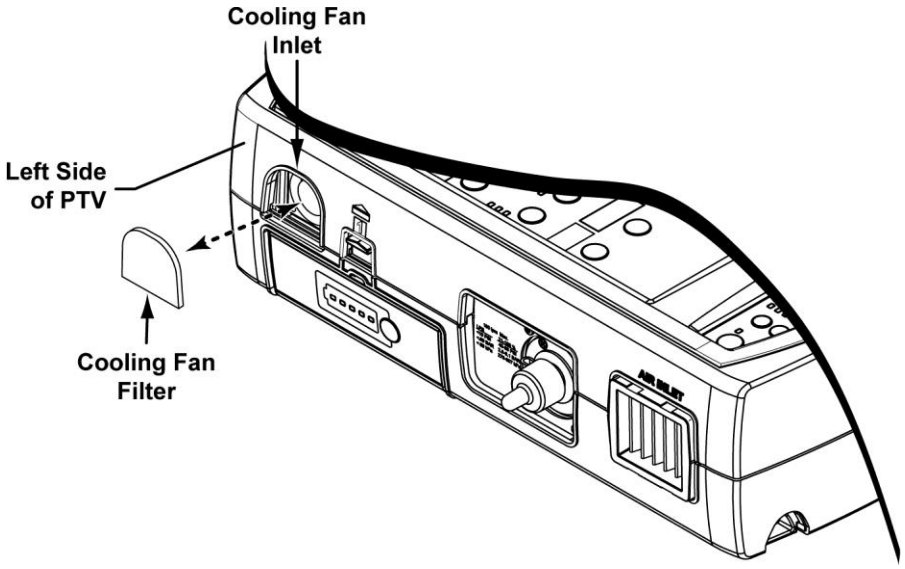
The Cooling Fan Filter

Check the cooling fan filter daily. Clean as detailed below and replace when worn or excessively soiled.

> **⚠ CAUTION**
>
> **Keep Filter Clean and Unobstructed** – The Cooling Fan Filter must be kept clean and unobstructed. Failure to do so can result in a dangerous buildup of oxygen and/or damage to the ventilator due to overheating.

To Remove the Cooling Fan Filter

1) To extract the Cooling Fan Filter, gently pinch the foam between thumb and forefinger and remove from the filter housing.
2) Examine the filter for wear or damage. Replace if necessary.



To Clean the Cooling Fan Filter

1) Gently bathe the filter in a solution of mild detergent and warm water.
2) Rinse thoroughly in clean water.
3) Examine the filter for excessive wear or damage (discard and replace when necessary) and allow it to air dry before reinstallation. See *Replacement Parts* in Appendix C – Reference Information for replacement part numbers and *Appendix A - Contact Information* for ordering information.

> **⚠ CAUTION**
>
> **Wet or Damp Filters** - Do not install a wet or damp filter into the ventilator. This could damage the ventilator.

To Replace the Cooling Fan Filter

Position the filter as shown in the previous illustration, fully insert it into the filter housing and tuck it behind each of the four retaining tabs (top, bottom and sides).

Chapter 12 - POWER SUPPLIES AND BATTERIES

The ventilator operates on Direct Current (DC; 11 to 16 VDC). The following power sources are available to operate the ventilator:

- AC Adapter
- Automobile Adapter
- Docking Station
- Removable Battery Pack
- Transition Battery
- PTV Vent-side Pigtail Cable Extension

NOTE

While the ventilator is connected to any valid source of external power, the Removable Battery Pack and Transition Batteries are charged.

To Connect External Power (other than a Docking Station)

⚠ WARNING

Risk of Electrical Shock - To avoid the risk of an electrical shock or ventilator damage;

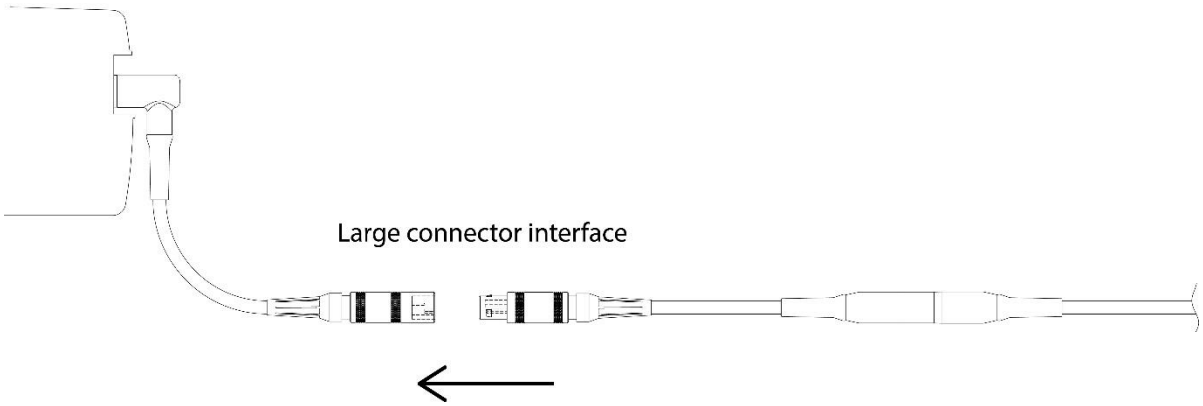
- Use only batteries, adapters, cables or external power supplies recommended by Vyaire
- Do not use batteries, adapters, cables or external power supplies with visible signs of damage
- Do not touch internal components
- Refer all servicing or repairs to Vyaire or a service technician certified by Vyaire

NOTE

When using the PTV Series Ventilators in combination with a Docking Station, Vyaire recommends connecting external power only to the Docking Station (the Docking Station in turn provides power to the ventilator).

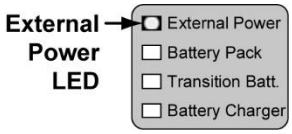
Either the optional AC Adapter or the Automobile Adapter is connected to the ventilator as follows:

1) Insert the large connector on the end of the AC adapter (13881-001) cable into the large mating connector on the end of the vent-side pigtail cable extension (24841-001) by aligning the internal half-moon keys as shown below.



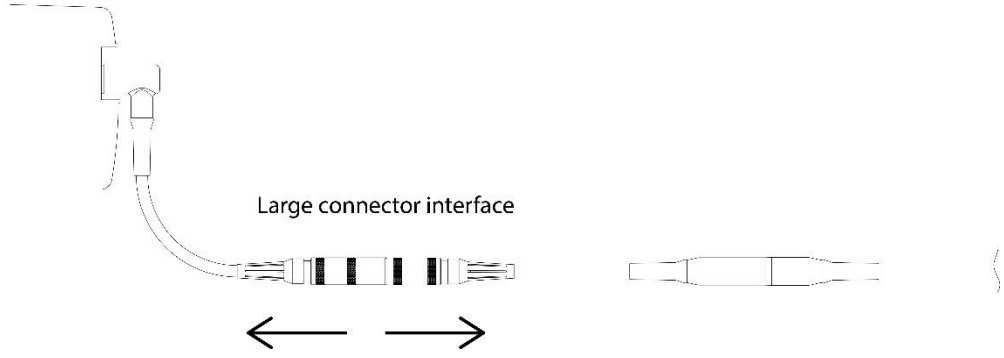
2) Connect the external power cable to a valid external power source.

3) Verify the **External Power** LED on the lower interface panel illuminates green. If not, recheck the power supply.



To Disconnect External Power

Grip the outer metal shells and pull apart the large mating connectors as shown below.



⚠ CAUTION

The vent-side pigtail cable extension is permanently attached to the ventilator and cannot be disconnected.

AC Adapter (Option)

The ventilator can be powered from a properly grounded AC supply using the AC Adapter. For complete connection and care instructions see the Instructions For Use supplied with your adapter.

Automobile Adapter (Option)

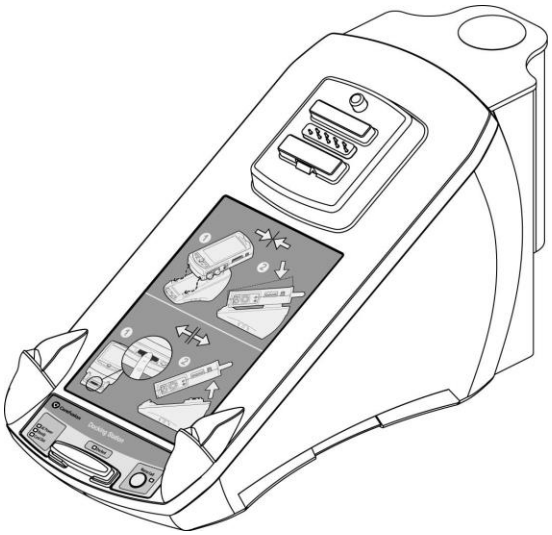
An optional adapter is available to power the ventilator while operating in an automobile. This adapter is designed to connect to a factory installed +12Volt - 20 Amp auxiliary power outlet or automobile cigarette lighter capable of supplying at least 20 amperes of current. The use of third-party-installed automobile cigarette lighter-style power outlets to power the ventilator is not recommended.

> ⚠ **WARNING**
>
> **Power Surges** - Do not operate the ventilator from an automobile power outlet or cigarette lighter while starting or jump starting the automobile. The resulting power fluctuations may cause damage to the ventilator and cause it to stop functioning.

See the Instructions For Use accompanying your Automobile Adapter for detailed care and usage information.

Docking Station (Option)

The ReVel ventilator can be powered directly from the Docking Station via the custom interface connection. Refer to the PTV Series Docking Station Operator's Manual, P/N 33870-001 for information and instructions.



NOTE

Docking a PTV Series Ventilator to a Docking Station which is not connected to a valid source of external power (or is switched off), will result in the ventilator continuing to run on internal battery power (Removable Battery Pack or Transition Battery, as applicable).

When using PTV Series Ventilators in combination with a Docking Station, Vyaire recommends connecting external power to the Docking Station only (the Docking Station in turn provides power to the ventilator) and confirming that external power is being supplied to the ventilator (**External Power** LED on the ventilators' lower interface panel is illuminated).

Removable Battery Pack

The ReVel ventilator uses a rechargeable lithium-ion Removable Battery Pack which is supplied with the ventilator. The Removable Battery Pack is exchangeable while the ventilator is running. To install or remove the Removable Battery Pack, see *Power Connection* and *Removable Battery Pack Installation* in Chapter 2 – Installation and Setup for detailed instructions.

> **⚠ WARNING**
>
> **Risk of Fire, Chemical Burn or Explosion** - The battery used in this device may present a risk of fire or chemical burn if mistreated. Do not disassemble, heat above 60°C, or incinerate. Replace battery with Vyaire P/N 13908-001 only. Use of another battery, may present a risk of fire or explosion.

The ventilator can charge a discharged Removable Battery Pack when Docking Station power or external DC power is available. Once the Transition Battery is charged, the Removable Battery Pack can be >90% charged by a ventilator connected to external power within 8 hours, from fully discharged.

The length of time the ventilator will operate using the Removable Battery Pack is a function of many factors such as settings, charge level and condition or age of the battery. Using "Standard Test Settings" settings (see *Removable Battery Pack* in Appendix B – Specifications), a new battery will power the ventilator for more than four (4) hours, although actual run time may vary.

> **NOTE**
>
> Battery operating times may vary significantly based on user settings. Specifically, Pressure Control breaths with fast rise times, high Breath Rates and high Peak Flows will typically decrease battery life.
>
> Dimming illuminated displays when not in use helps to improve battery performance. See *Dim After* in the Extended Features, Vent Config menus in Chapter 10 – Extended Features for additional information and detailed instructions.

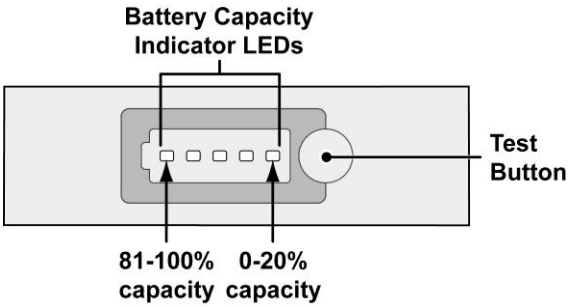
To Check the Level of Charge:

> **NOTE**
>
> To avoid an unexpected depletion of internal battery power, always check the Removable Battery Pack level of charge prior to disconnecting external power or operating the ventilator solely on the Removable Battery Pack (such as during transport situations).

There are two (2) methods for checking the remaining capacity of the Removable Battery Pack.

1) On the Removable Battery Pack there is a “Test” button which lights a series of 5 LEDs on the edge of the battery when pushed.

   Each Removable Battery Pack LED increments approximately 20% as shown.

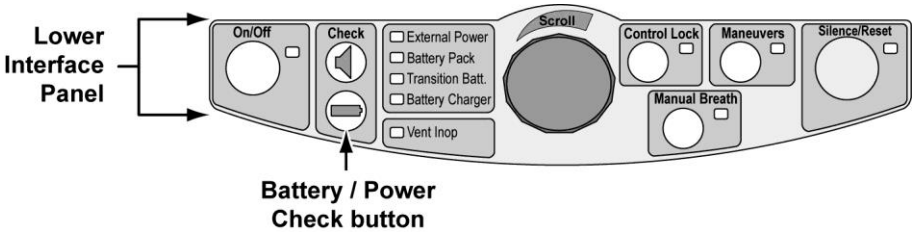


LEDs Lit	Approximate Charge Level
1	0-20%
2	21-40%
3	41-60%
4	61-80%
5	81-100%

   If the battery is being charged, the LED that is representative of the of the battery’s current charge level flashes while the test button is being pushed.

2) The ventilator monitors the power supplies connected to it. This data is displayed when the Battery/Power **Check** button is pushed.

   See *Battery/Power* in Chapter 5 – Controls for additional information.



NOTE

Battery Replacement - Capacity is measured as a percentage of the battery’s capacity when it was new. When a fully-charged battery does not display at least 50% capacity, the battery has reached the end of its useful life and it is time to replace that battery.

To Preserve Maximum Battery Life During Storage

1) Remove the Removable Battery Pack and store it separately, preferably with approximately a 40% charge.
2) After storage, it is advisable to condition the Removable Battery Pack prior to use using the Desktop Battery Charger.

⚠ CAUTION

Storage Temperature - Storing the ReVel ventilator at temperatures above 60°C (140°F) for long periods can cause battery duration to be reduced.

Transition Battery

The Transition Battery is an internal rechargeable lithium-ion battery which powers the ventilator while changing Removable Battery Packs or switching between external power sources.

When operating on power supplied by the Docking Station or other external source, the ventilator is able to fully recharge the Transition Battery within 5 hours. To avoid depleting the Removable Battery Pack, the Transition Battery is only partially charged by the ventilator when the Removable Battery Pack is the *only* source of power operating the ventilator.

⚠ WARNING

Reduced Flow/Pressure – To avoid possible harm to patients requiring a flow rate higher than 120 L/min or pressure greater than 65 cmH_2O, minimize use/length of time of Transition Battery powered ventilation. To conserve power, the ventilator may run with reduced performance, while using the Transition Battery at higher flows and pressures.

NOTE

Transition Battery Use - The Transition Battery is intended for use during very short periods while switching between external power supply connections or when changing Removable Battery Packs. The length of time the ventilator will operate on the Transition Battery is a function of many factors such as settings, charge level and condition or age of the battery. The Transition Battery is only intended to power the ventilator for up to one minute.

Charging Sequence - When the ReVel ventilator is connected to a valid external power source and both the Transition Battery and the Removable Battery Pack require charging, the internal battery charger will charge the Transition Battery to full capacity *before* charging the Removable Battery Pack.

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Chapter 13 - TROUBLESHOOTING

> **⚠ WARNING**
>
> **Vent Inop Alarm** - If a Vent Inop alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a service technician certified by Vyaire.

This chapter describes troubleshooting for the ReVel ventilator. Some problems may be easily corrected without any modification to the ventilator. Other problems may require that the ventilator be recalibrated or have parts replaced.

Do not attempt to repair or replace any part of the ventilator unless you are trained and authorized to perform service on the ReVel ventilator.

This chapter is organized into six sections:

- **Displays and Buttons** - Includes problems with control and window displays and with setting controls
- **Ventilator Performance** - Includes problems with delivered or monitored pressure, volume or PEEP, accuracy, and patient triggering (sensitivity)
- **Power and Battery Operation** - Includes problems with turning the ventilator on, operating from external power sources, battery operation or duration, and Vent Inop
- **Alarms** - Includes problems with recurring alarms
- **Test Failures** - Includes test problems detected during Startup or normal ventilation modes
- **Test Lung Operation** - Includes problems encountered when operating the ventilator with a Test Lung

The troubleshooting tables are organized as follows:

- Symptoms
- Possible Causes
- Suggested Action

The troubleshooting tables are organized by symptoms, then by possible causes and suggested methods for diagnosing and resolving the problem. If you do not find the symptom you are looking for under one section, you may find it listed under another section, or you may be able to diagnose the problem by reading sections with related symptoms.

For information on resolving problems that are not listed here, contact Vyaire or a service technician certified by Vyaire.

Displays and Buttons

Some of the symptoms listed in this section are part of the normal operation of the ventilator and do not indicate any problem with the ventilator. They are included here for information.

Symptoms	Possible Causes	Suggested Action
Pres. Control display flashing.	Pressure Control breath terminated by flow – Pressure Control Flow Termination is On.	When a Pressure Control breath is terminated by flow instead of time, the **Pres**. **Control** display flashes when Pressure Control Flow Termination is set to a value other than "- -" (off). This is normal performance. If this is not desired, review ventilator settings.
Pres. Support display flashes.	Pressure Support breath terminated by time rather than flow.	When a pressure support breath is terminated based on time, the **Pres. Support** display flashes. This is normal performance. If this is not desired, review ventilator settings.
High Pres. Limit alarm display turns red and **High Pres** flashes in display window.	High Airway Pressure alarm occurred.	Review alarm limits settings and check for common causes (i.e. patient cough or patient circuit occlusions).
Low Pk. Pres. alarm limit display flashing and **Low Pk Pres** flashes in display window.	Low Peak Pressure alarm occurred.	Review alarm limits settings and check for common causes (i.e. patient circuit leaks).
Low Min. Vol. alarm display flashing and **Low Min Vol** flashes in display window.	Low Exhaled Minute Volume alarm occurred.	Review alarm limits settings and check for common causes (i.e. patient circuit leaks).
Low FIO_2% display flashing and **Low FIO_2** flashes in display window.	Low FIO_2 alarm occurred.	Review alarm settings, re-calibrate FIO_2 sensor and check oxygen source.
Control display flashing when setting a control. Value will not change.	Control setting is limited.	A control's value may be limited by the current settings of other controls. Modify the setting of related controls if necessary. The limiting controls flash when the limit is reached. To change the value of the current control, change the value of the flashing controls.
A display or LED does not illuminate.	Internal problem with the ventilator.	Push the Display/Alarm **Check** button on the lower interface panel to perform a Display Test. If the display or LED does not illuminate, contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
Ventilator is running but displays are turned off.	Displays are extinguished while on battery power or the set **Dim After** period has expired.	To conserve battery life when running from the internal battery, most of the displays are turned off when no control settings are changed for 60 seconds or if the **Dim After** time, set in Extended Features, has expired. Pushing any button or adjusting the **Scroll** knob restarts the display dimming time period and returns the display to normal brightness. The display automatically returns to normal brightness while any high or medium priority alarm is active.
	Internal problem with the ventilator.	Push the Display/Alarm **Check** button on the lower interface panel to perform a Display Test. If the display or LED does not illuminate, contact Vyaire or a Service Technician certified by Vyaire.
A control or the **Scroll** knob doesn't operate.	Control not active in selected mode.	If a control is dimmed, it is not active in the currently selected mode and changing its setting does not affect current ventilation.
	Controls are locked.	If the controls are locked, a **Locked** message will be displayed when a control is selected. To unlock in Easy mode, push the **Control Lock** button. To unlock in Hard mode, push and hold the **Control Lock** button for 3 seconds.
	Control is not selected.	Before a control value can be changed, the control must be selected. To select a control, push the associated button.
	Control is limited.	A control's value may be limited by the current settings of other controls. To change the value of the current control you must first modify the value of associated flashing controls.
	Internal problem with the ventilator.	Remove patient, enter Startup mode and perform a Button Test. If the control does not operate, contact Vyaire or a Service Technician certified by Vyaire.
Can’t unlock the controls.	Hard unlock method selected.	Two unlock methods are available on the ventilator. To unlock in Easy mode, push the **Control Lock** button. To unlock in Hard mode, push and hold the **Control Lock** button for 3 seconds.
Ventilator does not turn off when the **On/Off** button is pushed for 3 seconds.	Internal problem with the ventilator.	Push and hold the **On/Off** button for at least 20 seconds to achieve the backup power-off sequence. If the ventilator still does not turn off, contact Vyaire or a Service Technician certified by Vyaire.

Ventilator Performance

Symptoms	Possible Causes	Suggested Action
Ventilator is auto cycling, monitored volumes are very small, negative flows exhibited during exhalation and positive flows during inspiration.	Sense Lines are reversed.	The Sense Lines are not designed to be removed from either the Wye or the Luer fittings. If the Sense Lines have been removed and replaced incorrectly, they may not seal correctly when replaced. Replace the complete patient Wye / Sense Lines assembly with a known functional assembly.
	There is water in the Sense Lines.	Clean or replace the Patient Wye Sense Lines assembly.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Ventilator won't allow patient to exhale.	Diaphragm incorrectly installed or poorly seated in Exhalation Valve.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Sense lines occluded or pinched.	Check high and low pressure Sense Lines at the ventilator and Wye ends. Verify lines are not occluded or pinched.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Inspiratory pressure rises initially, falls suddenly and then rises back to set pressure.	Rise time too fast; causing ventilator to enter active exhalation.	Reduce rise time (increase **Rise Time** setting).
Set Pressure (**Pres**. **Control**) not reached.	**Rise Time** setting is too slow for the set **Insp. Time**.	Adjust **Rise Time** setting.
	Patient circuit leak.	Perform a Circuit Test.
	Exhalation diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.

Symptoms	Possible Causes	Suggested Action
Monitored volume (**Vte**) is high.	Very small ET tube connected directly to Wye.	A very small ET tube connected directly to the Wye may cause turbulence that causes the flow differential to be read incorrectly. To reduce this turbulence, add a short larger bore extension between the ET tube and Wye. In this case, the monitored volume is high, but the delivered volume is accurate.
	Low Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Verify lines are not occluded or pinched.
	Sense Lines are reversed.	The Sense Lines are not designed to be removed from either the Wye or the Luer fittings. If the Sense Lines have been removed and replaced incorrectly, they may not seal correctly when replaced. Replace the patient Wye and Sense Lines with a known functional assembly.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
Monitored volume (**Vte**) is low.	High Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Verify lines are not occluded or pinched.
	Sense Lines are reversed.	The Sense Lines are not designed to be removed from either the Wye or the Luer fittings. If the Sense Lines have been removed and replaced incorrectly, they may not seal correctly when replaced. Replace the patient Wye and Sense Lines with a known functional assembly.
	Leak Compensation is not on.	Verify that Leak Compensation is turned On.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Delivered pressure is high. Monitored pressure is high.	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and free of obstructions or kinks.
	Patient Circuit Leak.	Perform a Circuit Test. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose. Verify lines are not occluded or pinched.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
Delivered flow is high or low.	Leaks in the Patient Circuit.	Perform a Circuit Test. Replace leaking circuit if necessary.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Sensitivity does not appear to be accurate and/or ventilator is auto cycling.	Patient Circuit leak.	Perform a Circuit Test and reseat or replace the leaking parts or connections.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	There is a leak between patient circuit Wye and the patient.	Adjust the **Sensitivity** control to compensate, or identify and eliminate the source of the leak.
	Sense lines are reversed.	The Sense Lines are not designed to be removed from either the Wye or the Luer fittings. If the Sense Lines have been removed and replaced incorrectly, they may not seal correctly when replaced. Replace the patient Wye and Sense Lines with a known functional assembly.
	High or Low Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Verify lines are not occluded or pinched.
	Leak Compensation is not on.	Verify that Leak Compensation is turned On.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
O_2% is high.	Low O_2 source incorrectly selected.	Verify that the ventilator **O_2%** is set to **LPS** when using a low flow, low pressure source of O_2 and to a percentage when connected to high pressure O_2.
	O_2 inlet pressure too high when Low Pressure Source (**LPS**) selected. O_2 inlet flow too high when Low Pressure Source (**LPS**) selected.	Verify the low pressure O_2 inlet has been correctly calculated and set using the Input O_2 Flow Chart in the ventilator Operator's manual. Vyaire recommends the use of an O_2 monitor to verify delivered O_2%. Adjust the entrained O_2 flow so the monitored value shows the desired FIO_2.
	FIO_2 Sensor reading inaccurate.	Recalibrate the FIO_2 Sensor. See *FIO2 Sensor Configuration and Calibration* in Chapter 3 for additional information. If calibration of the FIO_2 Sensor fails, replace the FIO_2 Sensor.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Delivered pressure is low, PEEP is low. Monitored pressure is low.	Circuit leak.	Perform a Circuit Test and reseat or replace the leaking parts or connections.
	High or Low Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Verify lines are not occluded or pinched.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Sense Lines are reversed.	The Sense Lines are not designed to be removed from either the Wye or the Luer fittings. If the Sense Lines have been removed and replaced incorrectly, they may not seal correctly when replaced. Replace the patient Wye and Sense Lines with a known functional assembly.
	Leak Comp is not on.	Verify that Leak Compensation is turned On.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
O_2% is low.	O_2 inlet flow too low when Low O_2 Source selected.	Verify the low pressure O_2 inlet has been correctly calculated and set using the Input O_2 Flow Chart in Chapter 2. Vyaire recommends the use of an O_2 monitor to verify delivered O_2%. Adjust the entrained O_2 flow so the monitored value shows the desired FIO_2.
	FIO_2 Sensor reading inaccurate.	Recalibrate the FIO_2 Sensor. See *FIO2 Sensor Configuration and Calibration* in Chapter 3 for additional information. If calibration of the FIO_2 Sensor fails, replace the FIO_2 Sensor.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
PEEP not working. PEEP low. PEEP sags during exhalation.	Circuit leak.	Perform a Circuit Test and reseat or replace the leaking parts or connections.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	High Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded.	Verify lines are not occluded or pinched.
	Leak Compensation is not on.	Verify that Leak Compensation is turned On.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
PEEP is too high.	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	High Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Check the Luer fitting connections for leaks. Check the elbow connectors at the Wye to be sure they have not loosened or been broken loose.
	High or Low Pressure Sense Lines are occluded.	Verify lines are not occluded or pinched.
Ventilator won't trigger at flow **Sensitivity** setting of 1 lpm	Patient effort inadequate.	Some very small patients and patients with very weak inspiratory efforts may not be able to generate a 1 L/min effort. Review ventilator settings.
	Leak Compensation is not on.	Verify that Leak Compensation is turned On.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Ventilator is on, gas is not delivered and blower is running.	Ventilator detected a disconnected patient circuit.	Perform a Circuit Test. Resolve leaks beyond the patient Wye.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Ventilator gets excessively hot.	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Power and Battery Operation

Symptoms	Possible Causes	Suggested Action
The ventilator does not power up.	Faulty power connection. Faulty AC Adapter or inadequate external DC power source. Removable Battery Pack not present or depleted and depleted Transition Battery.	Connect the ventilator to a verified source of AC power and verify the power cord for the AC Adapter is fully seated (**External Power** LED shows green). Install a fully charged Removable Battery Pack or allow the Removable Battery Pack and Transition Batteries to charge a minimum of 13 hours with the ventilator connected to AC power.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Vent Inop LED is on or flashing and ventilator is not ventilating.	Ventilator was running on Transition Battery and battery became depleted.	Connect the ventilator to a functional external power source or insert a charged Removable Battery Pack.
	Vent Inop. Due to causes other than normal power down.	If a **Vent Inop** alarm occurs during operation, immediately ventilate the patient using an alternative method, disconnect the ventilator and contact Vyaire or a Service Technician certified by Vyaire.
	Internal problem with the ventilator.	
The ventilator doesn't operate from external power.	Ventilator connected to Automobile Adapter and power from automobile outlet is faulty or inadequate.	Try rotating the Automobile Adapter (plug in connector) to seat it properly and obtain a better connection. Make sure the green light on the adapter is lit, if not, refer to the Automobile Adapter Instructions for Use to change the adapter fuse. Refer to your automobile manual to ensure the automobile power outlet is rated at 20 Amps or more. Turn off other automobile accessories, such as air conditioning. Monitor the remaining ventilator battery capacity and connect to a valid external power source as soon as possible.
	Defective DC power cord.	Replace with a functional DC power cord.
	Ventilator not properly docked into the Docking Station.	Push the **Eject** button on the front panel of the Docking Station to release the ventilator and re-dock following the instructions in the Docking Station Operator's manual.
	Defective AC source. AC Adapter power cord loose.	Make sure the Docking Station or AC Adapter power cord is fully seated, is securely plugged into a verified source of AC power and is securely connected to the ventilator.
	Defective AC Adapter.	Replace the AC Adapter.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
The ventilator does not operate from Removable Battery Pack and/or shuts off when external power is removed.	Both the Removable Battery Pack and the Transition Battery are depleted.	Connect then ventilator to a valid source of external power and charge the batteries for at least 13 hours.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Removable Battery Pack doesn't reach full charge or depletes too quickly.	Removable Battery Pack needs to be conditioned or has reached the end of its useful life.	Use the condition cycle on the Desktop Battery Charger to condition the Removable Battery Pack. If the Removable Battery Pack fails to charge after a conditioning cycle, re-place with a functional, fully charged Removable Battery Pack.
Battery Charger LED is amber.	Transition Battery is fully charged and the Removable Battery Pack is charging.	The Transition Battery has been fully charged and Removable Battery Pack charging is < 80% complete. Refer to *Battery Charger* in Chapter 6 – Displays and Indicators for detailed information. Allow up to 8 hours to complete charging.
Battery Charger LED is flashing amber.	Transition Battery is charging.	The **Charge Status** LED will flash slowly amber while the Transition Battery charges. When the Transition Battery is charged the LED will stop flashing. Refer to *Battery Charger* in Chapter 6 – Displays and Indicators for detailed information. Allow up to 5 hours to complete charging.
Battery Charger LED is off.	Both the Transition Battery and the Removable Battery Pack are fully charged.	Not charging (either no external power is applied to the ventilator or charging of both batteries is completed). Refer to *Battery Charger* in Chapter 6 – Displays and Indicators for detailed information. This is nominal performance.

Alarms

Many alarms such as High Airway Pressure or Low or Loss of O_2 Inlet Pressure can occur during normal operation. Single occurrences of some alarms, such as a Hardware Fault or Vent Reset may be caused by ESD[45]. If these alarms reoccur, and for any other alarms that do not usually occur during normal operation, discontinue use of the ventilator and follow the instructions in this section or contact Vyaire or a service technician certified by Vyaire.

> ⚠ **WARNING**
>
> **Check Alarms** – Alarm function should be tested periodically to ensure proper operation (see *Maintenance Schedule* in Chapter 11 – Maintenance and Cleaning, and *Display/Alarm Test* in Chapter 2- Installation and Setup for detailed instructions). If any alarm malfunctions, contact Vyaire or a service technician certified by Vyaire. Failure to immediately identify and correct alarm situations may result in serious patient injury or death.

Symptoms	Possible Causes	Suggested Action
SV HP Relief (Safety Valve High Pressure Relief) alarm occurs.	Sense Lines are occluded (pinched).	Free up the Sense Lines or if damaged, replace the patient circuit Wye and Sense Lines assembly.
	Sense Lines are occluded (contain fluid).	Clean or replace the patient circuit Wye and Sense Lines assembly. Refer to the Instructions For Use included with your patient circuit.
	Luer connections on the High and Low Pressure Sense Lines are not properly attached.	Check the Luer connectors on the Sense Lines. If damaged, replace the patient circuit Wye and Sense Lines assembly.
	High resistance circuit or components have been added to the inspiratory limb of the patient circuit.	Remove or replace circuit or components.
		Increase the Safety Valve Delta Pressure setting.

[45] ESD – Electro Static Discharge.

Symptoms	Possible Causes	Suggested Action
A **High Pres** alarm condition occurred but the alarm did not sound.	Alarm silence was already active (**Silence/Reset** LED is red).	The ventilator audible alarm can be silenced for 60 seconds by pushing the **Silence/Reset** button. If the alarm is already silenced (LED is red), it will not sound again until the silence period expires. Push the button again to turn off the silence period.
	High Airway Pressure alarm delay is on is set to a delay of one or two breaths.	Set the High Pressure Delay as required. When a high airway pressure condition is detected, if the High Pressure Delay option is set to **0** the audible alarm is sounded immediately. When the High Pressure Delay option is set to **1** or **2** breaths**,** the audible alarm is not sounded until the second or third consecutive breath of a high pressure condition.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Repeated **High Pres** alarms.	Patient circuit expiratory limb is occluded or pinched.	Resolve pinched/occluded expiratory limb.
	High Pressure Sense Line occluded or pinched.	Check High Pressure Sense Line to be sure it is correctly attached and securely seated at both the ventilator and Wye ends. Verify the line is not occluded or pinched.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a service technician certified by Vyaire.
Ventilator won't exhale, repeated **High Pres** alarms, blower stops and pressure drops, then cycles up to High Airway Pressure again.	Sense lines occluded or pinched.	Check High and Low Pressure Sense Lines to be sure they are correctly attached and securely seated at both the ventilator and Wye ends. Verify lines are not occluded or pinched.
	Exhalation Diaphragm not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action
Repeated **Pat Circuit** alarms.	High or Low Pressure Sense Lines disconnected from vent or Wye. High or Low Pressure Sense Line or elbow at patient Wye loose or leaking.	Check High and Low Pressure Sense Lines and connectors to be sure they are undamaged, correctly attached and securely seated at both ends (Luer fittings at ventilator end and elbow connectors on patient circuit Wye). Perform a Circuit Test.
	High or Low Pressure Sense Lines are occluded. High or Low Pressure Sense Line ports in the Wye are occluded.	Verify lines are not occluded or pinched.
	Circuit disconnected from patient, Wye or vent.	Check the circuit to verify it is securely connected.
	Exhalation limb is pinched or occluded.	Resolve pinched/occluded exhalation limb.
	Excessive leak in patient circuit.	Resolve leaks beyond the patient Wye.
	Exhalation Diaphragm is dirty or not properly seated.	If using a Reusable patient circuit, open the Exhalation Valve, clean and reseat the diaphragm and snap the Valve Cap back in place. If damaged or worn, replace the Exhalation Diaphragm with a new one. If using a Single Use patient circuit, replace with a functional assembly.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
HW Fault alarm.	Electro static discharge (ESD).	Reset the alarm. Reduce static causing conditions in the operating environment.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a Service Technician certified by Vyaire.
Vent Reset alarm occurs.	Electro static discharge (ESD).	Reset the alarm. Reduce static causing conditions in the operating environment.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a Service Technician certified by Vyaire.
Vent Reset alarm occurs after ventilator is operated on Transition Battery until it is fully depleted.	Ventilator shut off because Transition Battery is fully depleted.	Reset the alarm and charge the Transition Battery by inserting a Removable Battery Pack or connecting external power.

Symptoms	Possible Causes	Suggested Action
Config Reset alarm. Event Log indicates Configuration Reset.	Electro static discharge (ESD).	Reset the alarm. Reduce static causing conditions in the operating environment.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a Service Technician certified by Vyaire.
Repeated **High PEEP** alarms.	Monitored PEEP exceeds the set High PEEP alarm value.	Check **High PEEP** alarm value.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a Service Technician certified by Vyaire.
Batt Fault alarm	Ventilator detects that the Removable Battery Pack cannot operate the ventilator.	Replace with a fully charged Removable Battery Pack.
RBatTempFlt alarm.	Ventilating in pressure mode with excessive leak in the patient circuit.	Resolve leaks in the patient circuit and allow battery to cool.
	Ventilator is operating outside of the recommended operating temperature range for extended periods of time.	Operate the ventilator according to the specified operating temperature (see *Environmental Specifications* in Appendix B – Specifications).
	Internal problem with the Removable Battery Pack.	Replace with a fully charged Removable Battery Pack.
	Internal problem with the ventilator.	Contact Vyaire or a service technician certified by Vyaire.
T-Bat Fault alarm during normal ventilation.	Depleted Transition Battery.	Ensure Transition Battery is fully charged: Apply external power until the Transition Battery charging is complete if necessary.
	Internal problem with the ventilator.	If problem reoccurs, contact Vyaire or a Service Technician certified by Vyaire.
T-Bat Fault alarm when ventilator is powered on.	The Transition Battery charge is below the minimum usable voltage due to depletion during storage.	Apply external power until the Transition Battery charging is complete and follow charging procedures recommended in the Routine Maintenance Schedule while in storage.
	Aging Transition Battery is failing to retain charge.	Replace Transition Battery.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
TBatTempFlt alarm.	Ventilating in pressure mode with excessive leak in the patient circuit.	Resolve leaks in the patient circuit and allow battery to cool.
	Ventilator is operating outside of the recommended operating temperature range for extended periods of time.	Operate the ventilator according to the specified operating temperature (see *Environmental Specifications* in Appendix B – Specifications).

Symptoms	Possible Causes	Suggested Action
	Internal problem with the ventilator.	Contact Vyaire or a service technician certified by Vyaire.
Button Stuck alarm	Ventilator detects any button, except power control, is on for more than 60 seconds.	Perform a Button test, if problem persists; contact Vyaire or a Service Technician certified by Vyaire.
Vent Inop alarm is generated while ventilator is in storage.	The Transition Battery charge is depleted due to charging less frequently than recommended in the Routine Maintenance Schedule.	Apply external power until the Transition Battery charging is complete and follow charging procedures recommended in the Routine Maintenance Schedule while in storage.
	Aging Transition Battery is failing to retain charge.	Replace Transition Battery.
Blower Demand Exceeded alarm.	Ventilating in pressure mode with excessive leak in the patient circuit.	Resolve any leaks in the patient circuit.
	Internal problem with the ventilator.	Contact Vyaire or a service technician certified by Vyaire.

Test Failures

Symptoms	Possible Causes	Suggested Action
Button Test:		
Correct message is not displayed or incorrect message is displayed.	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Circuit Test:		
Failed FS message is displayed.	Luer fittings not seated.	Reseat the Luer fittings.
	Patient circuit Sense Lines occluded.	Clean/replace patient circuit.
	Patient Circuit leak.	Resolve any leaks in the patient circuit and verify circuit is properly attached.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Failed Flow is displayed.	Circuit connections or accessories are leaking. Wye is not completely occluded.	Reconnect or replace leaking circuit parts. Perform a Circuit Test and verify the Wye is completely occluded.
Failed SV message is displayed.	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Display/Alarm Test:		
Audible alarm level excessive.	Alarm volume set too high.	Reset the alarm volume.
Audible alarm too soft.	Alarm volume set too low.	Reset the alarm volume.
	Alarm Sounder ports blocked.	Check the Alarm Sounder ports and remove blockage.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Alarm does not sound.	Alarm Sounder ports blocked.	Check the Alarm Sounder ports and remove blockage.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
A display or LED fails to illuminate.	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Symptoms	Possible Causes	Suggested Action

Vent Inop Alarm Test:

Alarm does not sound.	Alarm Sounder ports blocked.	Check the Alarm Sounder ports and remove blockage.
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
The **Vent Inop** LED is not illuminated.	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.

Test Lung Operations

Symptoms	Possible Causes	What to Do
Delivered Pressure higher than set pressure on Test Lung.	Pressure > 40 cmH_2O used on small Test Lung (Vyaire or Siemens 190).	The compliance characteristics of some small Test Lungs (Vyaire or Siemens 190) cause incorrect readings when high pressures are used. For these lungs, use pressures under 40 cmH_2O or change to a larger lung.
	Rise Time too fast.	Reduce rise time (increase Inspiratory Rise setting).
	Internal problem with the ventilator.	Contact Vyaire or a Service Technician certified by Vyaire.
Monitored volumes very high on Test Lung.	Test lung with small aperture connected directly to Wye.	Some test lungs have a narrow opening or a restrictor, which may cause jetting and cause the flow differential to be read incorrectly. To reduce the jetting effect, add a short extension between the test lung and the Wye.
	Very small ET tube connected directly to Wye.	A very small ET tube connected directly to the Wye may cause jetting and cause the flow differential to be read incorrectly. To reduce the jetting effect, add a short larger bore extension between the ET tube and the Wye.
Blower sounds erratic during inspiration in Pressure Control.	Circuit leak.	Perform a Circuit Test and reseat or replace the leaking parts or connections.

Appendix A - CONTACT INFORMATION

To contact Vyaire, request technical/clinical support, schedule Service, or order parts or supplies for your PTV Series Ventilator, refer to the contact information as follows.

Manufacturer

Vyaire Medical, Inc.
26125 North Riverwoods Blvd.
Mettawa, IL 60045
USA

Customer and Clinical Support

Product, Accessories, and Parts Ordering

Vyaire Medical, Inc.
26125 North Riverwoods Blvd.
Mettawa, IL 60045
USA
1-833-327-3284
customersupport@vyaire.com
vyaire.com

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Appendix B - SPECIFICATIONS

NOTE

Flow / Volume Measurement – Delivered flow and volume are designed to be accurate at the ventilator's Inspiratory Port. The exact flows/volumes delivered to the patient are dependent upon the compliance of the patient circuit.

All references to compressible flow and compressible volume in the patient pneumatic pathway are BTPS (Body Temperature Pressure Saturated) unless stated otherwise. A BTPS measurement is achieved when the compressible fluid is at 98.6°F (37°C), ambient barometric pressure, and saturated with water vapor. For the ReVel ventilator, it is assumed that the ambient relative humidity is 30%.

Breath Modes and Breath Types

Breath Types	Volume Control, Pressure Control, PRVC (Pressure Regulated Volume Control) PRVS (Pressure Regulated Volume Support), Pressure Support, Spontaneous
Breath Modes	Control, Assist Control, Synchronized Intermittent Mandatory Ventilation (SIMV), Continuous Positive Airway Pressure (CPAP) plus Pressure Support, Non-Invasive Positive Pressure Ventilation (NPPV), Apnea Backup.

Controls

Lower Interface Panel Buttons

Control	Function
Battery/Power Check	Displays the remaining capacity of the Removable Battery Pack as a percentage of its capacity when new, the type and status of the external DC power, the Dock Docking Station power and the status of the Transition Battery.
Control Lock	Locks and unlocks the ventilation controls.
Display/Alarm Check	All LED indicators and displays are illuminated, the high priority audible alarm sounds for 2 seconds.
Maneuvers	Enables access to setup for maneuvers.
Manual Breath	After the minimum exhalation time has elapsed, pushing this button delivers one breath per the current Breath Type Settings.
On/Off	Powers the ventilator on or off.
Silence/Reset	Toggles a 60 second silence period on and off for audible portion of alarms. Removes, or suppresses for 15 seconds, the visual alarms display.

Adjustable Controls

Control	Range		Accuracy
Bias Flow	3 through 10 lpm		±1 lpm
Breath Rate	1 through 80 bpm		Greater of 1 breath per minute or ±10%,
Breath Type	Volume Control, Pressure Control, Pressure Regulated Volume Controlled (PRVC)		N/A
Flow Termination	10 through 40 percentage of peak flow		Greater of ±15% or ±2 lpm
High Pressure Alarm Delay	0, 1, 2 breaths		N/A
Inspiratory Time	0.3 through 9.9 Seconds		±0.05 seconds
Leak Comp	On, Off		N/A
LPP Alarm Control	"All Breaths", "Control Only"		N/A
NPPV	On, Off		N/A
O_2%	LPS, 21 through 100 %		±3 (21-50)[46] ±5 (51-100)[46]
PEEP	0 through 20 cmH_2O		Greater of ±1 or ±10%,
Pressure Control	1 through 99 cmH_2O		Greater of ± 8% or ±2 cmH_2O
Pressure Support	Off, 1 through 60 cmH_2O		Greater of ± 8% or ±2 cmH_2O
Pressure Trigger	1 through 20 below PEEP		Greater of ±10% or ±2 cmH_2O
Pressure Control Flow Termination	On, Off		N/A
Rise Time	**Rise Time** Setting	Commanded Rise Time (sec)	Pressure commanded to 90% of Target Pressure by specified rise time ±200ms
	1	0.100	
	2	0.133	
	3	0.178	
	4	0.237	
	5	0.316	
	6	0.422	
	7	0.562	
	8	0.750	
	9	1.000	
Safety Valve Delta Pressure	5 through 30 cmH_2O		N/A
Flow Sensitivity	P, 1 through 9 lpm		+1, -0.5 (<2)

[46] The accuracy given is valid for normal environmental temperatures of 18 to 30 °C and normal environmental pressure of 87 to 101 kPa. When operating outside of this temperature range, but within the specified full temperature range, add an additional ±0.1% for each degree C. When operating outside of this pressure range, but within the specified full environmental pressure range, add an additional ±0.1% for each kPa.

Control	Range	Accuracy
		±1 (≥2)
Tidal Volume	50 through 2000 ml	Greater of ±10% or ±10 ml
Time Termination	0.3 through 3.0 seconds	± 0.030 seconds
Ventilation Mode	Assist/Control (A/C), Synchronized Intermittent Mandatory Ventilation (SIMV), Continuous Positive Airway Pressure (CPAP) plus Pressure Support (PS).	N/A
SBT O_2	LPS, 21 through 100 %	±3% O_2 (21-50) ±5% (51-100)
SBT PEEP	0 through 20 cmH_2O	±1 or ±10%
SBT Pressure Support	'—" (Off), 1 through 30 cmH_2O	Greater of ±8% or ±2 cmH_2O
SBT Time	15 min through 120 min	±1 min
SBT f/Vt Display	"On", "Off"	N/A

Maneuvers

Maneuver	Function
E-Hold	Maintains the expiratory phase of a breath for 6 ± 0.1 seconds (Adult/Ped/Infant) or until the button is released. Calculates AutoPEEP
I-Hold	Maintains the inspiration phase of a volume breath for 6 ± 0.1 seconds (Adult/Ped/Infant) or until the button is released. Calculates C Static.

Procedures

Procedures	Function
O_2 Flush	Delivers a pre-selected increase in O_2 percentage for a pre-selected duration.
Nebulization	Provides a flow of 6 L/min ±10% O_2 to drive a nebulizer (optional). Configurable as continuous or inspiration only.
SBT (Spontaneous Breathing Trial)	During the SBT procedure, ventilation is delivered in CPAP+PS mode with the selected SBT control settings in Extended Features. Calculates f/Vt.

Alarms

Adjustable Alarms

Alarm	Range	Priority
Apnea (Interval)	10 through 60 seconds	High priority audible and visual alarm
High Pres	5 through 100 cmH_2O	High priority audible and visual alarm
High f	1 through 120 bpm, or "**- -**" (off)	Medium priority audible and visual alarm
High PEEP	3 through 40 cmH_2O, or "- -" (Off)	Medium priority audible and visual alarm
High Pulse	18 through 299, Beats/min or "**- -**" (off)	High priority audible and visual alarm
High SpO_2	80 through 99 %, or '--' (Off)	High priority audible and visual alarm
Low FIO_2	"**- -**" (off), or 18% through 95%	High priority audible and visual alarm
Low Min Vol	"**- -**" (off), or 0.1 through 99 liters	High priority audible and visual alarm
Low Pk Pres	"**- -**" (off), or 1 through 60 cmH_2O	High priority audible and visual alarm
Low PEEP	"- -" (off), or 1 through 20 cmH_2O	High priority audible and visual alarm
Low Pulse	'- -'(Off), or 19 through 300 Beats/min	High priority audible and visual alarm
Low SpO_2	'- -'(Off), or 60 through 99 %	High priority audible and visual alarm
SBT > f	15 through 80 bpm, or SBT Hi f Off	Medium priority audible and visual alarm
SBT > f/Vt	70 through 900 bpm/L, or Hi f/Vt Off	Medium priority audible and visual alarm
SBT < f	SBT Lo f Off, or 1 through 40 bpm	Medium priority audible and visual alarm
SBT < f/Vt	Lo f/Vt Off, or 5 through 90 bpm/L	Medium priority audible and visual alarm
SBT Hi PEEP	3 through 40 cmH_2O, or "- -" (off)	Medium priority audible and visual alarm
SBT Lo PEEP	"- -" (off), or 1 through 20 cmH_2O	High priority audible and visual alarm

Fixed Alarms

Alarm	Priority/Type
Bat Empty	High priority audible and visual alarm
Bat Fault	Medium priority audible and visual alarm
Bat Low	Medium priority audible and visual alarm
Battery Use	N/A / Periodic audible tone
Blwr Demand	High priority audible and visual alarm
ButtonStuck	Medium priority audible and visual alarm
ConfigReset	High priority audible and visual alarm
Dock Discon	Medium priority audible and visual alarm
Dock Fault	Medium priority audible and visual alarm
ExtPwrFault	Medium priority audible and visual alarm
ExtPwr Lost	Medium priority audible and visual alarm

Alarm	Priority/Type
Ext Pwr Low	Medium priority audible and visual alarm
FIO_2 Fault	Medium priority audible and visual alarm
HW Faultxxx	High priority audible and visual alarm
Hi O_2 Pres	Medium priority audible and visual alarm
Insert Batt	Medium priority audible and visual alarm
Low O_2 Pres	High priority audible and visual alarm
Pat. Circuit	High priority audible and visual alarm
P Maint xxx	Low priority audible and visual alarm
RBatTempFlt	High priority audible and visual alarm
Remove Ptnt	High priority audible and visual alarm
SVHP Relief	High priority audible and visual alarm
SBT Off	Low priority audible and visual alarm
SBT Time	Low priority audible and visual alarm
SchedSvcxxx	Low priority audible and visual alarm
SpO_2 Fault	High priority audible and visual alarm
SpO_2 LowSig	High priority audible and visual alarm
SpO_2 Module	High priority audible and visual alarm
SpO_2 Discon	High priority audible and visual alarm
SpO_2 Sensor	High priority audible and visual alarm
T-Bat Fault	Medium priority audible and visual alarm
TBatTempFlt	High priority audible and visual alarm
T- Bat Use	High priority audible and visual alarm. Resets only once for 60 seconds
Vent Inop	Audible and visual Inop Alarm. Pushing the alarm **Silence/Reset** button silences the audible indicator.
Vent Reset	Medium priority audible and visual alarm
Vol Limited	Medium priority audible and visual alarm

Patient Protection Mechanisms

The ventilator has a safety valve which opens under the following conditions.

Control	Range
Over Pressure Relief	Blower Estimated Airway Pressure ≥ 110 cmH_2O, or Blower Estimated Airway Pressure ≥ High Airway Pressure Alarm setting + Safety Valve Delta Pressure setting **Resistance with valve open:** ≤ 5 cmH_2O at 10 lpm, measured at the ventilator's inspiratory limb
Sub-Ambient (anti-asphyxia) Relief	**Sub-ambient activation: Sub-ambient activation:** Airway Pressure Monitor -10 to -5 cmH_2O, or Airway pressure based on Blower Differential Pressure transducer -10 to -5 (+0/-5) cmH_2O **Sub-ambient recovery:** Airway Pressure > -10 cmH_2O, ≥ 250 ms after activation, and Airway pressure based on Blower Differential Pressure transducer > -10 (+0/-5) cmH_2O, ≥ 250 ms after activation

Internal Compliance

Compliance < 0.1 mL/cm

Monitors

Patient Monitors

Monitor	Range	Accuracy
Airway Pressure (Paw)	-6 through 90+ cmH_2O measured at the patient Wye	Greater of ±5% or ±2
Exhaled Minute Volume (VE)	0 through 99.9 L	Greater of ±15% or ±0.015*f
Exhaled Tidal Volume (Vte)	0 through 4000 ml	Greater of ±15% or ±15
Fraction of Inspired Oxygen (F_{IO_2})	12% through 103% O_2	± 3
I:E Ratio, Calculated (IEcalc)	1:99 through 4.0:1	±1 significant digit
I:E Ratio, Measured	1:99 through 45:1	Greater of ±50 ms or ±5%
Inspiratory Tidal Volume (Vti)	0 through 4000 ml	Greater of ±15% or ±15
Mean Airway Pressure (MAP)	0 through 99 cmH_2O	Greater of ±5% or ±2
Peak Inspiratory Flow	3 through 190 lpm measured at the patient Wye	See Wye Flow monitor
Peak Inspiratory Flow, Calculated	10 through 120 lpm	Greater of ±10% or ±2
Peak Inspiratory Pressure (PIP)	0 through 120 cmH_2O or hPa	Greater of ±5% or ±2
Positive End-Expiratory Pressure (PEEP)	0 through 99 cmH_2O or hPa	Greater of ±10% or ±2
Pulse Oximetry Signal Strength	Green / Amber / Red	N/A
Pulse Rate	18 through 300 beats/min	± 3 (no motion)
SBT f/Vt	0 through 999 bpm/L	See Total Breath Rate and Exhaled Minute Volume monitors
SBT Time Remaining	00:00 (mm:ss) through 01:59:59 (hh:mm:ss)	± 1 minute
SpO_2	0 through 100 %	± 2 (no motion)
Spontaneous Breath Rate (Sp f)	0 through 120 bpm	Greater of ±5% or ±1 bpm
Spontaneous Tidal Volume (SpVte)	0 through 4000 ml	Greater of ±15% or ±15
Total Breath Rate (f)	0 through 120 bpm	Greater of ±5% or ±1 bpm

Device Monitors

Monitor	Range	Accuracy
Measured Leak	0.0 through 30.0 lpm	±1.5 if flow is < 10, ±15% or ±3 if flow is ≥ 10
O_2 Source Pressure	0.0 through 99.9 PSI	± 2 PSI
Peak Expiratory Flow	0 through 190 lpm	±1.5 if flow is < 10, ±15% or ±3 if flow is ≥ 10
Removable Battery Capacity Remaining	0% through 120%	±20%
Vent Usage Meter, Non re-settable	0.0 through 500000.0 hours	±5%
Vent Usage Meter, re-settable	0.0 through 500000.0 hours	±5%

Physical Dimensions

Size Approx. 11.3” (28.7 cm) x 7.1” (18.0 cm) x 3.3” (8.4 cm)
Weight Approx. 9.9 lb. (4.5 kg)

Alarm System

Audible Volume	The Sound System is capable of generating sound volumes in the range of 55 to 85 dBA, dependent on the sound type and the set Alarm Volume
Conformity	All audible signals conform to ISO 9703-2

Environmental Specifications

Storage[47]

Temperature	-20 to 60 °C
Humidity	5% to 95% Relative, non-condensing

Following storage at extreme temperature conditions ranging from -30°C to 70°C, the ReVel ventilator will function as intended for at least 20 minutes when it is returned to room temperature (20 +/- 2°C) for 10 minutes. (Ref: EN 13748-1)

Operating

Temperature	5 °C to 40 °C
Humidity	5% to 95% Relative, non-condensing

Altitude

Storage	50,000 ft. Max
Operating	-2,300 – 10,600 ft. (68 – 110 kPa)

Shock and Vibration

The ventilator is designed to withstand shock and vibration in accordance with relevant requirements set forth in the following standards:

- IEC 68-2-6 Vibration; 10-1000 Hz, 0.35mm/49 ms-2, 1 octave/min, 4 sweep cycles in each axis
- IEC 68-2-27 Shock; 30g, 6 ms, half sine
- IEC 68-2-29 Bump; 15g, 6 ms, 4000 bumps, vertical (normal operating position)
- IEC 68-2-32 Free Fall; 0.75m, one fall on each of the six surfaces when installed in its carrying case
- IEC 68-2-36 Vibration; Test Fdb, 0.01 g^2/Hz (10-200 Hz), 0.003 g^2/Hz (200-500 Hz), 1.7 g_{rms}, 30 min
- MIL-STD-810G Shock; method 516.6, Section 4.6.2, Procedure I, Functional Shock, Figure 516.6-10, terminal peak sawtooth, 20g, 11 ms, 3 pulses positive and negative in each axis
- MIL-STD-810G Vibration; method 514.6, Procedure I, Category 24, General, Minimum Integrity Exposure, Test Levels per figure 514.6E-1, 7.7 g(r.m.s), 3 axis, 1 hour/axis
- MIL-STD-810G Vibration; Helicopter Minimum Integrity, method 514.6. Procedure I, Category 24, Figure 514.6E-2, 3 axes, 30 min/axis
- RTCA/DO-160F category U2, Vibration; Helicopter, Unknown Frequencies. Performance, Figure 8-7 Curve F, Acceleration = 3.37 grms, 3 axes 10 minutes/Axis

[47] PTV® Series Ventilators stored at temperatures outside of the specified Operating Temperature range must be allowed to stabilize to within the operating temperature range before turning the ventilator on.

Liquids

Spillage	IEC 60601-1 Clause 44.3
Ingress	IEC 60529 IP Code: IPx1 “vertical dripping”

Inlet Air Filtration

The ventilator air filter is removable and cleanable by the operator.

Interfaces

Interface	Specification
Air Intake Port	Accommodates user replaceable filter
Dock Interface	Proprietary power / communications interface.
Exhalation Valve Drive Port	1/8” ID hose barbed fitting accommodates the Exhalation Valve Drive line.
F_{IO_2} Sensor connection	Compatible with cabling to Teledyne R-17 MED O_2 sensor.
Flow Sensor Interface	Proprietary. Consists of two pneumatic Luer connections: Flow Sense High (female) and Low (male).
Nebulizer Port	0.230” OD, straight barb fitting.
O_2 Blender Inlet	O_2 DISS. A filter is incorporated. Meets requirements of CGA V-5 Connection 1240. 2.8 bar (40 PSI or 276 kPa) to 6.1 bar (88 PSI or 607 kPa) inlet pressure. 0 – 180 lpm
Patient Circuit Inspiratory Limb	22mm OD, 15mm ID, male conical connector per ISO 5356-1.
SpO_2 Module connection	Proprietary power / communications interface.

Equipment Classification

Classification	Internally Powered Equipment per IEC 60601-1
Type	Type BF per IEC 60601-1

Emissions/Immunity

See *EMC and RF Environments* in Appendix C – Reference Information

Power Specifications

Input Voltage 11 to 16 VDC

AC Adapter

This AC/DC converter allows PTV Series Ventilators to be powered from an AC power source. It is shipped with complete specifications and Instructions for Use and care.

Removable Battery Pack

<table>
<tr><th>Feature/Spec</th><th>Details</th></tr>
<tr><td>Electrical</td><td>Nominal Voltage Output:..... 10.8 VDC
Nominal Capacity:..... 5800 mAHr (at 1C rate), minimum
Charge Rating:..... 12.3 VDC, 2.0 A maximum</td></tr>
<tr><td>Charge Time</td><td>The ventilator can charge a discharged Removable Battery Pack when Docking Station power or external DC power is available.
Once the Transition Battery is charged, the Removable Battery Pack can be >90% charged by a ventilator connected to external power within 8 hours, from fully discharged.</td></tr>
<tr><td>Battery Duration</td><td>A new fully-charged Removable Battery Pack provides at least 4 hours of operating time with controls at Standard Test Condition settings below.
NOTE
Battery operating times may vary significantly based on user settings. Specifically, Pressure Control breaths with fast rise times, high Breath Rates and high Peak Flows will typically decrease battery life. For optimal battery life, set display dimming as low as possible.
<u>Test Settings</u>:
Mode ..... A/C
Breath Type..... Volume
PEEP(cmH_2O)..... 5
Breath Rate (bpm) 15
O_2 (%)..... 21
Tidal Volume (ml)..... 500
Lung Compliance (ml/cmH_2O) 30
Insp. Time (sec) 1.5
ET Resistance (cmH_2O/L/S) 20
Sensitivity (lpm).....P
Pressure Trigger 10
Ambient Temp (^oC) 25
Bias Flow (lpm) 5
Leak Comp .....L. Comp Off
Alarm Vol (dBA)..... 6
Display Dimming (min)..... 5</td></tr>
<tr><td>Safety Standards</td><td>UL Listing per UL 60950-1 (UL 2054); UN Transportation Testing.</td></tr>
</table>

Transition Battery

Feature/Spec	Details
Electrical	Voltage: .....10.8 VDC Capacity:.....1800 mAHr (at 1C rate)
Charge Time	The ventilator can charge a discharged Transition Battery when Docking Station power or external DC power is available, or partially charge the Transition battery when operating on the Removable Battery Pack. The ventilator will fully recharge the Transition Battery from completely discharged within 5 hours when connected to a valid external power supply.
Transition Battery Duration	When fully charged, a new Transition Battery is designed to provide a minimum of 1 minute of operating time.

⚠ WARNING

Reduced Flow/Pressure – To avoid possible harm to patients requiring a flow rate higher than 120 lpm or pressure greater than 65 cmH_2O, minimize use/length of time of Transition Battery powered ventilation. To conserve power, the ventilator may run with reduced performance, while using the Transition Battery at higher flows and pressures.

NOTE

Transition Battery Use - The Transition Battery is intended for use during very short periods while switching between external power supply connections or when changing Removable Battery Packs. The length of time the ventilator will operate on the Transition Battery is a function of many factors such as settings, charge level and condition or age of the battery. The Transition Battery is only intended to power the ventilator for up to one minute.

Reliability

The PTV Series Ventilator is designed to meet the following reliability requirements:

Product Life: 10 years

National and International Standards

The ReVel ventilator is designed to comply with the following standards:

Number	Title
ASTM F1100-90	Ventilators Intended for User in Critical Care
ASTM F1246-91	Electrically Powered Home Care Ventilators
ASTM F1463-93	Alarm Signals in Medical Equipment Used in Anesthesia and Respiratory Care
CGA V-5	Specifications for DISS Connections
EN 865:1997	Pulse Oximeters – Particular Requirements
FDA Ventilator Guidance	Draft Reviewer Guidance For Ventilators July 1995
FDA Guidance	Reviewer Guidance For Pre Market Notification Submissions November 1993
IEC 529:1989	Degrees of Protection Provided by Enclosures
IEC 60601-1:1995	Medical Electrical Equipment, General Requirements for Safety
IEC 60601-1-2:2001(E)	Medical Electrical Equipment: General Requirements for Safety, Electromagnetic Compatibility Requirements and Tests.
IEC 60601-1-4:1996+A1:1999	General Requirements for Safety for Programmable Electrical Medical Systems.
IEC 60601-2-12:2001(E)	Medical Electrical Equipment: Particular requirements for the safety of lung ventilators – Critical care ventilators
CEI/IEC 68-2-6:1985	Basic Environmental Testing Procedures – Vibration
CEI/IEC 68-2-27:1987	Basic Environmental Testing Procedures – Shock
CEI/IEC 68-2-29:1987	Basic Environmental Testing Procedures – Bump
CEI/IEC 68-2-32:1975	Basic Environmental Testing Procedures – Free Fall
CEI/IEC 68-2-34:1991	Basic Environmental Testing Procedures – Random Vibration Wide Band
ISO 5356-1:2004(E)	Anesthetic and respiratory equipment – Conical Connectors
ISO 7767:1997(E)	Oxygen Monitors for Monitoring Patient Breathing Mixtures – Safety Requirements
ISO 9703-1:1992(E)	Anesthesia and respiratory care alarm signals Part 1: Visual alarm signals
ISO 9703-2:1994(E)	Anesthesia and respiratory care alarm signals Part 2: Auditory alarm signals
ISO 9703-3:1998(E)	Anesthesia and respiratory care alarm signals Part 3: Guidance on application of alarms
MDD EEC/93/42	Medical Device Directives, European Council Directive Concerning Medical Devices 1993
MIL-STD-810G	Shock, Ground Transport and Helicopter Transport Vibration. Category 24, General integrity for Helicopters, per Figure 514.6 E-2
prEN 13718-1	Air, Water, and difficult terrain ambulances – Medical device interference requirements for the continuity of patient care.
RTCA/DO-160F	Environmental conditions and test procedures for airborne equipment.[48] Category U2 – Random Test Curves for Helicopters Fuselage per Figure 8-7 Curve F

[48] Testing performed while the ventilator was operating on Removable Battery Pack power, and with SpO_2 and FIO_2 modules attached.

Shipping Requirements

The ventilator packed in its shipping container, conforms to the International Safe Transit Association requirements for packaged products weighing less than 100 pounds.

User Interfaces

Lower Interface Panel

Display	Range
Battery Charger	Off / Flashing Amber / Amber / Green LED
Battery Pack	Off / Red / Flashing Red / Amber / Green LED
Control Lock	Off / Green LED
External Power	Red / Amber / Green/ Flashing Red LED
Maneuvers	Off / Flashing green / Green LED
Manual Breath	Off / Green LED
On, Off	Off / Green LED
Silence/Reset	Off / Red LED
Transition Battery	Off / Red / Flashing Red / Amber / Green LED
Vent Inop.	Off / Red/Flashing red LED.

Front Panel

The front panel interface consists of the following major components:

- Airway Pressure Bar Graph display
- Alpha Numeric, dot matrix LED display, information bar
- Controls Area consisting of 7-segment numeric displays, indicators, and associated push buttons
- Alarms Area consisting of 7-segment numeric displays and associated push buttons
- Oximeter Area consisting of 7-segment numeric displays, and a Signal Strength Bar Graph

Primary control selection for the front panel is accomplished using momentary contact push buttons. Seven segment LED Displays display numeric information. These displays are associated with a push button:

Alpha Numeric Display

A single row of 12, 5x7 dot matrix LED, displays both text and numeric information.

Function LEDs

Individual LEDs indicate activation of specific features. An associated push button activates and de-activates the function.

Appendix C - REFERENCE INFORMATION

Factory Settings

Controls

Control	Factory-Set Values
Alarm Volume	6 (80 dB A)
Apnea Interval	20 seconds
Battery Use Tone	3
Bias Flow	5 lpm
Breath Mode	Assist/Control
Breath Rate	12 bpm
Breath Type	Pressure
Control Unlock	Off
Date Format	MM/DD/YYYY
Default Units	cmH_2O/PSI
Dim After time	Never
Flow Termination	25%
High Pressure Alarm Delay	Delay 0 Brth
Inspiratory Time	1 second
Language	English
Leak Compensation	L. Comp On
Local Date	GMT[49]
Local Time	GMT[49]
LPP Alarm	All Breaths
MV/BR Delay	No Delay
Nebulizer Duration	15 min
Nebulizer Synchronization	Continuous
NPPV	OFF
O_2 Flush Duration	3 Minutes
O_2 Flush Percentage	100%
O_2 %	21%
PC Flow Termination	Off
Patient	N/A
Patient Size	N/A
PEEP	0 cmH_2O
PEEP alarm delay	No Delay
Pressure Control	10 cmH_2O
Pressure Support	10 cmH_2O

[49] Greenwich Mean Time

Control	Factory-Set Values
Pulse Tone Volume	1
Rise Time	4
Safety Valve Delta Pressure	10 cmH_2O
SBT Time	20:00 (mm:ss)
SBT O_2	21%
SBT PEEP	0 cmH_2O
SBT Pressure Support	10 cmH_2O
Sensitivity	2 lpm
SpO_2 Averaging	8-beat
Tidal Volume	500 ml
Time Termination	3 seconds

Adjustable Alarm Limits

The factory-set values for the ReVel ventilator adjustable alarm limits are:

Alarm	Factory Setting
High Airway Pressure	20 cmH_2O
High Breath Rate	"--- " (Off)
High PEEP	5
High Pulse Rate	"---" (Off)
High SpO_2	99
Low FIO_2	18% (when sensor is connected)
Low Exhaled Minute Volume	2.5 L
Low Peak Pressure	5 cmH_2O
Low PEEP	"---" (Off)
Low Pulse Rate	"---" (Off)
Low SpO_2	85
Low Tidal Volume	10 ml
SBT Hi f	35
SBT Low f	10
SBT Hi f/Vt	105
SBT Low f/Vt	70

Replacement Parts

- Removable Battery Pack
- Air Inlet Filter
- Cooling Fan Filter
- Exhalation Diaphragm

Contact Vyaire for a complete list of replacement parts, part numbers and pricing information. See *Appendix A - Contact Information* for contact and ordering information.

Accessories

Vyaire offers a large variety of accessories for use with PTV Series Ventilators. Accessories are packaged with individual Instructions For Use providing part numbers, intended use, specifications and cleaning information.

Contact Vyaire for a complete list of available accessories, part numbers and pricing information. See *Appendix A - Contact Information* for contact and ordering information.

> **⚠ WARNING**
>
> **Patient Circuit Accessories, Risk of Patient Injury -** To avoid the risk of patient injury, only use accessories expressly approved by Vyaire for use with PTV Series Ventilators.

> **NOTE**
>
> The ReVel ventilator is designed for compatibility with Humidifiers meeting ISO 8185 standards and Bacteria Filters meeting ISO 5356-1 standards.

Patient Circuits / Accessories

- Reusable – Patient Circuit
- Single Use – Patient Circuit
- Single Use – Patient Circuit Heated Wire
- Reusable – Patient Wye w/Flow Sensors and Sense Lines
- Single Use – Patient Wye w/Flow Sensors and Sense Lines
- Humidifiers

Power Accessories

- AC Adapter
- Automobile Adapter
- PTV Vent-side Pigtail Cable Extension
- PTV AC Adapter Cable Extension
- Desktop Battery Charger
- Docking Station

Mounting and Transporting Accessories

- Carry Case
- Rolling Stand
- Table Top Mount
- Wall Mount

Sensor Accessories

- FIO_2 Sensor Cable
- SpO_2 Module
- SpO_2 Module with Sensor

Monitor Accessories

- PTM Graphics Monitor

EMC and RF Environments

The following tables are from 60601-1-2 © IEC:2001(E)

Table 201

Guidance and manufacturer's declaration – electromagnetic emissions		
The ReVel ventilator is intended for use in the electromagnetic environment specified below. The customer or the user of the ventilator should assure that it is used in such an environment.		
Emissions test	**Compliance**	**Electromagnetic environment – guidance**
RF emissions CISPR 11	Group 1	The ReVel ventilator uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The ReVel ventilator is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Class A	
Voltage fluctuations/ flicker emissions IEC 61000-3-3	Complies	

Table 202

Guidance and manufacturer's declaration – electromagnetic immunity			
The ReVel ventilator is intended for use in the electromagnetic environment specified below. The customer or the user of the ventilator should assure that it is used in such an environment.			
Immunity Test	**IEC 60601 test level**	**Compliance Level**	**Electromagnetic environment – guidance**
Electrostatic discharge (ESD) IEC 61000-4-2	± 6 kV contact ± 8 kV air	± 6 kV contact ± 8 kV air	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30 %.
Electrical fast transient/burst IEC 61000-4-4	± 2 kV for power supply lines ± 1 kV for input/output lines	± 2 kV for power supply lines ± 1 kV for input/output lines	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	± 1 kV differential mode ± 2 kV common mode	± 1 kV differential mode ± 2 kV common mode	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	<5 % U_T (>95 % dip in U_T) for 0,5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles <5 % U_T (>95 % dip in U_T) for 5 sec	<5 % U_T (>95 % dip in U_T) for 0,5 cycle 40 % U_T (60 % dip in U_T) for 5 cycles 70 % U_T (30 % dip in U_T) for 25 cycles <5 % U_T (>95 % dip in U_T) for 5 sec	Mains power quality should be that of a typical commercial or hospital environment. If the user of the ReVel ventilator requires continued operation during power mains interruptions, it is recommended that the ventilator be powered from an uninterruptible power supply or a battery.
Power frequency (50/60 Hz) Magnetic field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be at levels characteristic of a typical location in a commercial or hospital environment.

NOTE U_T is the A.C. mains voltage prior to application of the test level.

Table 203 - 60601-1-2 © IEC:2001(E)

Guidance and manufacturer's declaration – electromagnetic immunity			
The ReVel ventilator is intended for use in the electromagnetic environment specified below. The customer or the user of the ventilator should assure that it is used in such an environment.			
Immunity Test	**IEC 60601 test level**	**Compliance Level**	**Electromagnetic environment - guidance**
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz[50] outside ISM bands	3V	Portable and mobile RF communications equipment should be used no closer to any part of the ReVel ventilator, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance $d = 1.2\sqrt{P}$
	10 Vrms 150 kHz to 80 MHz in ISM bands[51]	10V	$d = 1.2\sqrt{P}$
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.5 GHz	10 V/m	$d = 0.60\sqrt{P}$ 80 MHz to 800 MHz $d = 1.2\sqrt{P}$ 800 MHz to 2.5 GHz Where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and d is the recommended separation distance in meters (m)51. Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey[52], should be less than the compliance level in each frequency range.[53] Interference may occur in the vicinity of equipment marked with the following symbol: 
NOTE 1 At 80 MHz and 800 MHz, the higher frequency range applies. NOTE 2 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

[50] The ISM (industrial, scientific and medical) bands between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz.

[51] The compliance levels in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range 80 MHz to 2.5 GHz are intended to decrease the likelihood that mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas. For this reason, an additional factor of 10/3 is used in calculating the recommended separation distance for transmitters in these frequency ranges.

[52] Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the ventilator is used exceeds the applicable RF compliance level above, the ventilator should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the ventilator.

[53] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

Table 205 - 60601-1-2 © IEC:2001(E)

Recommended separation distances between portable and mobile RF communications equipment and the ReVel ventilator.

The ReVel ventilator is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the ReVel ventilator can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the ReVel ventilator as recommended below, based on the maximum output power of the communications equipment.

Rated maximum output power of transmitter (W)	Separation distance according to frequency of transmitter (m)			
	150 kHz to 80 MHz outside ISM bands	150 kHz to 80 MHz in ISM bands	80 MHz to 800 MHz	800 MHz to 2,5 GHz
	$d = 1.2\sqrt{P}$	$d = 1.2\sqrt{P}$	$d = 0.60\sqrt{P}$	$d = 1.2\sqrt{P}$
0.01	0.12	0.12	0.060	0.12
0.1	0.37	0.37	0.19	0.36
1	1.2	1.2	0.60	1.2
10	37	37	19	36
100	12	12	6.0	12

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1 **At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.**

NOTE 2 **The ISM (industrial, scientific and medical) bands between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.66 MHz to 40.70 MHz.**

NOTE 3 **An additional factor of 10/3 is used in calculating the recommended separation distance for transmitters in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range 80 MHz to 2.5 GHz to decrease the likelihood that mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas.**

NOTE 4 **These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.**

Appendix D - GLOSSARY

Term	Definition
AC	Alternating Current (typically mains electrical power).
Airway Pressure	The airway pressure measured at the patient circuit, patient connection port.
Airway Pressure Display	A bar graph type display composed of 60 LEDs. This display shows the real-time breath by breath Airway Pressure.
Alarm	An audible and visual announcement that an alarm condition has been met. Audible notification includes an oscillating or continuous tone. Visual notification may include flashing displays, illuminated LEDs, and text messages shown in the front panel display window.
Apnea	Apnea happens when the time between breath starts exceeds the set Apnea Interval.
Apnea Backup Ventilation	Apnea Backup Ventilation begins when an Apnea alarm occurs and continues until the patient initiates 2 consecutive breaths or the alarm is canceled by an operator. Apnea Backup Ventilation is given in the Assist/Control mode.
Apnea Interval	The maximum period of time allowed between breath starts. If the time between breath starts exceeds this interval, an Apnea alarm occurs.
Assist Breath	A volume or pressure breath that the patient triggers, and which is then controlled and cycled by the ventilator. Assist breaths may occur in Assist/Control and SIMV modes.
Assist/Control Mode	A mode of ventilation where the patient receives a minimum number of machine and assist breaths. The available breath types are Volume Control and Pressure Control.
AutoPEEP	Residual pressure trapped in lungs due to incomplete exhalation.
Autozero	The procedure for determining the transducer zero offset for ambient pressure.
Barotrauma	The difference in pressure between internal organs and the outer surface of the body causes injuries to internal organs that contain gas, such as the lungs, gastrointestinal tract, and ear.
BdP	Blower differential pressure.
Beats/min	Pulse Rate per minute (pulse measured by the Pulse Oximetry Module).
Bias Flow	A constant stream of gas through the patient circuit during the exhalation phase of the breath.
bpm	Breaths Per Minute.
Breath Period	The time between consecutive breaths.
Breath Rate, monitored (f)	The quantity of breaths given per minute; includes all breath types.

Term	Definition
Breath Rate, set	The minimum quantity of machine breaths given in a minute.
BTPD	Body Temperature, Pressure Dry.
BTPS	Body Temperature Pressure Saturated[54]. A BTPS measurement is achieved when the compressible fluid is at 98.6°F (37°C), ambient barometric pressure, and saturated with water vapor.
C Static	Static Lung Compliance.
Circuit	See Patient Circuit.
Circuit Pressure	See Airway Pressure.
cmH_2O	Centimeters of water. A unit of measure for pressure.
CPAP	Continuous Positive Airway Pressure. A ventilation mode where the patient triggers and cycles all breaths and the ventilator continuously maintains positive gas pressure through the patient circuit during the entire breath cycle.
CPAP+PS Mode	A ventilation mode where the patient triggers all breaths. Available breath types are Pressure Support and Spontaneous.
DC	Direct Current. Typically electrical current delivered by means of a battery or via a converter which converts the mains supply to one usable by the device.
Display Window (LED)	A set of 12 dot-matrix displays used to show monitored data, alarm messages, Startup and Extended Features menu items.
E-Hold	Expiratory Hold
EPAP	Expiratory Positive Airway Pressure
Event	Any condition noted in the ventilator's Event Trace Log. This may include both error conditions and normal operational events.
Exhaled Minute Volume, (VE)	The total volume exhaled by the patient for the last 60 seconds. VE is based on the last 8 breaths.
Exhaled Tidal Volume (Vte)	The exhaled tidal volume quantified at the patient Wye. Exhaled Volume is measured for all breath types.
Expiratory Hold (E-Hold)	A maneuver which holds the expiratory phase of a delivered breath for a duration sufficient to determine the AutoPEEP of a patient.
Extended Features	A set of ventilator controls and options that is set/configured via menus that are displayed and accessed through the front panel display window.
f	See Breath Rate, monitored.
f/Vt	Rapid Shallow Breathing Index – Derived during a SBT maneuver by dividing the breath rate by the average monitored tidal volume.
FIO_2	Fraction of Inspired Oxygen.

[54] All references to compressible flow and compressible volume in the patient pneumatic pathway are BTPS unless stated otherwise.

Term	Definition
Flow (V)	The velocity of gas delivery to the patient, quantified in lpm.
Flow Trigger	A patient effort in which the amount of bias flow routed into the patient's lungs exceeds the flow trigger **Sensitivity** setting. A flow trigger will result in delivery of an Assist or Patient breath, according to the ventilation mode.
I Time	Inspiratory Time, measured
I:E	The ratio of the inspiration period to the expiration period for a breath. Calculated by dividing the measured Inspiratory Time by the measured Exhalation Time.
I:Ecalc	Calculated Inspiratory: Expiratory ratio, based on Inspiratory Time, Inspiratory Pause and Breath Rate settings.
I-Hold	Inspiratory Hold
Inspiratory Hold (I-Hold)	A maneuver which holds the inspiratory phase of a volume delivered breath for a duration sufficient to determine the static lung compliance of the patient.
IPAP	Inspiratory Positive Airway Pressure
L	Liters
Leak	Measured leak is the steady state exhalation flow measured at the patient Wye. It represents the amount of air leaking out of the system after the patient connection port of the Wye.
Leak Compensation	Leak Compensation is a feature that compensates triggering and monitor values for leaks after the patient Wye.
LED	Light Emitting Diode
lpm	Liters Per Minute. Measurement of flow rate.
Machine Breath	A volume or pressure breath that is started by the operator or the ventilator, and is controlled and cycled by the ventilator.
Manual Breath	A Machine Breath initiated by pushing the **Manual Breath** button.
MAP	Mean Airway Pressure
Mean Airway Pressure, monitored	The average airway pressure over a series of breaths.
Minimum Exhalation Time	The minimum time required for exhalation is 346 msec. Control settings are limited to ensure the Minimum Exhalation Time is provided. Breaths may not be triggered during the Minimum Exhalation Time.
Minimum Inspiratory Time	The minimum time required for inspiration is 300 msec. Control settings are limited to ensure the Minimum Inspiratory Time is provided.
Msec	Millisecond: One one-thousandth of a second.
Non Volatile Memory	Memory that is retained when ventilator is powered off.
O_2	Oxygen
O_2 Inlet	O_2 Source Pressure
Patient Breath	A Pressure Support or Spontaneous breath that is started by the patient, controlled by the ventilator and cycled by the patient.

Term	Definition
Patient Circuit	The airway tubing that connects the ventilator and the patient.
Patient Effort	Inspiratory effort by the patient.
Paw	Airway Pressure, measured at the patient Wye.
Peak Inspiratory Pressure, monitored (PIP)	The maximum circuit pressure occurring during the inspiration and first 346 ms exhalation phase of a breath. PIP is measured at the patient Wye.
PEEP	Positive End Expiratory Pressure.
PEFR	Peak Expiratory Flow Rate, measured at the patient Wye.
PIFR	Peak Inspiratory Flow Rate, measured at the patient Wye.
PIP	Peak Inspiratory Pressure, measured at the patient Wye.
Positive End Expiratory Pressure, monitored (PEEP)	The circuit pressure measured at the end of exhalation.
POST	Power On Self Tests. A set of self-tests the ventilator performs when turned on to verify the operational integrity and the validity of all stored configuration values, event log, RAM and program memory.
Presets	Automatically set ventilation control and alarm limit values initially clinically appropriate for the patient size and patient circuit type selected by the operator during ventilator setup for a New Patient.
Pressure Control Breath	A machine or assist breath where the circuit pressure is elevated to an operator-set pressure for an operator-set period of time. Pressure Control breaths have an optional flow termination criteria.
Pressure Support Breath	A patient breath where the circuit pressure is raised to an operator-set pressure and maintained until flow decreases to an operator-set percentage of the peak flow achieved. Pressure Support Breaths may also be terminated by a pre-set maximum time, or by exceeding 2 breath periods without otherwise achieving the termination criteria.
Pressure Trigger	A patient effort in which the airway pressure is less than the set PEEP minus the Pressure Trigger (**Pres Trigger**) setting.
∆ Pres	Delta Airway Pressure
PRVC	Pressure Regulated Volume Control
PS	Pressure Support Ventilation
PSI/PSIG	Pounds per Square Inch Gauge. A unit for measuring pressure.
SBT	Spontaneous Breathing Trial
Scrolling, Monitored Data Display	Allows the user to display the monitored values statically or automatically scroll them. While scrolling is active, each monitored value will be displayed for 3 seconds then the next value will be automatically displayed.
SIMV	Synchronized Intermittent Mandatory Ventilation.
SIMV Mode	A ventilation mode where a minimum number of Machine or Assist breaths are given and the patient is allowed to trigger additional Patient breaths.

Term	Definition
Sp f	Spontaneous Breath Rate
SpO_2	Functional oxygen saturation of arterial hemoglobin, measured non-invasively by Pulse Oximetry.
Spontaneous Breath	A breath which the patient triggers and cycles.
SpVte	Spontaneous Exhaled Tidal Volume
Startup Menus	A set of menus accessed while the ventilator is in Startup mode and used to initiate Same or New Patient ventilation, enter/revise Patient ID, set basic ventilator configurations, perform specific functional testing and access ventilator component revision and software version information.
Tidal Volume, set	The volume of air delivered to the patient circuit for each volume or PRVC breath.
Time Term	The Time Term menu is used to set the maximum inspiratory time for terminating Pressure Support, Pressure Regulated Volume Support (PRVS) and Spontaneous breaths.
Total Breath Rate	See Breath Rate, monitored.
Transducer	A measuring device. Transducers can be used to quantify flow or pressure.
UART	Universal Asynchronous Receiver/Transmitter
V/BR	Volume Breath Delay
VE	Exhaled Minute Volume
Volume Control Breath	A machine or assist breath where a pre-set volume is delivered over a pre-set time. Flow is delivered in a decelerating waveform where the peak and final flows are calculated so that the final flow is 50% of the peak flow.
Vte	Exhaled Tidal Volume, monitored
Vti	Inspiratory Tidal Volume
V	Flow
Vcalc	The calculated peak flow for Volume Control breaths. Vcalc is calculated based on the set Tidal Volume and the Set Inspiratory Time.
Vepk	Peak Expiratory Flow
Vpeak	Peak Inspiratory Flow

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Appendix E - INDEX

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