CARESCAPE™ R860

User's Reference Manual

Software Revision 10

User responsibility

Datex-Ohmeda, Inc. a General Electric Company, doing business as GE Healthcare.

This product will perform in conformity with the description thereof contained in this User's Reference manual and accompanying labels and/or inserts, when assembled, operated, maintained, and repaired in accordance with the instruction provided. This Product must be checked periodically. A defective Product should not be used. Parts that are broken, missing, plainly worn, distorted, or contaminated should be replaced immediately. Should repair or replacement become necessary, Datex-Ohmeda recommends that a telephonic or written request for service advice be made to the nearest Datex-Ohmeda Customer Service Center. This Product or any of its parts should not be repaired other than in accordance with written instructions provided by Datex-Ohmeda and by Datex-Ohmeda trained personnel. The Product must not be altered without the prior written approval of Datex-Ohmeda. The user of this Product shall have the sole responsibility for any malfunction which results from improper use, faulty maintenance, improper repair, damage, or alteration by anyone other than Datex-Ohmeda.

CAUTION U.S. Federal law restricts this device to sale by or on the order of a licensed medical practitioner.Outside the U.S.A., check the local laws for any restriction that may apply.

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1 Introduction

In this section

Welcome

Thank you for choosing the GE Healthcare CARESCAPE™ R860. Our goal is to provide you with the highest quality product and services available. This ventilator features a user interface specifically designed to streamline workflow while providing exceptional insight into patient needs.

Indications for use/Intended use

The CARESCAPE R860 ventilator is designed to provide mechanical ventilation or support to neonatal, pediatric, and adult patients weighing 0.25 kg and above.

The CARESCAPE R860 ventilator is a microprocessor based, electronically controlled, pneumatically driven ventilator that includes integrated monitoring of FiO2, airway pressure, flow, and volume. Additional respiratory gas monitoring capabilities are supported through the use of optional GE patient monitoring modules.

Not all features are available for all patient types or product configurations.

The CARESCAPE R860 ventilator is not a pulmonary function calculation device.

The system is designed for facility use, including within-facility transport, and should only be used under the orders of a clinician.

Contraindications

None known.

Operational use

The ventilator must only be operated by authorized medical personnel well trained in the use of this product. The ventilator must be operated according to the instructions in this User's Reference Manual.

WARNING This ventilator is not intended for use as a facility to facility transport ventilator.

- This ventilator is not indicated for use with anesthetic agents.
- MR unsafe. This ventilator is not suitable for use in a magnetic resonance imaging (MRI) environment.

Trademarks

CARESCAPE, D-fend, INView, SpiroDynamics, and ***Trim Knob*** are registered trademarks of General Electric Company and its subsidiaries.

All other brand names or product names used in this manual are trademarks or registered trademarks of their respective holders.

Serial numbers

Datex-Ohmeda products have unit serial numbers with coded logic which indicates a product group code, the year of manufacture, and a sequential unit number for identification.

AAAX11111
The AAA represents the product group code. The X represents an alpha character indicating the year the product was manufactured: R = 2012, S = 2013, etc. The letters I and O are not used. The 11111 represents a unique identifier.

General information

The CARESCAPE R860 combines sophisticated technology and an intuitive user interface. Icons represent configurable views of past (historical trends), present (patient status), and future patient needs (clinical decision support).

The ventilator consists of a display, ventilator unit, cart with AC outlet (optional), EVair compressor (optional), and module bay with gas module (optional).

A wide selection of performance options give the user full control of the system configuration. This ventilator is a complete system featuring patient ventilation, monitoring, and the capability of interfacing with central monitoring.

Full touchscreen capability allows the user to quickly and easily access patient information and procedures.

This ventilator supports adult, pediatric, and neonatal patients. The basic ventilator is equipped with adult and pediatric patient type software. The neonatal software option can be added or the ventilator can be set to enable the Neonatal-Only option. When the Neonatal-Only option is set, the ventilator is only intended to be used for neonatal patients and will not be able to enter the adult or pediatric patient types.

This ventilator comes with standard ventilation modes as well as purchasable ventilation modes and clinical decision support features.

See "*Ventilation modes*" section for detailed information describing each ventilation mode.

Standard ventilation modes:

- A/C VC (Assist Control Volume Control)
- A/C PC (Assist Control Pressure Control)
- A/C PRVC (Assist Control Pressure Regulated Volume Control)
- SIMV VC (Synchronized Intermittent Mandatory Ventilation Volume Control)
- SIMV PC (Synchronized Intermittent Mandatory Ventilation Pressure Control)
- CPAP/PS (Continuous Positive Airway Pressure/Pressure Support)
- SBT (Spontaneous Breathing Trial)

Purchasable options:

- Neonatal

Purchasable ventilation modes:

- nCPAP (nasal Continuous Positive Airway Pressure)
- SIMV PRVC (Synchronized Intermittent Mandatory Ventilation Pressure Regulated Volume Control)
- BiLevel

- BiLevel VG (BiLevel airway pressure ventilation Volume Guaranteed)
- VS (Volume Support)
- NIV (Non-Invasive Ventilation)
- APRV (Airway Pressure Release Ventilation)

Purchasable features:

- FRC (Functional Residual Capacity)
- SpiroDynamics

Configurations available for this product depend on local market and standards requirements. Illustrations or photos in this manual may not represent all configurations of the product. This manual does not cover the operation of every accessory. Refer to the accessory documentation for further information.

Note The assembly of the ventilator system and modifications during its service life require evaluation to ensure the requirements of IEC 60601-1:2005 are met.

Refer to the Technical Reference Manual for service information including: special installation instructions, installation checklist, means of isolating the main power supply, and replacement of fuses, supply cord, and other parts.

Neonatal manual

The neonatal manual is located within this manual and begins at Section 17 - Neonatal Introduction. The neonatal portion of this manual has been tailored to facilities whose main patient type is neonates. See Table of Contents for exact location information. Shared sections of this manual for adult, pediatric, and neonatal patient types:

- "*Introduction*"
- "*Symbols and abbreviations*"
- "*Navigation*"
- "*Setup and connections*"
- "*System configuration and service*"
- "*Cleaning and maintenance*"
- "*Clinical theory*"
- "*System theory of operation*"
- "*Parts and accessories*"

2 Symbols and abbreviations

In this section

Abbreviations

Abbreviation	Definition
A	
AaDO2	Alveolar arterial oxygen gradient
A/C PC	Assist control pressure control
A/C PRVC	Assist control pressure regulated volume control
A/C VC	Assist control volume control
APRV	Airway pressure release ventilation
B	
BiLevel	BiLevel airway pressure ventilation
BiLevel VG	BiLevel airway pressure ventilation volume guaranteed
BSA	Body surface area
BTPS	Body temperature and pressure, saturated humidity conditions
C	
C	Compliance
Cstat	Static compliance
CPAP/PS	Continuous positive airway pressure - pressure support
CO	Cardiac output
E	
EE	Energy expenditure
EtCO2	End tidal carbon dioxide
EtO2	End tidal oxygen
F	
F-V	Flow volume loop
FI-ET	Difference between inspiratory and expiratory concentrations
FiO2	Fraction of inspired oxygen
FRC	Functional residual capacity
H	
Hb	Hemoglobin
I	
I:E	Inspiratory to expiratory ratio
Insp Pause	Inspiratory pause time
K	
kg	kilogram
M	

ml	milliliters
MVexp	Expired minute volume
MVexp mech	Expired minute volume per mechanical breath
MVexp spont	Expired minute volume per spontaneous breath
MVexp/wt	Expired minute volume per patient weight
MVinsp	Inspired minute volume
N	
nCPAP	Nasal continuous positive airway pressure
NFS	Neonatal Flow Sensor
NIF	Negative inspiratory force
NIV	Non-invasive ventilation
O	
O2	Oxygen
P	
P 0.1	Airway occlusion pressure
PaO2	Arterial pressure of oxygen
PAO2	Alveolar arterial oxygen gradient
PaO2/PAO2	Alveolar arterial oxygen pressure gradient
PaCO2	Arterial partial pressure of carbon dioxide
Pa/FiO2	Oxygenation ratio
PvO2	Venous partial pressure of oxygen
P-V	Pressure volume loop
Paux	Auxiliary pressure
Paw	Airway pressure
PEEP	Positive end expiratory pressure
PEEPe	Extrinsic positive end expiratory pressure
PEEPe+i	Total positive end expiratory pressure
PEEPi	Intrinsic positive end expiratory pressure
P-F	Pressure flow loop
Pexp	Expiratory pressure
Phigh	High-pressure setting for APRV
Pinsp	Inspiratory pressure
Plimit	High pressure limit
Plow	Low-pressure setting for APRV
Pmax	Maximum pressure
Pmean	Mean pressure
Pmin	Minimum inspiratory pressure above PEEP
Ppeak	Peak pressure
Pplat	Plateau pressure
PS	Pressure Support
R	

Rate	Respiratory rate
Raw	Airway resistance
RR	Respiratory rate
RQ	Respiratory quotient
RSBI	Rapid shallow breathing index
S	
SaO2	Arterial oxygen saturation level (of hemoglobin)
SBT	Spontaneous breathing trial
SIMV PC	Synchronized intermittent mechanical ventilation pressure control
SIMV PRVC	Synchronized intermittent mandatory ventilation pressure regulated volume control
SIMV VC	Synchronized intermittent mechanical ventilation volume control
SD	Secure digital
STPD	Standard temperature pressure dry
SvO2	Venous oxygen saturation level (of hemoglobin)
T	
Thigh	Time setting for high pressure in APRV
Tinsp	Inspiratory time
Tlow	Time setting for low pressure in APRV
Tsupp	Maximum inspiratory time for a pressure-supported breath
U	
USB	Universal Serial Bus
V	
VA	Alveolar ventilation
VCO2	Carbon dioxide production
Vd	Dead space volume
Vd/Vt	Dead space ventilation
VO2	Oxygen consumption
VO2/kg	Oxygen consumption per kilogram
VO2/m2	Oxygen consumption per square meter
Vol	Volume
Vol/wt	Volume per patient weight
VT	Tidal volume
VTexp	Expired tidal volume
VTexp mech	Expired tidal volume per mechanical breath
VTexp spont	Expired tidal volume per spontaneous breath
VTexp/wt	Expired tidal volume per patient weight
VTinsp	Inspired tidal volume

Symbols, safety and manual terms

Read all user safety and manual instructions necessary to operate this device safely and in accordance with its functions and intended use.

Symbols replace words on the equipment, the user interface (display), the packaging, or in the product manuals.

WARNING Tells about a condition that can cause injury to the operator or the patient.

- Consecutive bullets after a warning denotes a list of warnings.

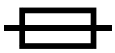
CAUTION Tells about a condition that can cause damage to the equipment.

- Consecutive bullets after a caution denotes a list of cautions.

Important Tells about information that must be followed in order to ensure proper functionality.

Note Tells about additional information.

Symbols on the equipment

	On (power)		Off (power)
	Refer to instruction manual or booklet (blue background)		Caution: federal law prohibits dispensing without prescription
	Type BF equipment		Type B equipment
	General warning (yellow background)		Caution
	Warning; dangerous voltage		Operating instructions
	Stock number		Serial number
	Direct Current		Alternating current
	Protective earth ground		Earth ground
	Equipotential		Fuse

	Variability		Variability in steps
+	Plus, positive polarity	−	Minus, negative polarity
	Movement in one direction		Movement in two directions
	Pneumatic inlet		Pneumatic outlet
AIR	Air inlet	O_2	Oxygen
INSP	Inspiratory port	EXP	Expiratory port
	Electronic micropump nebulizer		Heat transfer
P_{aux}	Paux	XXX Kg	Maximum mass of configured mobile equipment
	USB Port		Not a USB Port
	Display signal input/output		VGA connection
	Network		Serial port
	Electrical testing certification		Electrostatic sensitive devices
	Airway module bay port		Single use device
	Union made		Functional Residual Capacity option is installed
	Date of manufacture		Manufacturer
	Indicates that the waste of electrical and electronic equipment must not be disposed as unsorted municipal waste and must be collected separately. Please contact an authorized representative of the manufacturer for information concerning the decommissioning of equipment.	CE XXXX	Systems with this mark agree with the European Council Directive (93/42/EEC) for Medical Devices when they are used as specified in the User's Reference Manuals. The xxxx is the certification number of the Notified Body used by Datex-Ohmeda's Quality Systems.
EC REP	Authorized representative in the European Community		GOST R Russian certification
	Neonatal option is installed		SpiroDynamics option is installed

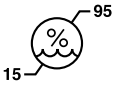
	Non-ionizing electromagnetic radation		MR unsafe MRI not compatible
	Standby		Batch number
	Use-by date		Autoclavable
	Not autoclavable		Active alarm
	Eurasian conformity		Ukraine national conformity
	Unique device identifier		

Symbols on the user interface

	Menu		Adult patient type
	Pediatric patient type		Neonatal patient type
	Start (green)		Stop (red)
	Alarm		Alarm audio off
	Audio pause		Settings
	Setup		Trends log view
	Increase O2		Information
	General Warning (yellow background)		Help
	Battery power		Main power
	Delta FRC (change in FRC)		Home
	Standby		Present /Patient Status workspace
	Basic view		Basic Waveform view

	Advanced Waveform view		Spirometry view
	Future/Clinical Decision Support workspace		Measured values (numeric trends) view
	Graphic trends view		Ventilator calculations view
	Charting view		FRC view
	FRC view (Brazilian Portuguese, Portuguese, French)		Save metabolics data
	Pass (green)		Fail (red)
	Metabolics view		Splitscreen view
	SBT (Spontaneous Breathing Trial) view		SBT (Spontaneous Breathing Trial) view (Brazilian Portuguese)
	SBT (Spontaneous Breathing Trial) view (French)		SBT (Spontaneous Breathing Trial) view (Portuguese)
	Dynostatic curve volume		Snapshot trends view
	Event		No battery
	More/Top (scroll bar)		Less/Bottom (scroll bar)
	Left (scroll bar)		Right (scroll bar)
	Pause		Past/Historical Trends workspace
	Invasive ventilation		Non-invasive ventilation
	Mode favorites (partial list of ventilator modes)		Full list of ventilator modes
	Patient data		Ventilator data
	Lock: used to identify a control or function is locked or to show the locked status.		Unlock: used to identify a control or function is not locked or to show the unlocked status.

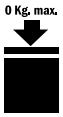
Symbols on the packaging



Humidity limitation

Temperature limitation

Do not stack



Stacking limit by mass

Fragile; handle with care

Recyclable material

Keep dry

Protect from heat and radioactive sources

This way up

Atmospheric pressure limitation

3 Navigation

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

Ventilator display

The 15-inch touchscreen display provides audible and visual alarms, integrated key pad, and a Trim Knob control. The display unit uses the Panasonic CR2477/BN battery (1000 mAh and 3V). To select menu options or settings, touch only one touch point at a time to make sure the correct selection is made. Touch the setting or press the Trim Knob to confirm settings.

The touchscreen allows swipe gestures to move from one workspace to another workspace.

Do not use pencils, pens, or other objects to activate the touchscreen. The touchscreen will not function properly if tape or paper is stuck to the display surface.

WARNING Liquids on the display may degrade the performance of the touchscreen. If liquids come in contact with the display, lock the touchscreen and clean the display. Unlock the touchscreen once the display has been cleaned to resume use of the touchscreen.

CAUTION Do not apply excessive force to the touchscreen as damage may occur.

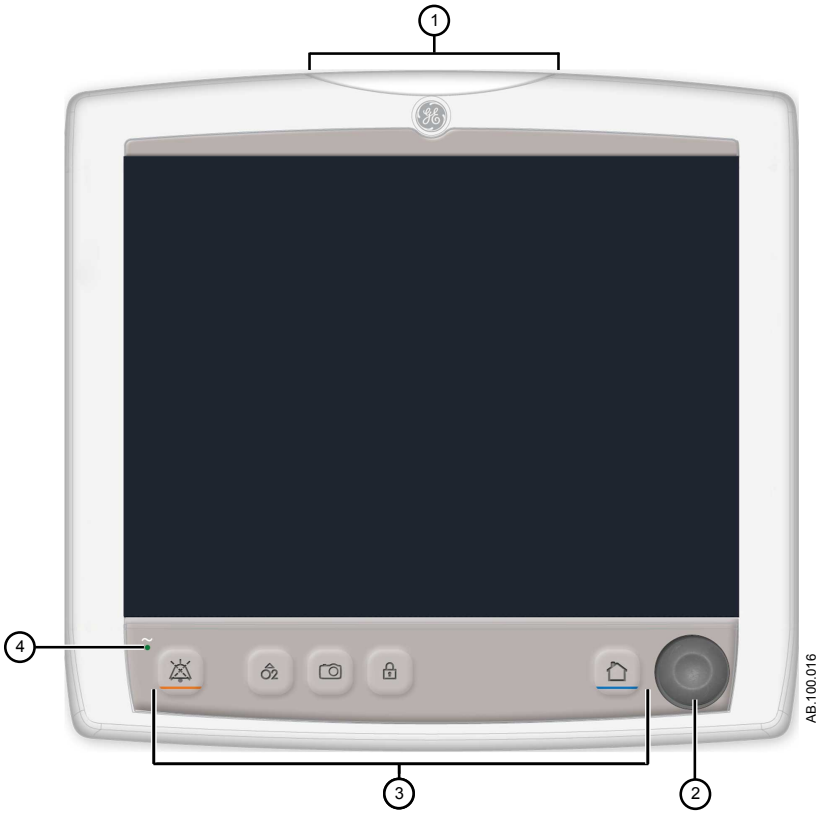


Figure 3-1 • Display controls and indicators

1.	Alarm light	The integrated alarm light provides a visual alarm when an alarm condition occurs. The alarm light also provides a visual indicator when Audio Pause is active and alarm audio is silenced.
2.	Trim knob control	Turn the Trim Knob clockwise or counterclockwise to change a setting. Press the Trim Knob to confirm a setting.
3.	Hard keys (key pad)	Press the Audio Pause, Increase O2, Snapshot, Lock/Unlock, or Home hard keys to access the associated features. • Audio Pause: Press to silence alarms for 120 seconds.
4.	LED indicator	The green LED illuminates when the ventilator is connected to the main power supply. The internal battery is charging when the LED is lit.

Display user interface

The user interface incorporates the Menu, Current Patient menu, alarm management, and Favorites procedures at the top of the display. The patient status (airway pressure bar) and workspace/ monitoring area are located in the middle of the display. The navigation bar, message areas, battery status, standby, and quick keys are located at the bottom of the display.

Figure 3-2 • Display user interface components

1. Favorites — Provides short-cuts for up to four procedures (as selected by the user). Use to select specific procedures such as Increase O2, Inspiratory Hold, Expiratory Hold, and Manual Breath. See "*Setting Favorites*" in the "*Operation*" section.
2. Patient status — The airway pressure bar shows a dynamic view of the patient airway pressure, Pmax, Ppeak, PEEP, FiO2, and VTexp. Use the tab on the pressure bar to collapse (hide) from view when available.

3.	Navigation	Select an icon to open the corresponding view. See "*Navigating the user interface*" for detailed information.
4.	Additional Information	Shows current time and additional setting information.
5.	Main power	Indicates whether the ventilator is connected to the main power supply or is running on battery. Also shows battery status when running on battery.
6.	Standby	Select the Standby quick key to go into Standby (pause/stop ventilation). See "*Standby*" in the "*Operation*" section.
7.	Quick Keys	Select to change the corresponding ventilator setting. Turn the Trim Knob to make a change. Select the quick key or press the Trim Knob to activate the change. When a quick key setting is selected, a Trim Knob visual cue indicates the change may be made by turning the Trim Knob and pressing to confirm the setting.
8.	Current Mode and Mode Settings	Shows the active ventilation mode. Select to access ventilation modes, and change mode settings.
9.	General Messages	Shows notices, procedure status, and system status information to the user. See "*General messages*" in the "*Alarms and troubleshooting*" section.
10.	Monitoring	This area is used to view waveforms, measured data, and settings.
11.	Menu	Select to quickly access options such as: System menu, Procedures, Lung Mechanics, Suction, and Nebulizer. See "*Main menu*" in the "*Navigation*" section.
12.	Current Patient menu	Select to enter the Current Patient menu. This menu allows entry of the patient ID using an alpha-numeric keyboard. Entered values for patient gender, height, and weight are used to calculate BSA (body surface area), and IBW (ideal body weight). This menu also allows the selection of tube type and diameter. See"*New Patient*" and "*Current Patient*" in the "*Operation*" section.
13.	Alarm management	Select to view alarms, alarm history, alarm setup, and alarm help. See "*Alarms and troubleshooting*" section.

Navigating active alarms

When an alarm occurs for measured data, the number and alarm limits are shown with a border around them. The color of the border and the alarm limit shows the priority of the alarm. Select within the border of the active alarm to open the Alarm Setup menu. Select the alarm limit that needs adjustment, then use the Trim Knob to adjust the setting and confirm changes. See "*Alarm management*" in the "*Alarms and troubleshooting*" section for additional information.

Figure 3-3 • Select inside of the border to open the Alarm Setup menu.

Standby

Standby is displayed upon system startup or when the Standby quick key is selected. When the system is in Standby, the Standby quick key and the patient status (airway pressure) bar are colored tan. A “Standby” message is displayed in the navigation bar when in the Present/Patient Status workspace. Standby is used to stop ventilation to the patient, select a New or Previous patient, perform a System Check, and Park/Unpark the patient circuit. The Setup button accesses the password protected Configuration (Super User) and Service menus.

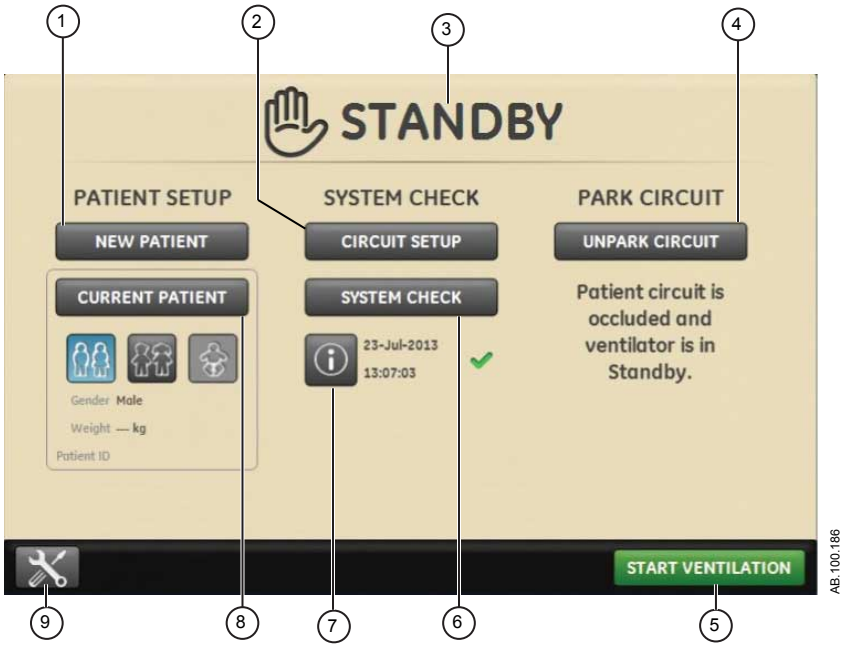


Figure 3-4 • Standby menu

1.	New Patient	Select New Patient to enter patient information.
2.	Circuit Setup	Select Circuit Setup to select HME or Humidifier for adult and pediatric patient types.
3.	Standby	When Standby (hand icon) is selected the Standby menu displays. If the Patient detected alarm occurs, the Standby menu automatically displays.
4.	Park/Unpark Circuit	When the circuit is parked a message displays: Patient circuit is occluded and ventilator is in Standby.
5.	Start Ventilation	Select to start patient ventilation.
6.	System Check	Select System Check to perform a ventilator system check.
7.	Information	Select to access information regarding the system check status and troubleshooting.
8.	Previous Patient/Current Patient	Select Previous Patient to use the previous patient's ventilator settings and patient information. Select Current Patient to open the Current Patient menu and use the current patient's ventilator settings and patient information.
9.	Setup	Select to access the Configuration (Super User) and Service menus. A password is required to enter these menus. Contact a training representative to obtain the password.

Main menu

Select Menu to quickly access ventilator features and options.

Figure 3-5 • The main Menu accesses the System menu, Procedures, Lung Mechanics, Nebulizer, and Suction options.

1. System — Use the System menu to access data source, module type and version, calibrations (Paux Zero and Purge Flow), and display brightness. The System menu shows the software version, running hours, altitude, O2 supply pressure, air supply pressure, and battery status. See "*System menu*" located in this section.
2. Procedures — Use the Procedures menu to access the Assign Favorites menu and the following procedures: Manual Breath, Increase O2, Inspiratory Hold, Expiratory Hold, and Auto PEEP. See "*Setting Favorites*" in the "*Operation*" section.
3. Lung Mechanics — Use the Lung Mechanics menu to access the Assign Favorites menu and the following procedures: P0.1, Negative Inspiratory Force (NIF), and Vital Capacity. See "*Setting Favorites*" in the "*Operation*" section.
4. Nebulizer — Use the Nebulizer menu to access the Aerogen and Pneumatic Nebulizer procedures. See "*Setting Favorites*" section in the "*Operation*" section.
5. Suction — Use the Suction menu to access the Assign Favorites menu and the Suction procedure. See "*Setting Favorites*" in the "*Operation*" section.

System menu

The System menu contains settings for data source selection, calibration options, display brightness, and system information.

1. Select ***Menu*** > ***System***.

The Airway Module type and software version number are shown under data source.

2. Select Data Source (***Ventilator*** or ***Airway Module***).

   - For Neonatal; select ***Ventilator*** or ***NFS***. See "*System menu*" in the "*Neonatal Operation*" section.

3. Select Calibrations (***Airway Module***, ***Paux Zero***, or ***Purge Flow***).

   - Select Airway Module to calibrate the airway module.
   - Select Paux Zero. A green check mark indicates Paux Zeroing calibration was successful.
   - Select Purge Flow. The Purge Flow check box may be checked or unchecked when performing a Paux Zero. Continuous purge flow will come from the Paux outlet when the Purge Flow check box is selected. A white check mark indicates Purge Flow is active.

Note See "*Purging the auxiliary pressure tubing*" and "*Zeroing auxiliary pressure*" in the "*Setup and connections*" section.

4. Select ***Display Brightness*** to adjust the brightness level of the user interface.

   Select brightness level of 1 (low) to 5 (high).

5. View system information: software version, service packet version, running hours, altitude, O2 supply pressure, air supply pressure, and battery status.

Changing a setting

1. Touch the setting.
2. Change the value by turning the Trim Knob or selecting a menu item.
3. Touch the setting or push the Trim Knob to confirm the setting.

Figure 3-6 • The Trim Knob graphic is used to indicate that the use of the Trim Knob is necessary to change or confirm a setting

Note To cancel or back out of a setting change, select X in the lower right corner of the menu, touch outside of the setting twice,

select the Home hard key, or wait for the selection to time out. For example, ventilation and alarm setting changes can be cleared by selecting the Home hard key prior to confirming a setting.

Navigating the user interface

The ventilator user interface uses three different workspaces: Past/ Historical trends, Present/Patient status, and Future/Clinical decision support. Each workspace (rectangle icon) contains views (circle icons) that contain different configurations of data and functions.

When a workspace is selected, the correlating view icons are displayed.

- Use a swipe gesture or touch a workspace icon to go to a new workspace (swipe gesture: touch display and move finger tip left or right).
- When you navigate away from a workspace and then navigate back, the display will show the last view that was displayed from the workspace.
- If a view is not supported by the current patient type or software is not installed, it will not display.

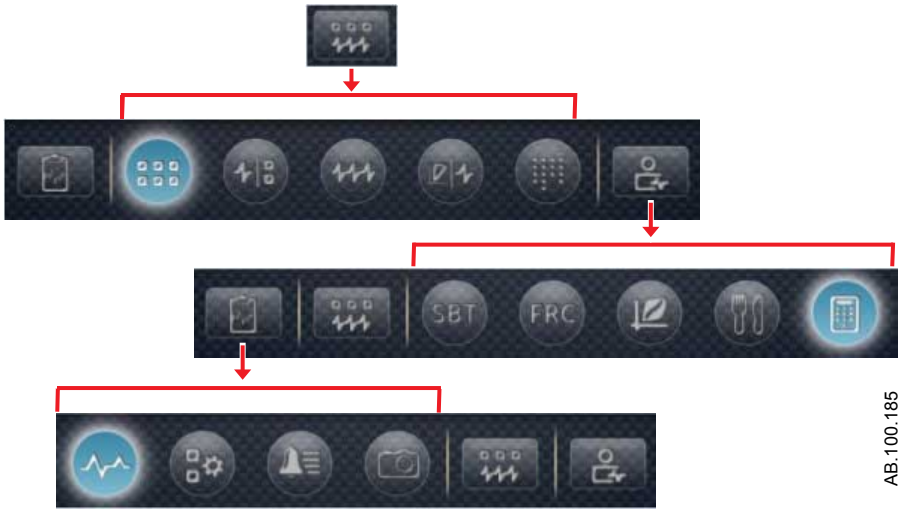


Figure 3-7 • Navigation example; select a workspace (rectangle) to see correlating views (circle).

Present/Patient Status workspace and views

The Present/Patient Status workspace shows the following views: Basic, Basic Waveform, Advanced Waveform, Splitscreen, and Charting. This workspace allows the user to choose the view in which they would like to see patient data displayed. See "*Measured data definitions*" in the "*Patient monitoring*" section for information on the numerics displayed in the Present views. See "*Neonatal measured data definitions*" in the "*Neonatal patient monitoring*" section for information on the numerics displayed in the Present views for a neonatal patient type.

- Touch the icon to display the corresponding view.
- Use a swipe gesture to view and move to Past (Historical trends) and Future (Clinical decision support) workspaces.

Present/Patient Status Workspace


Basic View	
	 AB.100.129
	Use the Basic view to see measured data in a large format that can be easily viewed from a distance. Note: The patient status (airway pressure) bar is permanently displayed to easily view patient airway pressure, tidal volume, and FiO2.

Basic Waveform View	
	 AB.100.119
	Use the Basic Waveform view to see patient waveforms and measured data. Note: the airway pressure bar may be collapsed to expand the monitoring area when the Paw and Flow waveforms are displayed.

Advanced Waveform View	
	 AB.100.120
	Use the Advanced Waveform view to see additional measured data associated with the patient waveforms. Note: The airway pressure bar may be collapsed to expand the monitoring area when the Paw and Flow waveforms are displayed.

Splitscreen View	
	 AB.100.121
	Use the Splitscreen view to see spirometry, measured data, and waveforms. Select the upper right corner of the spirometry waveform to change settings. Note: The airway pressure bar may be collapsed to expand the monitoring area when the Paw and Flow waveforms are displayed.

Charting View	
	 AB.100.122
	Use the Charting view to see a complete list of patient data.The airway pressure bar is permanently displayed to easily view patient airway and pressure settings, tidal volume and FiO2.

Past/Historical Trends workspace and views

The Past/Historical trends workspace shows information for the following views: Graphical trends, Numerical trends, Trends log, and Snapshot trends.

- Touch the icon to display the corresponding view.
- Use a swipe gesture to view and move to Present/Patient status or Future/Clinical Decision Support workspaces.

Past/Historical Trends Workspace


Graphical Trends View	
	 AB.100.123
	Use the Graphical trends view to review historical waveforms and patient trends. See "*Graphical trends view*" and "*Graphical trends view - Neonatal*" in the Patient Monitoring section.

Numerical Trends View	
	 AB.100.124
	Use the Numerical trends view to review patient ventilation modes and settings, measured data, and alarm settings. See "*Numerical trends view*" and "*Numerical trends - Neonatal*" in the Patient Monitoring section.

Trends Log View	
	 AB.100.125
	Use the Trends Log to review patient alarms and settings, and events that have occurred during ventilation. See "*Trends log view*" and "*Trends log view - Neonatal*" in the Patient Monitoring section.

Snapshot Trends View	
	 AB.100.126
	Use Snapshot trends to view saved patient data. See "*Snapshot trends view*" and "*Snapshot trends view - Neonatal*" in the Patient Monitoring section for more information.

Future/Clinical Decision Support workspace and views

The Future/Clinical Decision Support workspace shows the following views (if software is installed): SBT, FRC, Spirometry, Metabolics, and Calculations.

- Touch the view icon to display the corresponding view.
- Use a swipe gesture to move to Present/Patient Status or Past/ HistoricalTrends workspaces and associated views.

Future/Clinical Decision Support


SBT View	
SBT	 AB.100.127
	Use the SBT view to evaluate spontaneous breathing trial data. See "*SBT view*" and "*SBT view - Neonatal*" in the Clinical Decision Support section.

FRC View	
FRC	 AB.100.128

FRC View	
	Use the FRC view to evaluate and review patient respiratory data. The FRC view includes three tabs: Evaluate, FRC INview (FRC procedure), and PEEP INview (PEEP INview procedure). See "*FRC INview procedures*" in the Clinical Decision Support section.

Spirometry View	
	 AB.100.130
	Use the Spirometry view to evaluate and review graphs and data from spirometry and spirodynamic measurements. The Spirometry view includes the Spirometry tab and SpiroDynamics tab. See "*Spirometry view*" and "*Spirometry view - Neonatal*" in the Clinical Decision Support section.

Metabolics View	
	 AB.100.131
	Use the Metabolics view to evaluate and review Metabolics measurements. See "*Metabolics view*" in the Clinical Decision Support section.

Calculations View	
	 AB.100.132
	Use the Calculations view to calculate and review data based on the ventilator, measured data, and laboratory blood gas analysis data. See "*Calculations view*" in the Clinical decision support section.

4 Setup and connections

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

General use and safety precautions

The following section describes the setup of the ventilator. Follow all safety precautions and warnings.

WARNING Make sure system batteries are fully charged before use.

It is recommended that the ventilator maintain connection to the main power supply at all times to prevent battery discharge and degradation. A green LED indicator located on the front lower left of the display unit indicates (when illuminated) that the ventilator is connected to a main power source.

- Access to an appropriate alternative means of ventilation at all times is required to prevent patient injury or death in the event of ventilator failure.
- Do not modify the ventilator equipment without authorization of the manufacturer.
- Adding attachments or other components to the breathing system may change the pressure gradient. Ensure the inspiratory and expiratory resistance do not exceed 6 cmH2O for the following flows:
  - 30 l/min for adult use: VT >= 300 mL
  - 15 l/min for pediatric use: 300 mL >= VT >= 50 mL
  - 2.5 l/min for neonatal use: VT <= 50 mL
- Do not attach a gas scavenging system or other accessories to the gas exhaust port. Occluding the gas exhaust port will prevent proper ventilation for the patient.
- If sampled gas is returned to the breathing system, there is a risk of patient cross-infection.
- Use of other electrical equipment adjacent to or stacked with the ventilator may cause interference. If adjacent or stacked use is necessary, the ventilator should be observed to verify normal operation in the configuration in which it will be used.
- Use of portable phones or other radio frequency (RF) emitting equipment, which exceed electromagnetic interference levels specified in "*Guidance and manufacturer's declaration - electromagnetic immunity*", near the ventilator may cause unexpected or adverse operation. Monitor the function of the ventilator when RF emitters are in the vicinity, including RFID readers and interrogators.
- The ventilator must not be used in a hyperbaric chamber.

- The ventilator must not be used with helium or mixtures with helium.
- A movable part or removable component may present a pinch or crush hazard. Use care when moving or replacing system parts and components.
- Do not cover fans and exhaust ports or position the ventilator in such a way that the operation or performance is adversely affected. Do not place near a radiator or heating unit.
- A compressor should be used if a reliable air pipeline source is not available.
- Do not reuse single-use accessories. Reuse of single-use accessories may cause inaccurate monitoring, alarms, and infection risk to the patient.
- Two gas sources (Air and O2) must be used during clinical use.

CAUTION Use only cables and accessories approved by GE Healthcare. Other cables and accessories may damage the system or cause inaccurate measurements.

Ventilator overview front

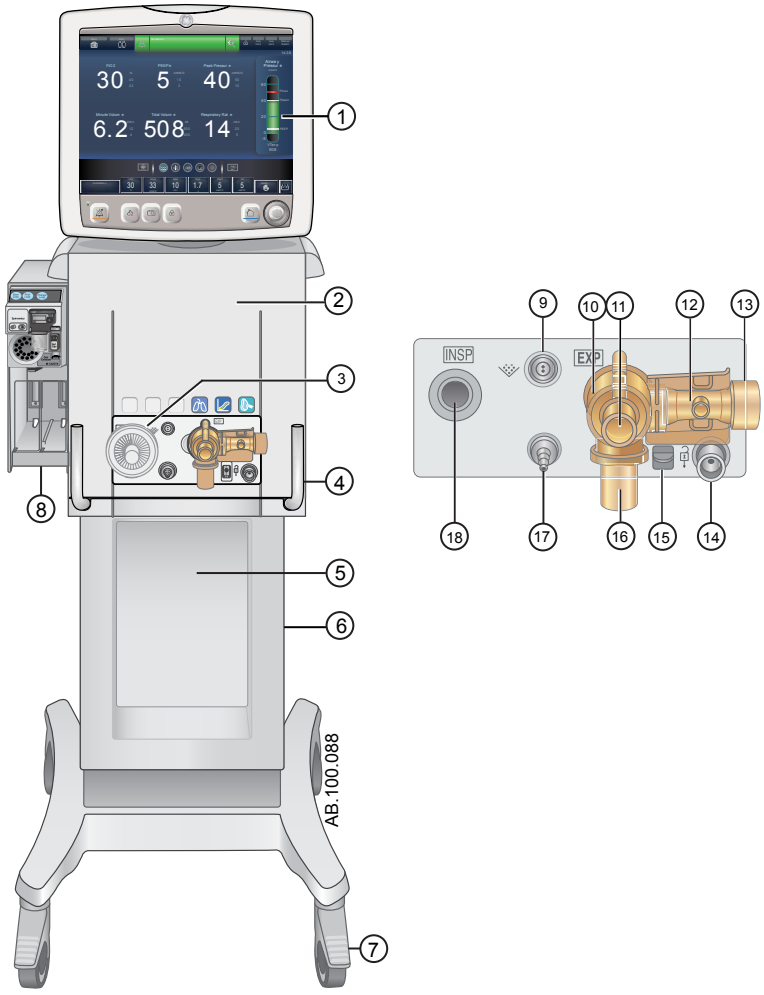


Figure 4-1 • Ventilator front view

1. Display
2. Ventilator unit
3. Inspiratory safety guard
4. Ventilator lock
5. Cart
6. Dovetail rails
7. Caster (wheel)
8. Airway module bay (optional)
9. Nebulizer connection
10. Exhalation valve housing
11. Expiratory port
12. Expiratory flow sensor
13. Gas exhaust port
14. Park circuit port
15. Exhalation valve housing latch
16. Water trap
17. Auxiliary pressure port
18. Inspiratory port

Ventilator overview back

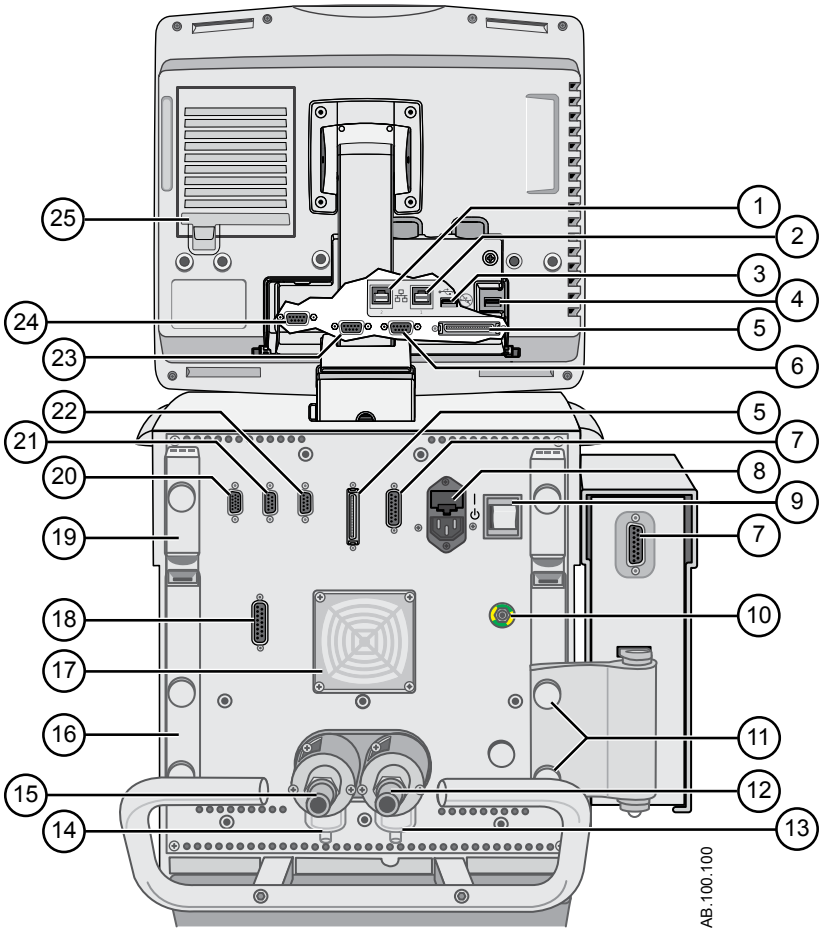


Figure 4-2 • Ventilator back view

Note Not all connections may be available on all ventilator configurations.

1. Ethernet connection (not supported)
2. Ethernet connection (not supported)
3. USB connection (not supported)
4. USB connection (Service connection)
5. Display Unit connection
6. VGA (not for clinical use)
7. Module bay connection
8. Main power inlet and fuse holder
9. Power switch
10. Equipotential stud
11. Module bay mounting thumbscrews
12. Oxygen supply connection (pipeline)
13. O2 high-pressure inlet filter (optional)
14. Air high-pressure inlet filter
15. Air supply connection (pipeline)
16. Retaining channel
17. Ventilator unit fan filter
18. Port 4 (Nurse call)
19. Patient circuit support arm
20. Port 1 (neonatal flow sensor connection)
21. Port 2 (not supported)
22. Port 3 (exhalation valve heater connection)
23. Port 6 (RS232 Serial communication port)
24. Port 5 (RS232 Serial communication port)
25. Display unit fan filter

Connecting power

The power cord is connected on the back of the ventilator as shown. The input power is less than 200 VA.

1. Connect the power cord to the AC power outlet.
2. Press the power switch to turn on the ventilator.
    - Wait approximately 30 seconds to allow the system to warm up.

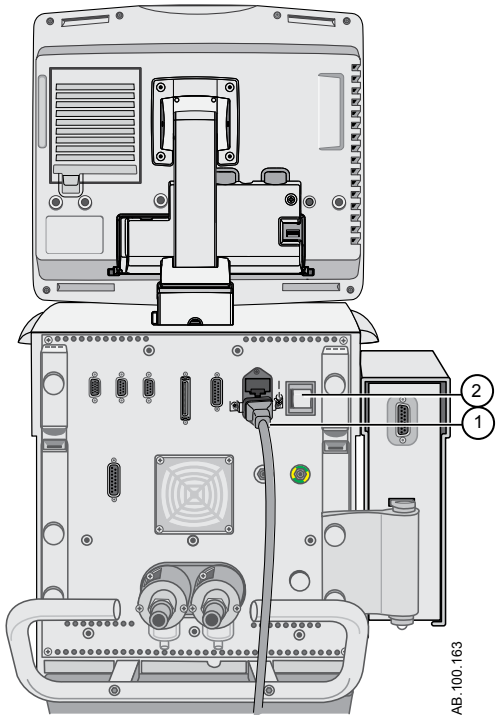


Figure 4-3 • Power connection and switch

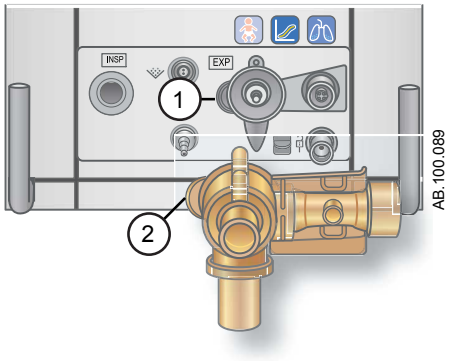
1. Power plug connection
2. Power switch

Connecting and removing the exhalation valve housing

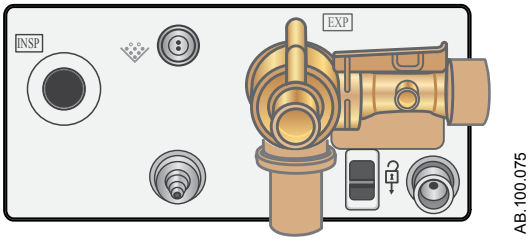
The exhalation valve housing contains the expiratory flow sensor and water trap.

1. To attach the housing, place the tab (2) of the housing into the groove (1) and push the housing into position.

   - Listen for audible click and then gently pull on the housing to make sure it is securely latched.



2. To remove the housing, press down on the latch to release the exhalation valve housing and then pull the housing from the ventilator.



3. Unscrew the water trap to remove from the housing to empty or clean.

Connecting gas supplies

The O2 and air supply connections are located on the back of the ventilator. The air supply connection is on the left side and the O2 supply connection is on the right side as labeled on the ventilator.

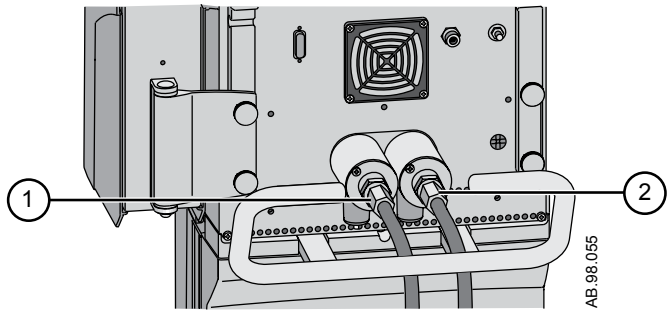
The ventilator comes with a standard air pipeline inlet assembly which includes a filter bowl, o-ring, and filter element. The O2 pipeline inlet filter assembly can be ordered. See the "*Parts and accessories*" section for ordering information.

WARNING Use only gas supply hoses that meet ISO 5359.

- Gas supply sources must contain a safety device which prevents supply pressure from exceeding 1000 kPa during a single fault failure of the gas supply system.

CAUTION Use only clean and dry medical oxygen and air supplies.

1. Connect the air supply connection to the back of the ventilator and tighten.
2. Connect the O2 supply connection to the back of the ventilator and tighten.



1. Air supply connection
2. O2 supply connection

Note To disconnect the air or O2 gas supply connections: unscrew the hoses from the gas supply source, then unscrew the hoses and remove them from the back of the ventilator.

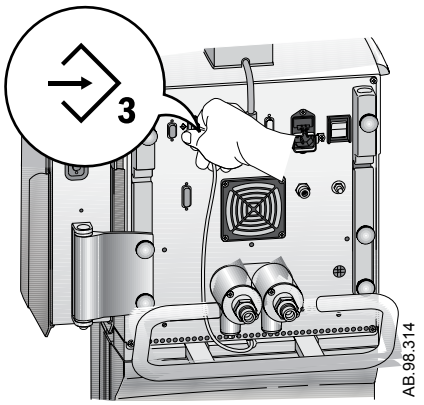
Connecting the exhalation valve heater

Use the exhalation valve heater to prevent moisture from condensing in the expiratory flow sensor when a humidifier is used.

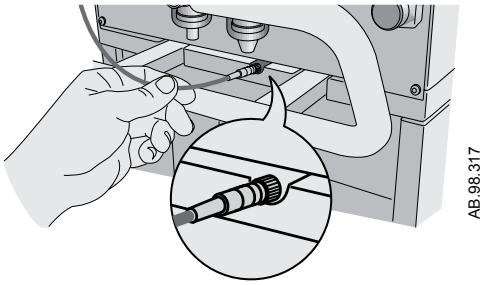
CAUTION Port 3 must only be used for connecting the exhalation valve heater cable.

Important Order cable separately. See Exhalation valve heater in the "*Parts and accessories*" section for ordering information.

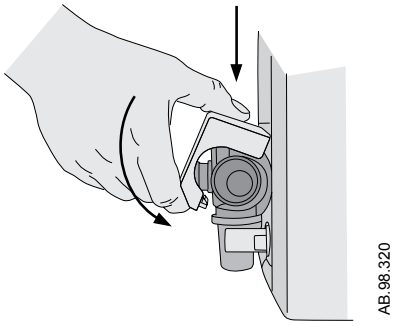
1. Attach and tighten the cable to Port 3 on the back of the ventilator.



2. Thread the cable through the rear channel to the front of the ventilator.

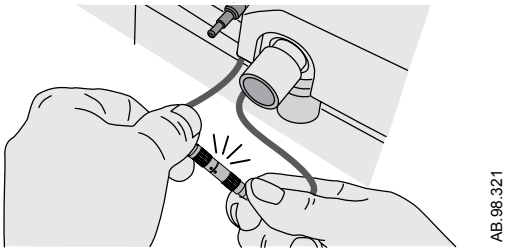


3. Angle the cover over the exhalation valve housing and gently press into place.



4. Align and match the red dots from the exhalation valve heater cable to the power cable and snap together.

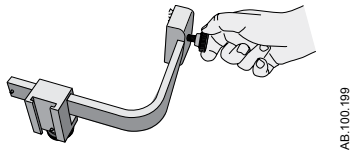
   Connecting the cable will power on the exhalation valve heater.



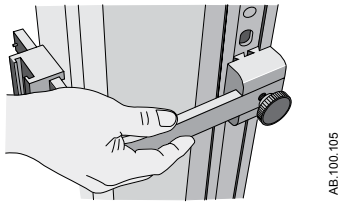
Note To disconnect and remove the exhalation valve heater, follow instructions in reverse order.

Connecting the accessory rail

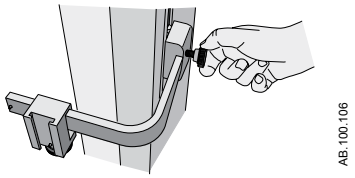
1. Lock the casters on the ventilator cart.
2. Loosen the rail mount thumbscrew.
   - The wedge assembly on the rail is spring-loaded to allow rail installation into the dove-tail of the cart.



3. Use the leading edge of the wedge assembly to insert the rail into the dovetail located on either side of the ventilator cart.



4. Tighten the thumbscrew to secure the rail at the desired height.

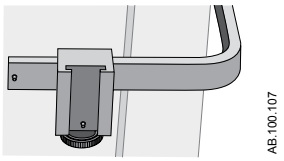


   - The accessory rail position can be adjusted by loosening the thumbscrew, sliding the accessory rail to the desired location, and then tightening the thumbscrew.

Attaching the rail adapter to the accessory rail

1. Loosen the thumbscrew on the rail adapter and attach it to the rail.
2. Slide the rail adapter to the desired location and tighten the thumbscrew to secure the adapter to the rail.

- The rail adapter position can be adjusted by loosening the thumbscrew, sliding the rail adapter to the desired location, and then tightening the thumbscrew.



3. Add accessories to the rail adapter.

   - Make sure the rail adapter is positioned correctly (thumbscrew down).
   - Slide accessories into the rail adapter.

Important Maximum capacity for the accessory rail is 10 kg.

Attaching system accessories

The accessory rail and rail adapter are used to mount systems accessories to the cart.

Important Maximum capacity for the accessory rail is 10 kg.

Add accessories to the accessory rail adapter.

- Slide accessories into the adapter.
- Make sure the adapter is positioned correctly (thumbscrews down).

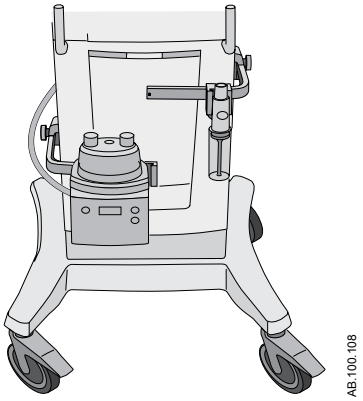


Figure 4-4 • Accessory rails shown with a water trap and a humidifier

Connecting the breathing circuit

WARNING Do not use antistatic or electrically conductive breathing tubes or masks.

- Check all connections to the breathing circuit to make sure that there are no unintended connections made to other equipment, especially equipment that delivers fluids, as the patient could be harmed.
- The inspiratory safety guard is required to connect the breathing circuits to the ventilator. The inspiratory safety guard must be used at all times during ventilation.

Note See "*Cleaning and maintenance*" for information on the replacement of the inspiratory safety guard. See "*Parts and accessories*" for ordering information.

The exhalation valve heater should be used when an active humidifier with a heated expiratory limb is used.

Important Consult your hospital guidelines for proper use of expiratory filters in conjunction with heated humidifiers.

Connecting the water trap to the breathing circuit

1. Connect the patient circuit to the front port of the water trap housing.
2. Connect the water trap connector tubing to the top port of the water trap housing.
3. Connect the water trap connector tubing to the expiratory filter (if used) or expiratory port.

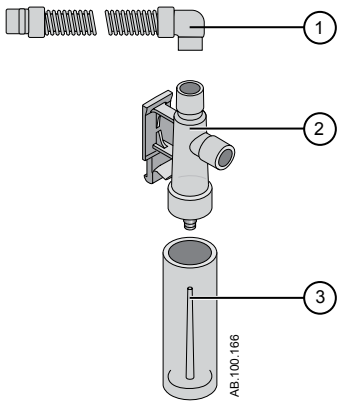


Figure 4-5 • Cart-mounted water trap

1. Water trap connector tubing
2. Water trap housing
3. Water trap

Connecting a HME (heat and moisture exchanger)

Note To prevent excessive resistance in the breathing circuit, the HMEF500 should not be used for Adult patients.

Note If using optional accessories see Figure in "*Connecting the Pedi-lite(+) and D-lite(+) sensors*".

1. Connect the inspiratory safety guard to the inspiratory port.
2. Attach the inspiratory limb of the patient circuit to the inspiratory safety guard.
3. Attach the expiratory limb of the patient circuit to the expiratory port or expiratory filter (if used).
4. Connect the Pedi-lite(+) or D-lite(+) sensor to the patient wye (if used). Use a 5 ml (minimum) spacer and elbow when using the Pedi-lite(+) or D-lite(+) sensor.
5. Connect the HME.
   - Place the HME between the SpiroDynamics catheter (if used), but after the Pedi-lite(+) and D-lite(+) sensor (if used).
   - The HME should be removed when a nebulizer is active. Replace the HME when the nebulizer is not in use.
6. Connect the circuit elbow to the HME (if used).

Note To disconnect, follow instructions in reverse order.

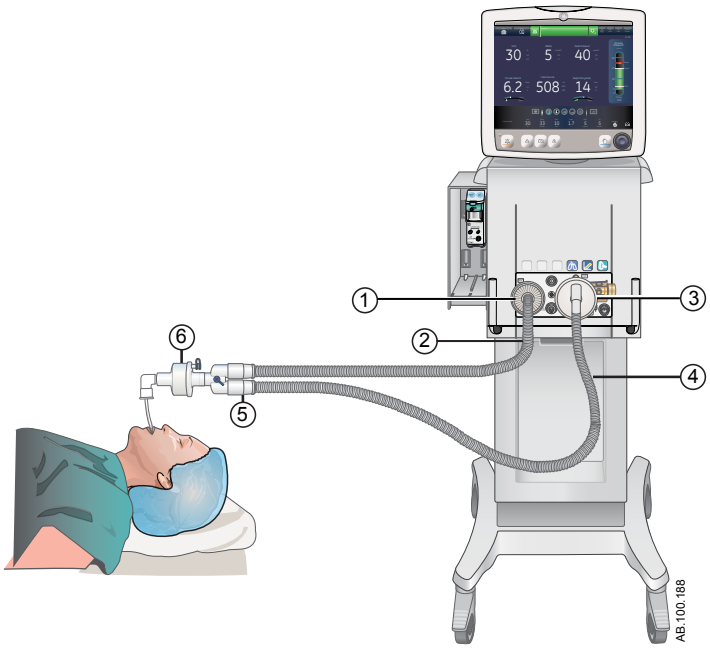


Figure 4-6 • Overview of setup and connections with a HME

1. Inspiratory safety guard
2. Inspiratory limb
3. Expiratory port/expiratory filter if used
4. Expiratory limb
5. Patient wye
6. HME

Connecting the humidifier

The ventilator is designed to work with active humidification. GE Healthcare recommends the use of the Fisher & Paykel MR850 humidifier (refer to humidifier instructions for detailed information on humidifier connections and use).

WARNING Never position any filter in the inspiratory limb downstream of a humidifier.

- When adding attachments or other components to the ventilator, the pressure gradient across the breathing circuit may change.

1. Slide the humidifier heater onto the accessory rail (do not plug in).
2. Press down on the light blue lever of the humidifier and slide the water chamber into the humidifier heater.

   Release the light blue part of the humidifier heater.
3. Unwrap the water feed line from the humidifier water chamber and puncture the water reservoir. The water reservoir should be elevated above the humidifier at all times and water should flow down into the humidifier.
4. Use the short blue circuit tubing from the humidifier circuit pack and connect one end to the inspiratory safety guard and the other end to the appropriate port on the humidifier chamber.
5. Connect the longer piece of of blue circuit tubing to the remaining port on the humidifier. Connect the end of the white circuit tubing to the expiratory port or expiratory filter (if used).
6. Connect the heater wire to the humidifier heater, then connect the two leads to the ends of the patient circuit (the shorter lead to the blue tube).
7. Connect the temperature probe to the humidifier heater, connecting the keyed lead to the end of the blue tube of the patient circuit and the other to the patient wye for adult (near the patient wye on the blue tube for pediatric/neonatal).

Note The thermal operating temperature of the humidifier is 18-26° C according to the manufacturer.

8. Turn on the ventilator and perform the System Check. See "*System Check*" in the Operation section for more information.
9. If the System Check passes, plug in the humidifier and attach the exhalation valve heater. See "*Connecting the exhalation valve heater*".

Note To disconnect; follow the instructions in reverse order.

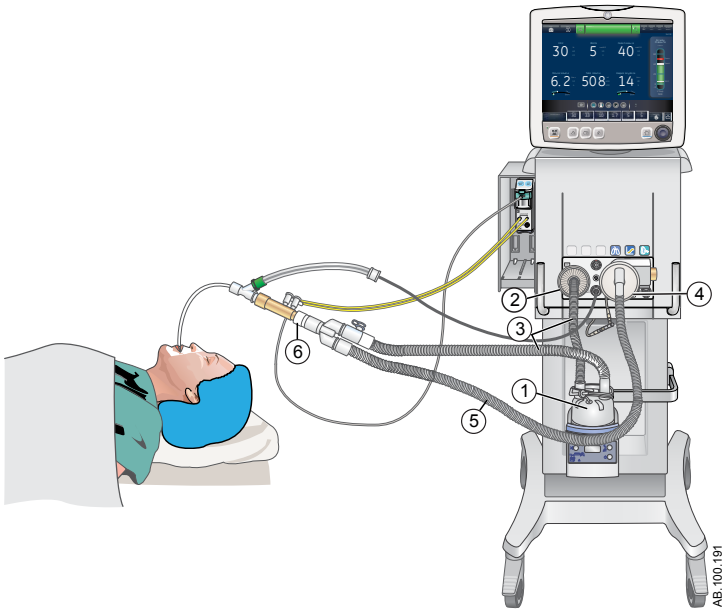


Figure 4-7 • Overview of setup and connections with a humidifier

1. Humidifier (Fisher & Paykel)
2. Inspiratory safety guard
3. Inspiratory limb to and from humidifier to patient wye
4. Expiratory port/expiratory filter if used
5. Expiratory limb
6. Spacer (5 ml - minimum)

Connecting the nebulizer

The Aerogen® Professional Nebulizer System is a portable medical device for multiple patient use that is intended to aerosolize physician-prescribed solutions and suspensions for inhalation to patients on and off ventilation or other positive pressure breathing assistance.

The CARESCAPE R860 supports the Aerogen Professional Nebulizer System (Aerogen® Pro and Aerogen® Solo). Both nebulizer devices operate in-line using the ventilator nebulizer menu and nebulizer cable. The Aerogen Pro and Aerogen Solo are purchasable parts, see "*Parts and accessories*" section for ordering information.

The Aerogen Pro and Aerogen Solo (disposable) may be used with neonatal, pediatric, and adult patients in acute and subacute care environments. Both nebulizer models operate without changing the patient ventilator parameters and can be refilled without interrupting ventilation.

The nebulizers may be used with a neonatal, pediatric, or adult breathing circuit. The T-adapter for the nebulizer is specific to the breathing circuit type.

WARNING Do not use a filter, heat-moisture exchanger or heat-moisture exchanger filter between the nebulizer and the patient airway.

- Use of a heat-moisture exchanger or nebulizer in the breathing circuit can substantially increase flow resistance when a nebulizer is active. Monitor the breathing system filter frequently for increased resistance and blockage.
- Use of an external pneumatic nebulizer may significantly impact volume delivery and monitoring, decrease trigger sensitivity, and cause alarms if external flow is introduced and Pneumatic Nebulizer Flow Compensation is not used.

CAUTION It is strongly recommended to use an expiratory filter when a nebulizer is used to help protect the expiratory flow sensor.

Disposable nebulizer

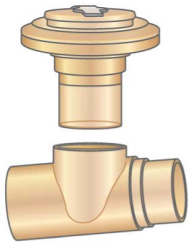
The Aerogen Solo nebulizer is a disposable nebulizer for single patient use. The Aerogen Solo can be used with neonatal, pediatric, and adult patients. The Solo nebulizer operates in-line like the Aerogen Pro, utilizing the ventilator nebulizer menu and nebulizer cable. See "*Nebulizer treatment*" in the "*Procedures*" section for additional information.

Note The Aerogen Solo and accessories are disposable and should not be cleaned or reused after single patient use.

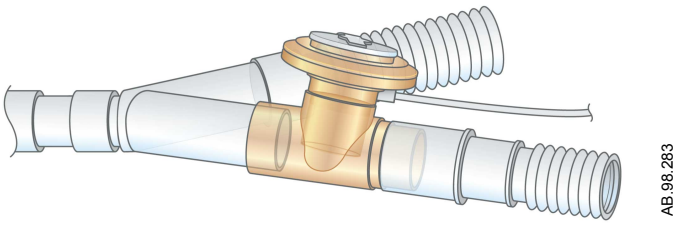
Assembling the nebulizer

WARNING Always maintain the nebulizer in a vertical orientation while it is in the patient circuit. This orientation helps prevent patient secretions and condensation from contaminating the aerosol generator of the nebulizer and ensures proper nebulization.

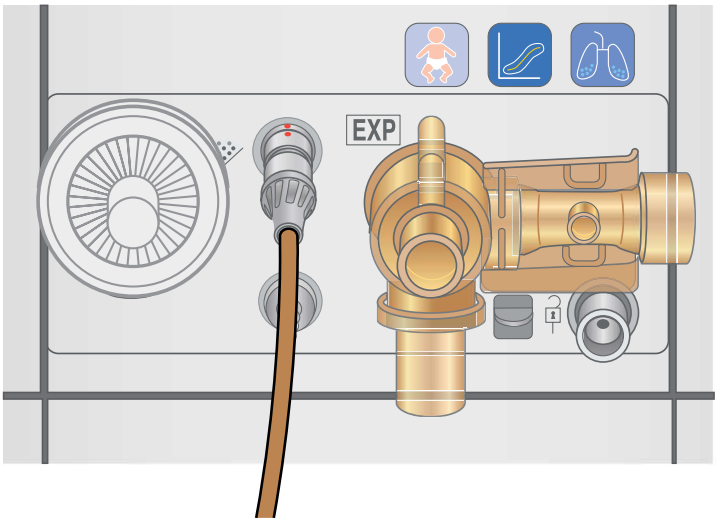
1. Connect the nebulizer to the T-adapter by pushing the nebulizer firmly onto the adapter.



2. Connect the nebulizer and T-adapter into the inspiratory limb of the breathing circuit before the patient wye.



3. Attach the nebulizer cable to the nebulizer connection as shown, matching the red dots.



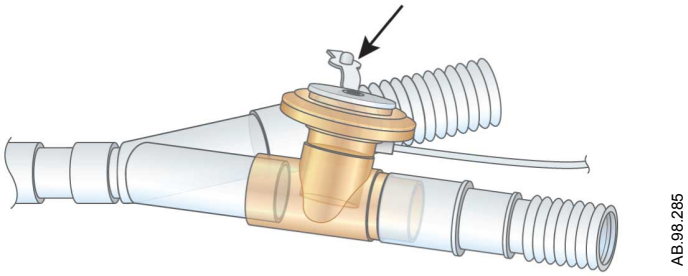
4. Complete a System Check prior to use on a patient. See "*System Check*" in the "*Operation*" section for additional information.
5. Follow the "*Nebulizer treatment*" procedure in the "*Procedures*" section.

Filling the nebulizer

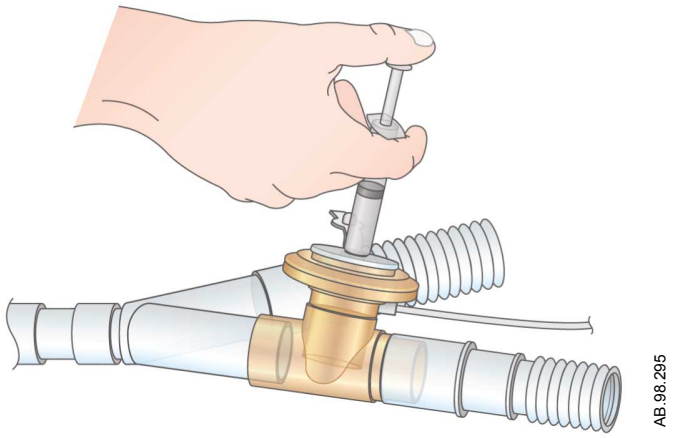
CAUTION To help avoid damage to the nebulizer, do not use a syringe with a needle. Do not push or apply undue pressure to the domed aperture plate in the center of the nebulizer.

- The maximum capacity of the Pro nebulizer unit is 10 ml. The maximum capacity of the Solo nebulizer is 6 ml. Do not fill the nebulizer beyond the maximum fill indication point. The underside of the filler cap represents the maximum fill indication point.

1. Open the filler cap tab on the nebulizer.



2. Use a prefilled nebule or syringe to inject the medication into the filler port.



3. Close the filler cap tab.

Disassembling the nebulizer

The nebulizer and T-adapter may remain in the patient circuit when not in use. The nebulizer may be removed from the T-adapter and replaced with a plug to avoid leaks.

1. To remove the nebulizer cable from the nebulizer, grasp it close to the ventilator and pull straight out.
2. Remove the nebulizer and T-adapter from the inspiratory limb of the patient breathing circuit. Reconnect the circuit.
3. Clean and sterilize the Pro nebulizer and T-adapter as described in the "*Cleaning and maintenance*" section.

Functional test

Perform a functional test of Aerogen nebulizers prior to first use, after each sterilization, before each patient use, or at any time to verify proper operation.

Inspect all parts before use, and do not use if any parts are missing, cracked or damaged.

Note The time and approximate volume of nebulized medication are shown in the table. The calculated volume is based on an average nebulization rate of 0.38 ml/min, but the actual nebulization rate of each individual nebulizer cannot be guaranteed and may vary.

1. Visually inspect each part of the device for cracks or damage and replace if defects are visible.
2. Pour 1-5 ml of normal saline (0.9%) into the nebulizer unit.
3. Connect the nebulizer. Follow the instructions in Connecting the nebulizer in the Setup and Connections section.
4. Select ***Menu*** > ***Nebulizer*** > ***Aerogen***.
5. Select ***Time*** > 16 minutes.

   The time and approximate volume of nebulized medication are shown in the table.

   Selecting Continuous will deliver nebulized medication until medication delivery is stopped or runs out.

Time (min)	7	8	11	16	21	26	32
Volume (ml)	2.5	3.0	4.0	6.0	8.0	10.0	12.0

6. Select Start and verify that aerosol is visible.
7. Select Stop to end the nebulizer treatment and verify that aerosol is not visible.
8. Discard any remaining liquid before patient use.

Airway modules

Airway modules measure and monitor gases delivered to and from the patient.

Airway modules have:

- Nondispersive infrared technology to measure CO2, N2O, and anesthetic agents.
- Paramagnetic technology to measure O2. The displayed FiO2 is adjusted by the ratio of the barometric pressure and 1.3 second moving average of the cyclic pressures obtained by the inspiratory pressure transducer.
- Differential pressure detection to measure spirometry inputs from the D-lite(+) or Pedi-lite(+) sensor.
- D-fend water trapping system to prevent moisture from entering the measurement chamber.

Some measurements are made by internal sensors in either the ventilator or the airway module. The Airway Module (Patient) data icon is shown below the airway pressure bar when selected as the data source. The Ventilator data icon is shown when it is selected as the data source.

Ventilator Data Source Icons	
	
Ventilator data	Airway Module (Patient) data

When Airway Module is selected as the data source, the data source icon will not be updated until the module is able to provide information. This may take 2 to 5 minutes when a module is first installed into the module bay. Only information available from the installed airway module will be displayed on the ventilator; all other data will be from the ventilator.

For example, if a module capable of measuring CO2 and O2 only is installed, CO2 and O2 data displayed will be from the module; all other data will be from the ventilator. If Airway Module is selected as the data source and the airway module is removed from the module bay, the data source icon will show Ventilator as the data source.

Monitoring that is critical to patient safety comes from both the ventilator and the airway module when the data source is Airway Module. In some conditions, alarms might be triggered by the ventilator sensors, while the measurements shown are from the airway module sensors.

Note The airway module spirometry keys do not function when it is installed in the ventilator. These functions are available through the ventilator.

Important The ventilator is not intended for use with anesthetic agents and does not measure or show anesthetic agent data.

Compatible airway modules

The following airway modules are compatible with the ventilator:

- E-miniC
- E-CO
- E-COV
- E-COVX
- E-CAiO
- E-CAiOV
- E-CAiOVX
- E-sCO
- E-sCOV
- E-sCOVX
- E-sCAiO
- E-sCAiOV
- E-sCAiOVX

The letters in the airway module model number correspond to its model and capabilities.

- E = plug-in gas module
- s = single width airway module
- C = CO2 detection
- O = patient O2 detection
- A = anesthetic agent detection (not supported)
- i = anesthetic agent identification (not supported)
- V = patient spirometry capability
- X = metabolics

E- series airway modules

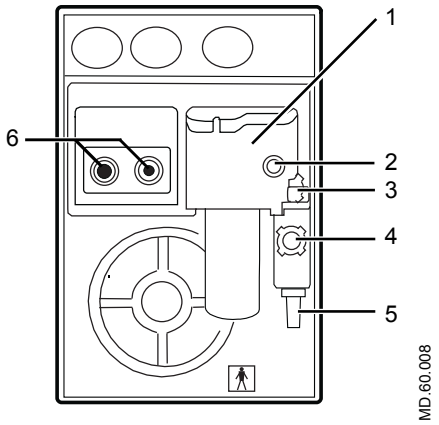


Figure 4-8 • E-series airway module

1. D-fend water trap
2. Gas sampling line connector on the water trap
3. Water trap latch
4. Reference gas inlet
5. Gas sampling outlet
6. Connectors for patient spirometry

CARESCAPE airway modules

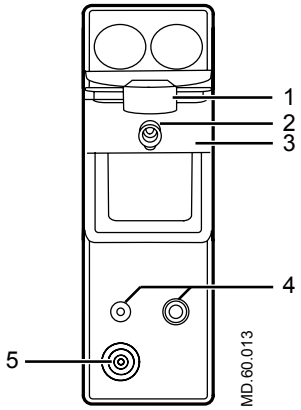


Figure 4-9 • CARESCAPE airway module (figure may not represent all models)

1. Water trap latch
2. Gas sampling line connector on the water trap
3. D-fend Pro water trap
4. Connectors for patient spirometry
5. Gas sampling outlet

D-fend water trap

The airway module includes a single use D-fend water trap. The water trap has a hydrophobic membrane that prevents condensed water and secretions from entering the airway module measuring chamber. The condensed water and secretions are collected in a washable container.

Note Airway module error alarm messages related to the D-fend are shown until the condition is corrected.

Connecting the airway module and module bay

The airway module bay may be attached on either side of the ventilator.

WARNING Do not place the airway module in the lower slot when the airway module bay is on the right side of the system. Exhaust from the gas exhaust port will adversely affect the accuracy of airway module CO2 and O2 measurements.

- Install only one airway module into the airway module bay. The system does not support the use of multiple airway modules.
- Only install single width airway modules (E-miniC and CARESCAPE respiratory modules) in the upper right slot of the airway module bay. The upper left slot of the module bay does not support communication between the module and the system.

CAUTION The airway module bay port must only be used for connecting the module bay to the ventilator.

1. Lock the ventilator cart wheels.
2. Connect one end of the cable to the airway module bay connection on the back of the ventilator, and tighten the screws.
3. Attach the module bay to the desired side of the ventilator.
   - Loosen the thumbscrews.
   - Slide the airway module bay behind the thumbscrews and tighten.
4. Connect the end of the cable to the airway module bay connection, and tighten the screws.

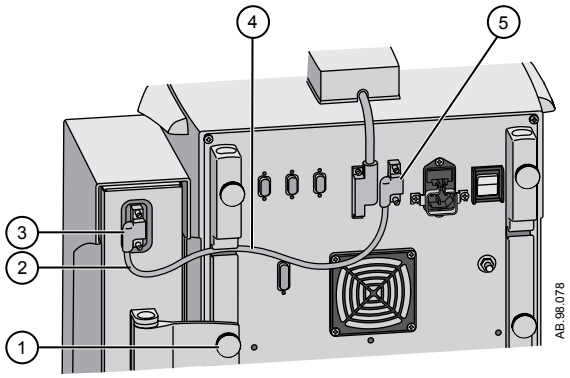


Figure 4-10 • Attaching and connecting the airway module bay

1. Thumbscrew
2. Excess cable
3. Module bay connection
4. Module bay cable
5. Ventilator airway module bay connection

5. Slide the airway module into the upper portion of the airway module bay.
6. Attach the tubing to the airway module.

Note To disconnect the airway module bay:

- Remove the airway module from the airway module bay.
- Remove the cable from the airway module bay from the back of the ventilator.
- Loosen the airway module bay thumbscrews and remove the airway module bay.

Connecting the Pedi-lite(+) and D-lite(+) sensors

WARNING Use the Pedi-lite(+) sensor for patients with tidal volumes up to, and including 200 ml.

- Use the D-lite(+) sensor for patients with tidal volumes greater than 200 ml.
- To ensure patient safety, make sure that the gas sampling connectors are connected as described in these instructions and are not interchanged with connectors on other equipment.

The D-lite(+) and Pedi-lite(+) sensors have a port to provide gas samples to the airway module. Both sensors are available as reusable (yellow) or disposable (clear).

Airway pressures are measured between the patient wye and the patient airway with a D-lite(+) or Pedi-lite(+) sensor. The sensors have a two-sided Pitot tube used to measure pressure. The pressure difference across a flow restrictor is used to calculate flow. From the flow, inspiratory volume and expiratory volume are calculated.

1. Connect the inspiratory safety guard to the inspiratory port.
2. Connect the inspiratory limb of the patient circuit to the inspiratory safety guard.
3. Connect a 5 ml (minimum) spacer at the circuit wye.
4. Connect the Pedi-lite(+) or D-lite(+) sensor to the patient circuit and make the following connections:
   - Connect the spirometry tubes from the Pedi-lite(+) or D-lite(+) sensor to the airway module.
   - Connect the gas sampling line from the Pedi-lite(+) or D-lite(+) sensor to the D-fend water trap on the airway module.
5. Connect the heat and moisture exchanger with filter (HMEF) (optional) after the 5ml spacer.
6. Connect an elbow after the HMEF (if used), or after a D-lite or Pedi-lite sensor (if used and an HMEF is not used).

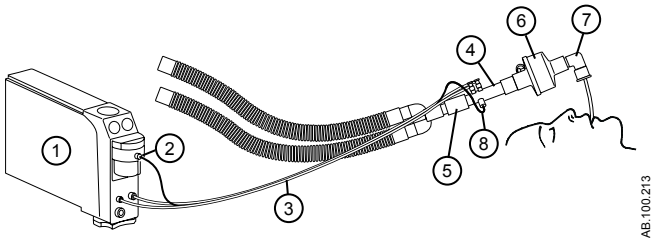


Figure 4-11 • Airway module connection to the patient breathing circuit

1. Airway module
2. Gas sample, gas sampling line connector on the water trap
3. Gas sampling and spirometry tubes
4. D-lite(+)/Pedi-lite(+) sensor
5. Spacer (5 ml - minimum)
6. Heat and moisture exchanger with filter (HMEF) (optional)
7. Elbow
8. Gas sampling line

Note To disconnect, follow the steps in reverse order.

Airway module calibration

Airway module calibration should be performed once every two months or when there is an indication of an error in the gas measurements and waveforms. Use only the calibration gas and regulator specified for the airway module. See "*Calibrating the airway module*" in the "*System configuration (Super User) and service*" section.

CAUTION Use only GE Healthcare authorized calibration gas. Do not use other calibration gases or the calibration will not be successful. Dispose of calibration gas containers in accordance with local environmental procedures.

Note During gas calibration, CO2 is always in % regardless of the measurement unit selected.

Install this regulator on the gas calibration cylinder:

- 755534-HEL (Quick cal regulator)
- M1006864 (US only)

Airway Module	Calibration Gas
E-miniC	755581-HEL
E-CO	755587 (US only)
E-COV	
E-COVX	
E-sCO	
E-sCOV	
E-sCOVX	
E-CAiO	755583-HEL
E-CAiOV	755571-HEL (US only)
E-CAiOVX	
E-sCAiO	
E-sCAiOV	
E-sCAiOVX	

Connecting the support arm

The support arm may be placed on either side of the ventilator to support the patient breathing circuit. To connect to the ventilator, place the post into the arm holder and tighten the thumbscrew.

WARNING Do not exceed 2 kg load at the patient end of the support arm.

CAUTION Do not hang fluids on the support arm above the ventilator or accessories.

Important The support arm is not a sterile component and cannot be autoclaved or immersed in cleaning solution.

1. Loosen the thumbscrew.
2. Place post in the arm holder located on the back of the ventilator.
3. Tighten the thumbscrew to hold the arm in position.
4. To position the arm, loosen the central tension handle counter-clockwise while holding the patient side of the arm in the other hand.

   There is a stop to prevent the central tension handle from being completely loosened.
5. Move the arm to the desired position.
6. Tighten by turning the central tension handle clockwise.

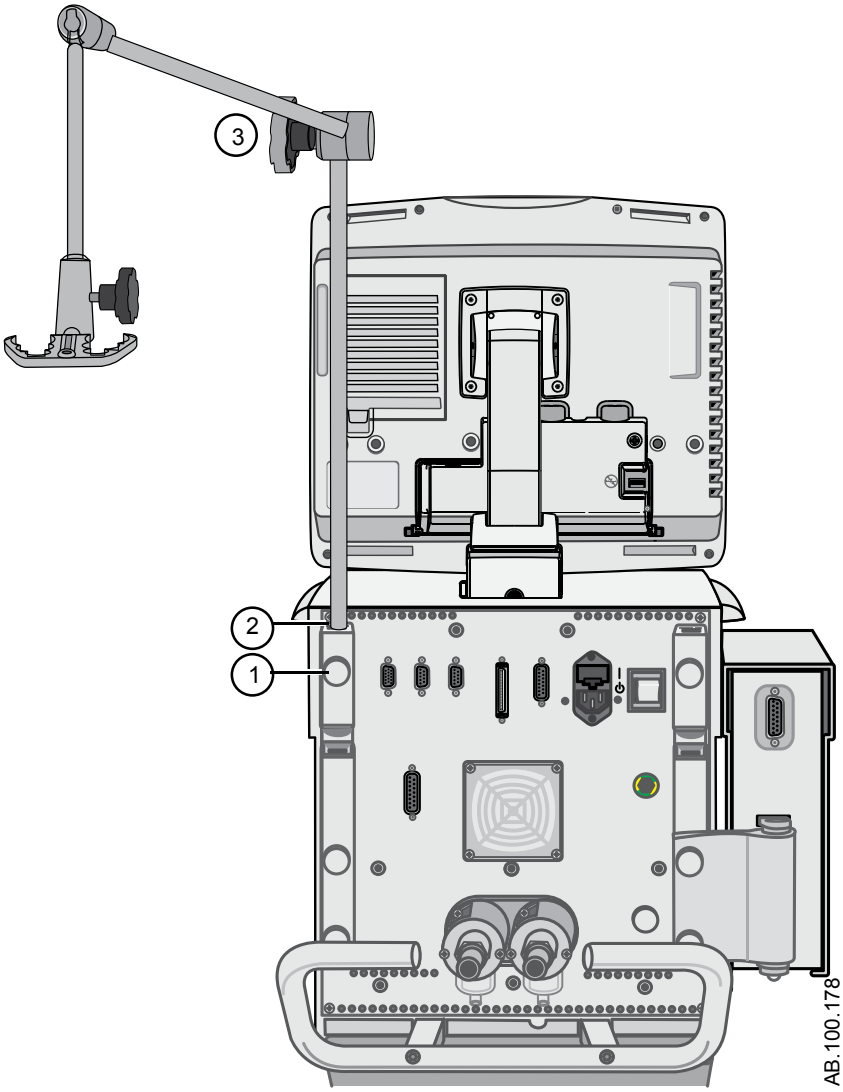


Figure 4-12 • Support arm installation

1. Thumbscrew
2. Support arm holder
3. Central tension handle

Removing the display unit

WARNING A movable part or a removable component may present a pinch or crush hazard. Use care when moving or replacing system parts and components.

CAUTION The display unit is top heavy when removed from the ventilator.

1. Power down the ventilator and lock casters if using the ventilator cart.
2. Position the display arm so that it is vertical and the display unit so that it is horizontal (screen facing up).
3. Firmly hold the display unit at the junction of the display arm and display screen.
4. Open the primary latch (1).
5. Pull and hold the secondary latch (2) toward the front of the arm assembly to disengage the display unit.
6. Carefully lift and remove the display unit from the ventilator.

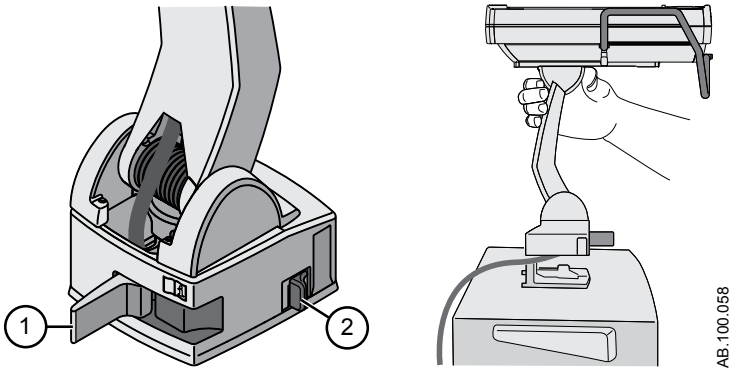


Figure 4-13 • Removing the display unit

Installing the display unit on a rail system

Use these instructions to install the display unit to a 10x25 mm, ISO 19054 rail system (medi-rail).

Note Make sure that the display cable length is long enough to reach from the ventilator to the desired mounting location. See the "*Parts and accessories*" section for ordering information.

1. Align and seat the arm onto the rail system. Listen for an audible click of the secondary latch.
2. Close the primary latch to secure the arm onto the rail system.

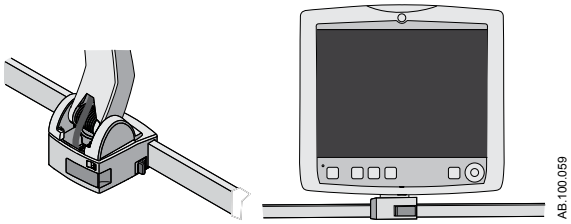


Figure 4-14 • Display unit mounted on a rail system

Installing the display unit on the ventilator

1. Firmly hold the display unit at the junction of the display arm and display screen.
2. Open the primary latch (1).
3. Press and hold the secondary release latch (2) to disengage the display unit from the remote rail.
4. Align the arm assembly with the receiver mount. Make sure the cable is positioned in the cable channel of the receiver mount.
5. Make sure the primary latch is open and seat the arm assembly onto the receiver mount. Listen for an audible click of the secondary latch.
6. Close the primary latch to secure the arm assembly onto the ventilator.

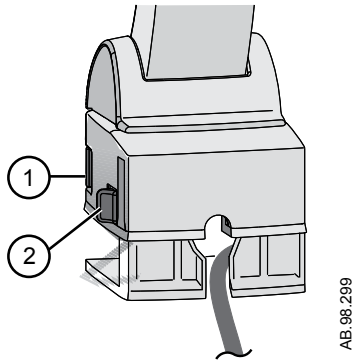


Figure 4-15 • Installing the display unit on the ventilator

Connecting the auxiliary pressure tubing

Auxiliary pressure is a supplementary pressure measurement that can be displayed with a waveform and patient data (measured data).

1. Attach the auxilliary pressure tubing to the Paux port by sliding the tubing over the barbed end of the port.

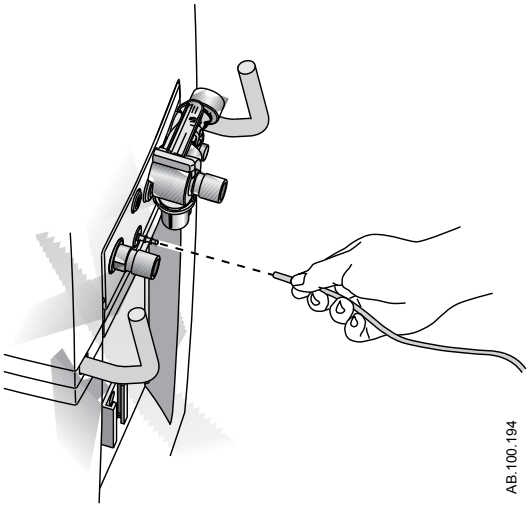


Figure 4-16 • Connecting the auxiliary pressure tubing

2. To display the Paux waveform follow the instruction in "*Waveform settings*" in the "*Patient monitoring*" section.
3. To disconnect the auxiliary pressure tubing from the Paux port; grasp the tubing and pull straight off from the barbed port.

Purging the auxiliary pressure tubing

Monitoring lines may become clogged and effect performance. To purge the line, complete the following steps.

WARNING Purge flow will deliver 35 +/- 15 ml of air. Do not initiate purge flow when the Paux port is connected to a closed system such as an endotracheal cuff.

1. Disconnect the patient end of the tubing.
2. Select ***Menu*** > ***System***.
   - Check the box to turn on Purge Flow.
   - Uncheck the box to turn off Purge Flow

Purge Flow will automatically turn off if auxiliary pressure becomes greater than 100 cmH2O to prevent overpressuring the tubing.

3. Reconnect the patient end of the tubing.

Zeroing auxiliary pressure

Auxiliary pressure measurements and waveforms will be more accurate if the pressure is zeroed before use.

1. Select ***Menu*** > ***System***.

   The System Menu shows.

2. Select ***Purge Flow*** to keep purge flow continuously on.

   The auxiliary pressure should be zeroed with Purge Flow On and the monitoring line connected when Purge Flow is used. This will ensure that any pressure offset caused by the auxiliary pressure monitoring line resistance is accounted for.

3. Select ***Paux Zero***.

   When zeroing is complete a green check mark indicating pass or a red X indicating a failure will show next to Paux Zero.

Connecting to a compressor

The EVair compressor can be connected to the ventilator and used as the primary air supply or as the backup air supply if pipeline air is connected to the compressor. See the EVair User Reference Manual and Technical Reference Manual for additional information.

WARNING If the compressor is the primary air supply to this system, ensure that a compressed oxygen supply is also connected.

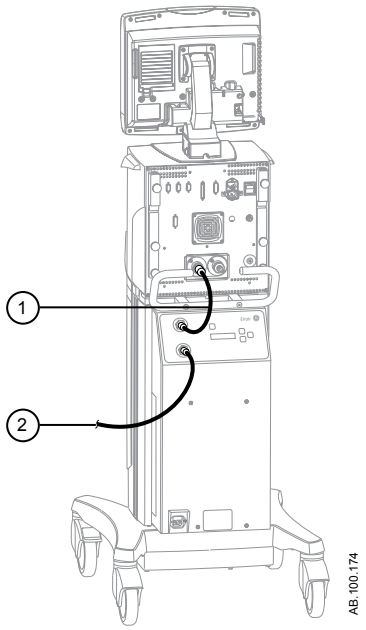


Figure 4-17 • Compressor showing Air pipeline connections

1. Air hose from the compressor to the ventilator housing
2. Air hose from the air supply to the compressor

WARNING The compressor must be used in a well ventilated area to prevent overheating.

- Do not place the compressor near a source of airborne contamination such as cleaning products or other chemicals, vapors, odors, or exhaust gases. The compressor uses air from its surroundings for delivery to the ventilator and patient.
- Do not block air inlet or exhaust vents. Do not place the compressor near a radiator or heating unit. The compressor may overheat and shut down.

Nurse call connection

WARNING The ventilator should be used as the primary source of alarm information and awareness of alarm activity.

- User must rely on the ventilator primary displays and controls for ventilation therapy decisions.
- Do not rely on the nurse call connection for distribution and receipt of alarm signals.
- An authorized service representative is required to install the nurse call isolation cable prior to using the nurse call feature.
- The nurse call system enables the availability of ventilator alarm information at a secondary location.

Port 4 may be used to output alarm signals to a nurse call system. The ventilator will signal an alarm with a normally open or normally closed signal. The nurse call will be triggered by all audible medium and high priority alarms.When alarm audio is paused, the nurse call signal will be off.

Note The delay time from the onset of an alarm condition to the alarm signal leaving the nurse call port is up to two seconds. The facility is responsible for any additional delays introduced by equipment connected to the nurse call ports.

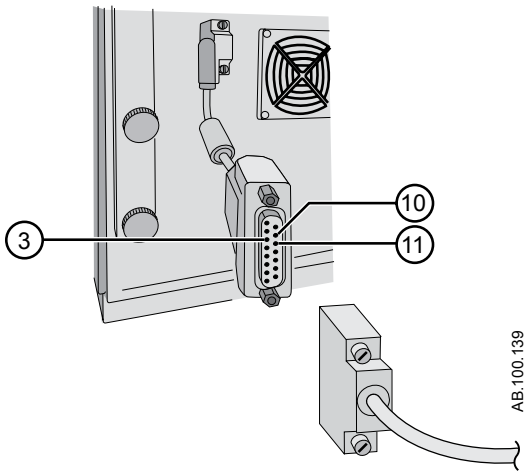


Figure 4-18 • Port 4 nurse call shown with isolation cable

The 15-pin female D connector configuration:

- pin 3 - relay common
- pin 10 - normally open
- pin 11 - normally closed

Load current:

- minimum: 100 uA at 100 mVdc
- maximum: 1 A at 30 Vdc
- relay isolated

Communication port connection

WARNING Port 5 and port 6 interface cables must be shielded.

- An authorized service representative is required to install the Ohmeda Com isolation cable prior to using the Ohmeda Com communication feature.

  See Electrical safety section of the Specification for precautions on connection to these communication ports.

Note The delay time from the onset of an alarm condition to the signal leaving the Ohmeda Com port is up to two seconds. The facility is responsible for any additional delays introduced by equipment connected to the display ports.

Only the ventilator should be relied upon for alarm signal generation and information. Do not rely on the communication port connection for distribution and receipt of alarm signals.

The port 5 and port 6 connectors allow serial input/output of commands and data. The 9 pin connectors are located on the back of the display unit and are labeled port 5 and port 6. The output protocol is available at www.datex-ohmeda.com (under Products/ Interfacing Commitment Products) or by contacting GE Healthcare at InterfaceCommitment@ge.com.

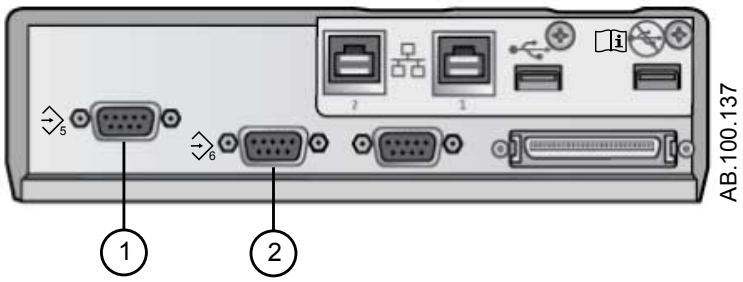


Figure 4-19 • Communication Port 5 (1) and Port 6 (2)

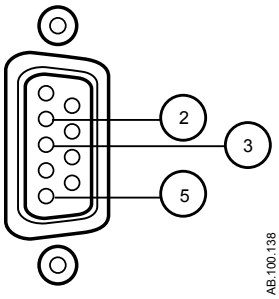


Figure 4-20 • Communication Port 5 and Port 6 pin configuration

- Pin 2 - display unit receive
- Pin 3 - display unit transmit
- Pin 5 - ISO ground
- All other pins are not connected

IT network connection

The RS 232 connection on the display unit may be used to output data to other equipment. In order to share information from the ventilator, the receiving system must be compatible with Datex-Ohmeda Com 1.3, 1.5, and 1.7 Serial Protocol. Information on the Datex-Ohmeda Com protocols are available by contacting Technical Support. The output protocol is available at www.datex-ohmeda.com (under Products/Interfacing Commitment Products) or by contacting GE Healthcare. at InterfaceCommitment@ge.com. To enable the use of the Ohmeda Com communicaation feature, it may be necessary to connect the ventilator to the facility IT Network. This allows the user to view values, such as measured data, waveforms and associated status information, reported by the ventilator display unit remotely. See "*Communication port connection*".

CAUTION Failure to meet the requirements of the Datex Ohmeda Com 1.3, 1.5, or 1.7 Serial Protocols will not allow the transfer of data from the ventilator to the receiving system.

- Connection of the ventilator to an IT network that includes other equipment may result in previously unidentified risks to patients, operators, or third parties. The facility should identify, analyze, evaluate, and control these risks. Subsequent changes to the network/data coupling may introduce new risks and require additional analysis.

  Changes to the IT network include the following:

  - Changes in the IT network configuration.
  - Connection of additional items to the IT network.
  - Disconnecting items from the IT network.
  - Update of equipment connected to the IT network.
  - Upgrade of equipment connected to the IT network.

Connecting isolated electrical outlets

The configuration of the electrical outlets varies by country.

WARNING Do not overload the electrical outlets.

Maximum permitted load for each output socket in the electrical outlet panel:

Voltage	Current
100 to 120 V	2 A
220 to 240 V	1 A

5 Ventilation modes

In this section

Ventilation mode basics

Invasive and non-invasive ventilation

The ventilator provides several standard modes for invasive ventilation and non-invasive modes (nCPAP for neonates).

- Invasive ventilation modes provide a range of patient support, from fully controlled mechanical breaths to pressure supported breaths for spontaneously breathing patients.
- Non-invasive modes are intended to be used for spontaneously breathing patients only.

Note See ventilation mode descriptions for details about the settings and features each mode provides.

The primary difference between setting up a patient for invasive and non-invasive ventilation is the accessories used.

- Invasive ventilation is delivered through an artificial airway (e.g., endotracheal tube), which is inserted into the patient's trachea.
- Non-invasive ventilation is delivered using positive-pressure ventilation through an accessory such as a nasal mask or mouthpiece. These accessories are often attached to the patient’s head to increase the quality of the airway seal to minimize airway leaks.

  Non-invasive ventilation masks should be non-vented and must not include an entrainment (inspiratory) valve. Patient circuits for use with non-invasive ventilation must be dual-limb with connections for both the inspiratory and expiratory ports of the ventilator.

Mechanical and spontaneous breaths

The ventilator offers multiple ventilation modes, which support mechanical and spontaneous breaths.

Mechanical breaths are controlled by the ventilator. The ventilator uses the selected mode settings to determine the characteristics of the breath such as timing, volume, and pressure. Depending on which mode is set, mechanical breaths are initiated by the ventilator or the patient.

- Ventilator-initiated: the ventilator uses the set respiratory rate to initiate a breath.
- Patient-initiated: the patient activates the set inspiratory trigger (flow or pressure) to initiate a breath.

Spontaneous breaths are initiated and controlled by the patient.

Note In ventilation modes with a PS setting, spontaneous breaths are pressure-supported at the PS level.

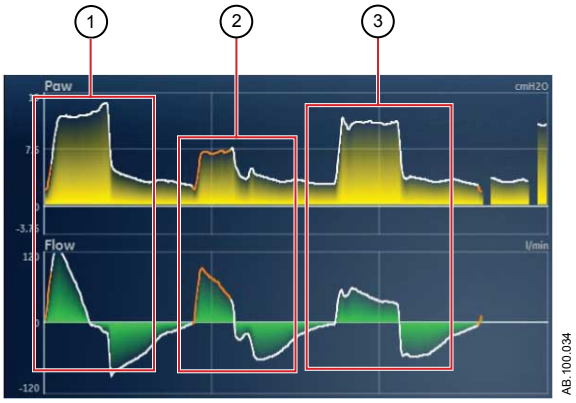


Figure 5-1 • Breath Types

1. Patient-initiated, mechanical breath
2. Spontaneous pressure supported breath
3. Ventilator-initiated, mechanical breath

Note The segment colored orange in the waveform represents the breath trigger.

Ventilation mode settings

Ventilation mode settings are separated into four categories:

- Main Parameters
- Breath Timing
- Patient Synchrony
- Safety

Each ventilation mode has a unique set of settings. See each ventilation mode description for a list of applicable settings.

Quick Keys on the lower portion of the display provide access to ventilation mode settings that are likely to be adjusted frequently. The remaining settings can be adjusted in the ***Current Mode*** > ***Mode Settings*** menu.

Note When changing ventilation modes, some settings may change if the two modes do not share the same limits or increments.

- When the setting is greater than the maximum value allowed in the new mode, the maximum value is set.

- When the setting is less than the minimum value of the new numeric range, the minimum value is set.
- When the setting is between increments, the value is rounded to the increment above or below it.

Main Parameter	**Definition**	
FiO2	Fraction of inspired oxygen	The percentage of oxygen that the ventilator delivers to the patient.
PEEP	Positive End Expiratory Pressure	The pressure that the ventilator holds in the patient's lungs during the expiratory phase.
VT	Tidal Volume	The volume of gas that the ventilator delivers with each volume-regulated or controlled breath.
Pinsp	Inspiratory Pressure	The pressure above PEEP that is maintained during the inspiratory phase of a pressure-regulated breath. In BiLevel mode, Pinsp is the pressure above PEEP at which the patient can spontaneously breathe.
PS	Pressure Support	The pressure above PEEP that is maintained during a pressure-supported breath.
Plow	Low Pressure	The low pressure level at which the patient can spontaneously breathe in APRV mode. This setting is equivalent to PEEP in other modes.
Phigh	High Pressure	The high pressure level at which the patient can spontaneously breathe in APRV mode.

Breath Timing	**Definition**	
Rate	Respiratory rate	The number of breaths delivered to the patient in one minute.
Flow	Inspiratory flow	The rate at which the gas is delivered to the patient during the inspiratory phase of a volume-controlled breath.
I:E	Inspiratory time:Expiratory time	The ratio of inspiratory time to expiratory time.
Tinsp	Inspiratory Time	The time in seconds that the ventilator uses to deliver the inspiratory phase of the breath cycle.
Insp Pause	Inspiratory Pause	The percentage of the inspiratory phase during which the breath is held and no additional flow is delivered by the ventilator during volume controlled breaths.
Tpause	Pause Time	The period in seconds at the end of the inspiratory phase during which the breath is held and no additional flow is delivered by the ventilator during volume controlled breaths.
Thigh	High Time	The time in seconds that the ventilator holds the high pressure level in APRV mode.

Breath Timing	Definition	
Tlow	Low Time	The time in seconds that the ventilator holds the low pressure level in APRV mode.

Patient Synchrony	Definition	
Insp Trigger	Inspiratory Trigger	The patient effort required to initiate the inspiratory phase of a breath. The trigger can be set as either a positive flow value (Flow Trigger) or a negative pressure deflection below PEEP (Pressure Trigger).
Exp Trigger	Expiratory Trigger	The percentage of peak flow at which the pressure supported breath inspiratory phase ends and the expiratory phase begins.
Rise Time	Rise Time	The time in milliseconds for pressure to reach 90% of the set inspiratory pressure.
PS Rise Time	Pressure Support Rise Time	The time in milliseconds for pressure to reach 90% of the set pressure support level.
Bias Flow	Bias Flow	The continuous flow that is circulated through the patient circuit during the expiratory phase of the breath cycle. The bias flow may be increased above this setting by the ventilator for some FiO2 settings.
Tsupp	Pressure Support Time	The maximum inspiratory time for a pressure-supported breath.

Safety	Definition	
Pmax	Maximum Pressure	The maximum pressure allowed in the patient breathing circuit. Once reached, the inspiratory phase ends, and the ventilator immediately begins the expiratory phase.
Plimit	Pressure Limit	The pressure at which the breath is limited and held for the remaining inspiratory time in a volume-controlled breath.
Pmin	Minimum Pressure	The minimum target pressure offset from PEEP allowed in PRVC, VS, SIMV PRVC, and BiLevel VG modes.
Minimum Rate	Minimum respiratory rate	The minimum number of breaths per minute a patient must draw before the ventilator delivers a backup breath.
Backup Pinsp	Backup Inspiratory Pressure	The pressure above PEEP that the ventilator maintains as it delivers a mechanical breath in CPAP/PS and NIV modes.
Backup Tinsp	Backup Inspiratory Time	The time in seconds that the ventilator uses to deliver the inspiratory phase for a mechanical breath in VS, CPAP/PS and NIV modes.

Positive end expiratory pressure (PEEP)

PEEP is the low pressure maintained in the patient's airway during the expiratory phase. PEEP prevents the patient's lungs from collapsing at the end of expiration. Maintaining a PEEP level improves the possibility of increasing oxygenation. PEEP (or the equivalent setting of Plow) is available in all ventilation modes.

Pressure support

Pressure support provides additional pressure during the inspiratory phase of spontaneous breaths in spontaneous breathing modes. The PS setting is available in the following ventilation modes:

- CPAP/PS
- SIMV VC
- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG
- NIV
- SBT

The maximum duration of the inspiratory phase for pressure-supported breaths is Tsupp or 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates. The inspiratory phase of pressure-supported breaths ends when one of the following occurs:

- Set Exp Trigger is detected.
- Set VT is delivered (VS mode only).
- Pressure exceeds PEEP + PS + 2.5 cmH2O.
- Set Tsupp is reached.

Flow and pressure triggering

The ventilator detects a patient's spontaneous breathing effort based on changes in flow or pressure.

- Flow trigger: A breath is delivered when the patient's inspiratory effort reaches the Insp Trigger setting.
- Pressure trigger: A breath is delivered when the patient's negative airway pressure (below PEEP) reaches the Insp Trigger setting.

To set a flow or pressure trigger, adjust the Insp Trigger setting.

- To set a flow trigger, select Current Mode, select the trigger setting, set a positive value using the Trim Knob and confirm.
- To set a pressure trigger, select Current Mode, select the trigger setting, set a negative value using the Trim Knob and confirm.

The ventilator synchronizes mechanical breaths with patient triggers when in the following modes:

- SIMV VC
- SIMV PC
- SIMV PRVC

- BiLevel
- BiLevel VG

And when assist control is active in the following modes:

- A/C VC
- A/C PC
- A/C PRVC

Breath timing preferences

The parameters used to represent the timing of a delivered breath or inspiratory phase of a delivered breath may be selected by the facility.

Note Timing and Flow default settings may be changed by a Super User. See the "*Configuration menu (Super User)*" section for more information.

The following table shows which settings are available based on the ventilation mode and Timing and Flow selections.

Timing	**I:E**	**I:E**	**Tinsp**	**Tinsp**	**Tpause**
Flow	**On**	**Off**	**On**	**Off**	**On**
A/C VC	I:E Flow	I:E Insp Pause	Tinsp Flow	Tinsp Insp Pause	Tpause Flow
A/C PC	I:E	I:E	Tinsp	Tinsp	Tinsp
A/C PRVC	I:E	I:E	Tinsp	Tinsp	Tinsp
SIMV VC	Tinsp Flow	Tinsp Insp Pause	Tinsp Flow	Tinsp Insp Pause	Tpause Flow
SIMV PC	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
SIMV PRVC	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
BiLevel	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
BiLevel VG	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
APRV	Thigh Tlow	Thigh Tlow	Thigh Tlow	Thigh Tlow	Thigh Tlow
CPAP/PS	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
VS	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
NIV	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
nCPAP	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp

Note Selecting a breath timing for the modes listed in the table will not affect other ventilation modes.

Ventilation mode features

Tube compensation

When a patient is intubated, the endotracheal or tracheostomy tube creates resistance in the airway. Tube compensation provides additional pressure to compensate for the difference between the lung pressure and breathing circuit pressure during the inspiratory phase of pressure-controlled and pressure-supported breaths.

Tube compensation can be used to offset all or a percentage of the additional resistive pressure created by the endotracheal tube.

Note To set Tube compensation, a Tube Type and Tube Diameter must be set in the New Patient or Current Patient menu.

WARNING Tube compensation increases the pressure delivered to the patient. The pressure delivered with tube compensation is limited to Pmax - 5 cmH2O. Make sure that Pmax is set appropriately for the patient when using tube compensation.

To set Tube Compensation, select ***Current Mode*** > ***Mode Settings*** and select ***Tube Comp***. A general message shows when tube compensation is on.

Note The options for tube compensation are: Endotrach, Trach, or ---. When --- is selected, the ventilator will not compensate for tube resistance.

Assist control

Assist control allows the ventilator to synchronize mechanical breaths to the patient's spontaneous efforts and the patient to trigger additional mechanical breaths to the set respiratory rate in the following ventilation modes:

- A/C VC
- A/C PC
- A/C PRVC

When the patient initiates a breath with assist control enabled, the ventilator delivers a breath based on the mode settings. After a patient-initiated mechanical breath, the ventilator may delay the delivery of the next mechanical breath to prevent two mechanical breaths from being delivered consecutively (breath stacking).

Note Under certain conditions, such as high spontaneous breathing rates or high leakage, the rate of mechanical breaths may not meet the set respiratory rate.

A general message shows when assist control is off. When assist control is off, the patient is able to draw spontaneous breaths at the set PEEP level between mechanical breaths.

To set Assist Control, select ***Current Mode*** > ***Mode Settings*** and select ***Assist Control*** (On or Off).

Leak compensation

WARNING The exhaled volume of the patient can differ from the measured exhaled volume due to leaks.

To set Leak Compensation, select ***Current Mode*** > ***Mode Settings*** and select ***Leak Comp***. A general message shows when leak compensation is on.

When the ventilator detects a leak in the breathing circuit, and leak compensation is active, the ventilator will respond in the following ways:

- Flow and volume waveforms and measured volume data are adjusted to account for leaks.

In the following volume-controlled modes, the ventilator adjusts the tidal volume delivered to compensate for leaks:

- A/C VC
- A/C PRVC
- SIMV VC
- SIMV PRVC
- BiLevel VG
- VS

The maximum tidal volume adjustment depends on the patient type:

- Adult - 25% of the set tidal volume
- Pediatric - 100% of the set tidal volume or 100 ml, whichever is less
- Neonatal - 100% of the set tidal volume

Trigger compensation

Leaks can cause the ventilator to initiate breaths automatically (auto-triggering). Trigger compensation adjusts the flow trigger to compensate for leaks, reducing the need to manually adjust the Insp Trigger setting to prevent auto-triggering.

Trigger compensation is available in all ventilation modes. To set trigger compensation, select ***Current Mode*** > ***Mode Settings***, and select ***Trigger Comp***.

Backup mode

Backup mode is available if the ventilator detects insufficient ventilation in modes that allow spontaneous breaths. When enabled, the ventilator automatically enters the set Backup mode if either of the following occur:

- The Apnea alarm is activated.
- The patient's expired minute volume (MVexp) is below 50% of the set low MVexp alarm.

The set Backup mode is shown under the Backup mode check box in ***Current Mode*** > ***Mode Settings*** . To enable Backup mode, select the check box.

Backup settings are a subset of available settings in each ventilation mode. Adjust Backup settings in ***Current Mode*** > ***Mode Settings*** > ***Backup Settings***.

Note Settings that are not designated as Backup settings remain at the current value when the ventilator transitions to the set Backup mode.

WARNING Ensure that all users at the facility have been trained and notified of the facility default Backup mode settings. Before deactivating backup ventilation for a specific mode, ensure that all users at the facility have been trained and notified of these settings.

Backup mode is available in the following ventilation modes:

- SIMV VC
- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG
- CPAP/PS
- VS
- APRV

The following ventilation modes may be set as the Backup mode:

- A/C VC
- A/C PC
- A/C PRVC
- SIMV VC
- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG

Assist control volume control (A/C VC)

During A/C VC mode, the ventilator delivers mechanical breaths of the set tidal volume (VT) at intervals based on the set respiratory rate (Rate).

Note The amount of pressure required to deliver the tidal volume depends on the patient's lung compliance and resistance.

Note Actual ventilation settings may be different if breath timing settings (Timing and Flow) have been changed.

In A/C VC mode, assist control is available to synchronize mechanical breaths to the patient's spontaneous efforts and to allow triggering of additional mechanical breaths. With assist control disabled, the patient can initiate spontaneous breaths at the set PEEP level during the expiratory phase.

Note To set Assist Control, select ***Current Mode*** > ***Mode Settings*** and select ***Assist Control***.

During A/C VC mode, the ventilator calculates an inspiratory flow based on the set tidal volume, inspiratory time, and Tpause. Constant gas flow to the patient is maintained during the inspiratory phase while the airway pressure is below the pressure limit (Plimit) setting. If the Plimit setting is reached, the gas flow is reduced to maintain the Plimit level for the remainder of the inspiratory period. The ventilator monitors delivered tidal volume and adjusts the delivered inspiratory flow as needed to maintain the set tidal volume for subsequent breaths.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in A/C VC mode:

Category	**Setting**
Main Parameters	FiO2
	VT
	PEEP
	Flow
Breath Timing	Rate
	I:E, Tinsp, or Tpause
	Insp Pause
Patient Synchrony	Insp Trigger
	Bias Flow
Safety	Plimit
	Pmax

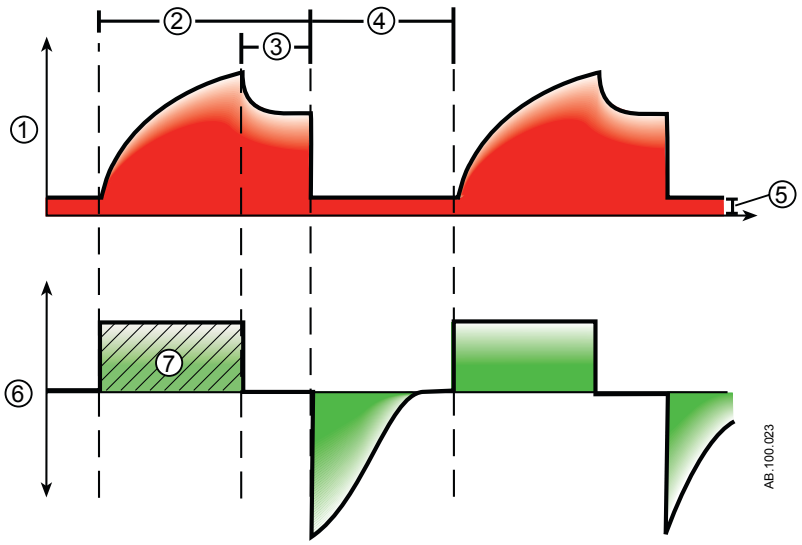


Figure 5-2 • A/C VC Waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Inspiratory pause (Tpause)
4. Expiratory time (Texp)
5. PEEP
6. Flow waveform
7. Tidal volume (VT)

Assist control pressure control (A/C PC)

During A/C PC mode, the ventilator delivers mechanical breaths at the set inspiratory pressure level (Pinsp) for a set inspiratory time (Tinsp) at intervals based on the set respiratory rate (Rate).

Note The tidal volume delivered depends on the compliance of the patient's lungs.

In A/C PC mode, assist control is available to synchronize mechanical breaths to the patient's spontaneous efforts and to allow triggering of additional mechanical breaths. With assist control disabled, the patient can initiate spontaneous breaths at the set PEEP level during the expiratory phase.

Note To set Assist Control, select ***Current Mode*** > ***Mode Settings*** and select ***Assist Control***.

During A/C PC, the gas flow to the patient decreases after the pressure level reaches the pressure setting (Pinsp). A high initial flow pressurizes the circuit to the set inspiratory pressure (Pinsp). The flow then decreases to maintain the set pressure for the remaining inspiratory time.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in A/C PC mode:

Category	**Setting**
Main Parameters	FiO2
	Pinsp
	PEEP
Breath Timing	Rate
	I:E or Tinsp
Patient Synchrony	Insp Trigger
	Bias Flow
	Rise Time
Safety	Pmax

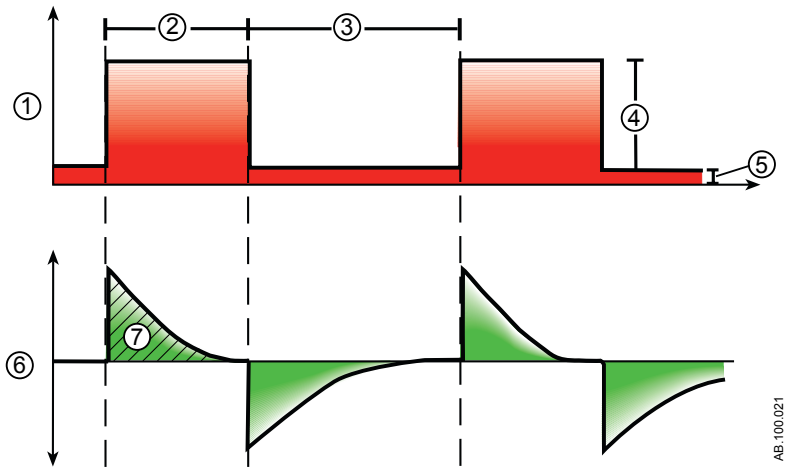


Figure 5-3 • A/C PC waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Expiratory time (Texp)
4. Inspiratory pressure (Pinsp)
5. PEEP
6. Flow waveform
7. Tidal Volume (VT)

Assist control pressure regulated volume control (A/C PRVC)

During A/C PRVC mode, the ventilator delivers mechanical breaths of the set tidal volume (VT) at intervals based on the set respiratory rate (Rate). For each breath, the ventilator adjusts the inspiratory pressure to use the lowest pressure required to deliver the tidal volume.

Note Actual ventilation settings may be different if breath timing settings (Timing and Flow) have been changed.

To determine the patient's lung compliance, the ventilator delivers volume-controlled ventilation for 10 seconds or two breath periods, whichever is longer when the mode is initiated. Based on the patient's lung compliance, the inspiratory pressure is established and used for the subsequent breaths.

The ventilator uses the following pressure range when adjusting inspiratory pressure:

- Low limit: PEEP + Pmin
- High limit: Pmax - 5 cmH2O

The difference in inspiratory pressure between breaths does not exceed ± 3 cmH2O.

Note If a high airway pressure alarm is active for the current breath, the next breath's pressure target is 0.5 cmH2O lower.

In A/C PRVC mode, assist control is available to synchronize mechanical breaths to the patients spontaneous efforts and to allow triggering of additional mechanical breaths. With assist control disabled, the patient could draw spontaneous breaths at the set PEEP level during the expiratory phase.

Note To set Assist Control, select ***Current Mode*** > ***Mode Settings*** and select ***Assist Control***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in A/C PRVC mode:

Category	**Setting**
Main Parameters	FiO2
	VT
	PEEP
Breath Timing	Rate
	I:E or Tinsp
Patient Synchrony	Insp Trigger
	Bias Flow
	Rise Time

Category	Setting
Safety	Pmax
	Pmin

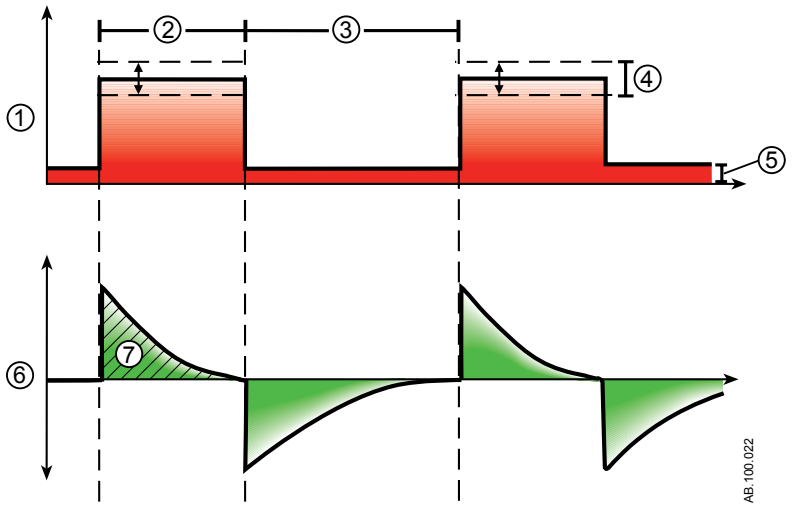


Figure 5-4 • A/C PRVC waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Expiratory time (Texp)
4. Variable pressure to deliver set TV
5. PEEP
6. Flow waveform
7. Tidal volume (VT)

Synchronized intermittent mandatory ventilation volume control (SIMV VC)

During SIMV VC mode, the ventilator delivers synchronized volume-controlled breaths at the set respiratory rate (Rate). All other spontaneous efforts are delivered as pressure-supported breaths.

Note Actual ventilation settings may be different if breath timing settings (Timing and Flow) have been changed.

Note Backup ventilation is available in SIMV VC mode. Set a Backup Mode in ***Current Mode*** > ***Mode Settings***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in SIMV VC mode:

Category	**Setting**
Main Parameters	FiO2
	Flow
	VT
	PEEP
	PS
Breath Timing	Rate
	Tinsp or Tpause
	Insp Pause
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
Safety	Plimit
	Pmax

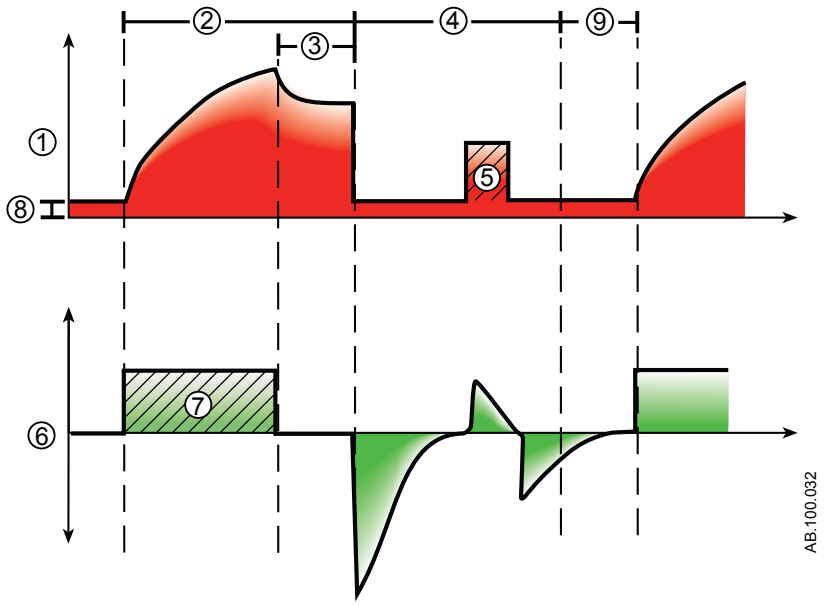


Figure 5-5 • SIMV VC waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Inspiratory pause (Insp Pause)
4. Spontaneous breathing period
5. Pressure-supported breath
6. Flow waveform
7. Tidal volume (VT)
8. PEEP
9. Trigger window

Synchronized intermittent mandatory ventilation pressure control (SIMV PC)

During SIMV PC mode, the ventilator delivers synchronized pressure-controlled breaths, the number of which is determined by the set respiratory rate (Rate). All other spontaneous efforts are delivered as pressure-supported breaths.

Note Backup ventilation is available in SIMV PC mode. Set a Backup Mode on the ***Current Mode*** > ***Mode Settings*** menu.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in SIMV PC mode:

Category	Setting
Main Parameters	FiO2
	Pinsp
	PEEP
	PS
Breath Timing	Rate
	Tinsp
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
	Rise Time
Safety	Pmax

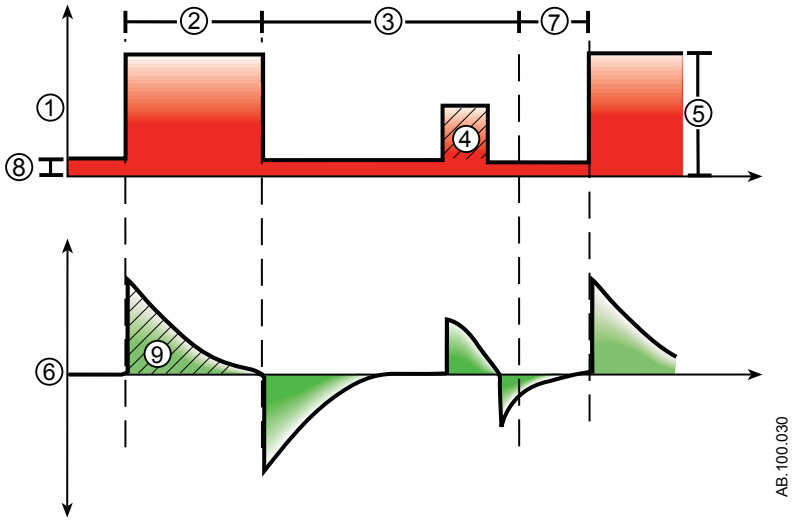


Figure 5-6 • SIMV PC waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Spontaneous breathing time
4. Pressure-supported breath
5. Inspiratory pressure (Pinsp)
6. Flow waveform
7. Trigger window
8. PEEP
9. Tidal Volume (VT)

Synchronized intermittent mandatory ventilation pressure regulated volume control (SIMV PRVC)

Note SIMV PRVC mode is a purchasable option.

During SIMV PRVC mode, the ventilator delivers synchronized pressure regulated volume controlled breaths at the set respiratory rate (Rate). For each mechanical breath, the ventilator adjusts the inspiratory pressure to use the lowest pressure required to deliver the tidal volume. All other spontaneous efforts are delivered as pressure-supported breaths.

To determine the patient's lung compliance, the ventilator delivers volume controlled ventilation for 10 seconds or two inspiratory periods, whichever is longer when the mode is initiated. Based on the patient's lung compliance, the inspiratory pressure is established and used for subsequent breaths.

The ventilator uses the following pressure range when adjusting inspiratory pressure:

- Low limit: PEEP + Pmin
- High limit: Pmax - 5 cmH2O

The difference in inspiratory pressure between breaths does not exceed ±3 cmH2O.

Note If a high airway pressure alarm is active for the current breath, the next breath's pressure target is 0.5 cmH2O lower.

Note Backup ventilation is available in SIMV PRVC mode. To set a Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

Note Tube Comp, Leak Comp, and Trigger Comp modes may be set if desired.

The following settings are available in SIMV PRVC mode:

Category	Setting
Main Parameters	FiO2
	PEEP
	PS
	VT
Breath Timing	Rate
	Tinsp

Category	Setting
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
	Rise Time
Safety	Pmax
	Pmin

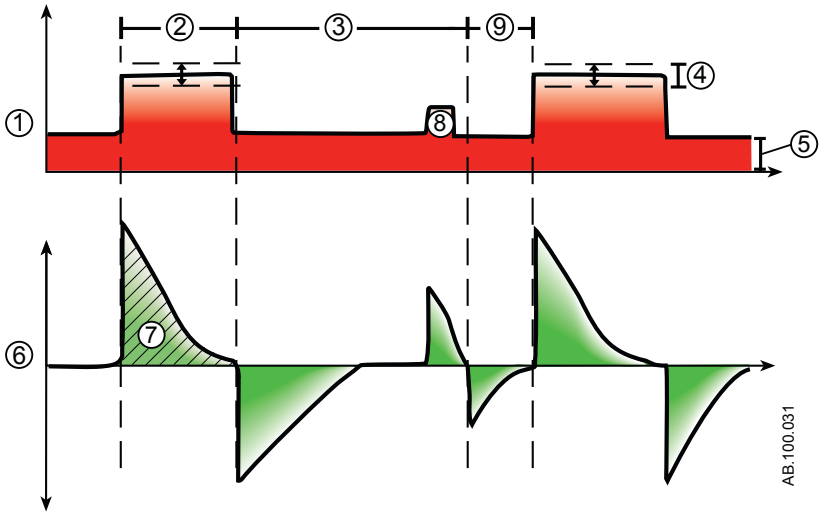


Figure 5-7 • SIMV PRVC waveform

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Spontaneous breathing time
4. Variable pressure
5. PEEP
6. Flow waveform
7. Tidal volume (VT)
8. Pressure supported breath
9. Trigger window

Continuous positive airway pressure / pressure support (CPAP/PS)

CPAP/PS mode is intended to be used on spontaneously breathing patients. During CPAP/PS mode, the ventilator maintains a PEEP level and provides pressure support (PS). The patient initiates spontaneous breaths and determines respiratory rate, timing, and tidal volume.

When the Minimum Rate is set during CPAP/PS, the ventilator will deliver a pressure controlled mechanical breath if the patient's spontaneous respiratory rate is less than the Minimum Rate. The mechanical breath will be delivered at the Backup Pinsp pressure setting for the time duration of the Backup Tinsp setting.

To deliver mechanical breaths during CPAP/PS mode, a Super User can enable the following settings.

- Minimum Rate
- Backup Pinsp
- Backup Tinsp

Note Backup ventilation is also available in CPAP/PS mode. To set a Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in CPAP/PS mode:

Category	**Setting**
Main Parameters	FiO2
	PEEP
	PS
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
Safety	Pmax
	Minimum Rate
	Backup Tinsp
	Backup Pinsp

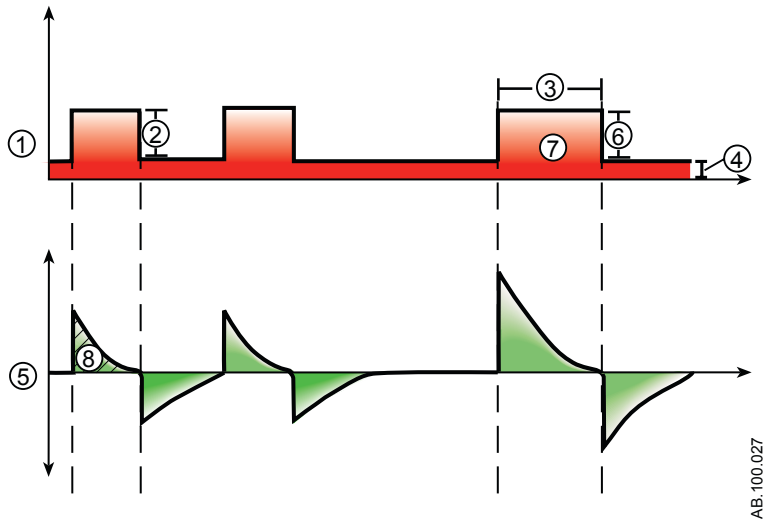


Figure 5-8 • CPAP/PS waveforms

1. Airway pressure (Paw) waveform
2. Pressure support (PS)
3. Inspiratory time (Backup Tinsp)
4. PEEP
5. Flow waveform
6. Backup Pinsp
7. Minimum rate backup breath
8. Tidal Volume (TV)

BiLevel airway pressure ventilation (BiLevel)

Note BiLevel mode is a purchasable option.

During BiLevel mode, the ventilator alternates between the set PEEP level and the set inspiratory pressure level (Pinsp) based on the set Rate and Tinsp. The patient can breathe spontaneously at either level. If the patient initiates a breath at the PEEP level, a pressure-supported breath at the set PS setting is delivered.

If the patient initiates a spontaneous breath during the high pressure period (Tinsp), the level of inspiratory pressure provided depends on the PS and Pinsp settings.

- If PS is greater than Pinsp, the ventilator provides the additional pressure to support the breath.
- If Pinsp is greater than PS, the ventilator provides no additional pressure support.

If the patient initiates a spontaneous breath near the end of Thigh, the ventilator continues to deliver at Pinsp or PS, whichever is greater, until it detects the Exp Trigger or the maximum inspiratory duration for a pressure-supported breath. The ventilator will then transition to the PEEP level.

Note Backup ventilation is available in BiLevel mode. To set a Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

The following settings are available in BiLevel mode:

Category	**Setting**
Main Parameters	FiO2
	Pinsp
	PEEP
	PS
Breath Timing	Rate
	Tinsp
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
	Rise Time
Safety	Pmax

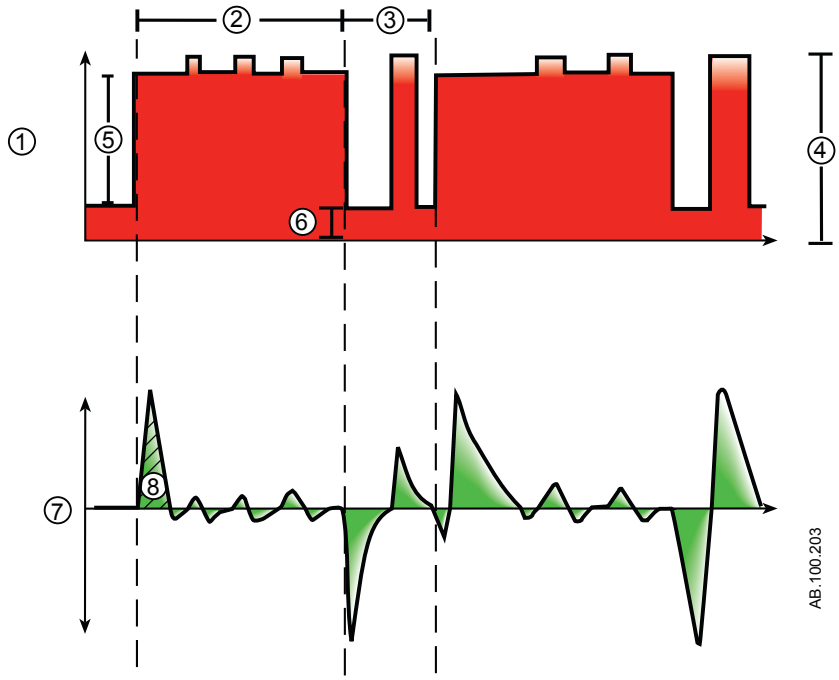


Figure 5-9 • BiLevel waveforms

1. Airway pressure (Paw) waveform
2. Tinsp
3. Exp time
4. Pressure Support (PS)
5. Pinsp
6. PEEP
7. Flow waveform
8. Tidal Volume (VT)

BiLevel airway pressure ventilation volume guaranteed (BiLevel VG)

Note BiLevel VG mode is a purchasable option.

During BiLevel VG mode, if the patient initiates a breath at the PEEP level, a pressure-supported breath at the PS setting is delivered. The ventilator alternates between a set PEEP and the minimum pressure to deliver the set tidal volume (VT) based on the set Rate and Tinsp.

To determine the patient's lung compliance, the ventilator delivers volume-controlled ventilation for 10 seconds or two inspiratory periods, whichever is longer when the mode is initiated. Based on the patient's lung compliance, the inspiratory pressure is established and used for subsequent breaths.

The ventilator uses the following pressure range when adjusting inspiratory pressure:

- Low limit: PEEP + Pmin
- High limit: Pmax - 5 cmH2O

The difference in inspiratory pressure between breaths does not exceed ±3 cmH2O.

If the patient initiates a breath at the PEEP level, a pressure-supported breath at the set PS setting is delivered.

Note If a high airway pressure alarm is active for the current breath, the next breath's pressure target is 0.5 cmH2O lower.

Note Backup ventilation is available in BiLevel VG mode. To set a Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in BiLevel VG mode:

Category	**Setting**
Main Parameters	FiO2
	VT
	PEEP
	PS
Breath Timing	Rate
	Tinsp
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
	Rise Time

Category	Setting
Safety	Pmax
	Pmin

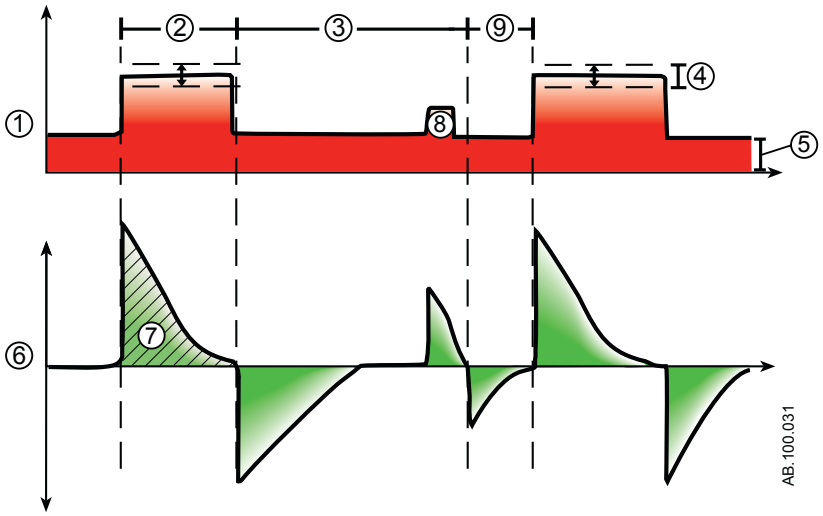


Figure 5-10 • BiLevel VG waveforms

1. Airway pressure (Paw) waveform
2. Inspiratory time (Tinsp)
3. Spontaneous breathing period
4. Trigger window
5. Variable pressure
6. Flow waveform
7. Tidal volume (VT)
8. Pressure-supported breath
9. PEEP

Airway pressure release ventilation (APRV)

Note APRV mode is a purchasable option.

APRV mode is intended to be used on spontaneously breathing patients. During APRV mode, the ventilator alternates between a set high (Phigh) and low (Plow) pressure level. The ventilator will deliver the set (Phigh) pressure for the set (Thigh) duration of time. The ventilator will deliver the set (Plow) pressure for the set (Tlow) duration of time. The patient can initiate spontaneous breaths at either level.

Note Backup ventilation is available in APRV mode. To set Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in APRV mode:

Category	**Setting**
Main Parameters	FiO2
	Phigh
	Plow
Breath Timing	Thigh
	Tlow
Patient Synchrony	Insp Trigger
	Bias Flow
	Rise Time
Safety	Pmax

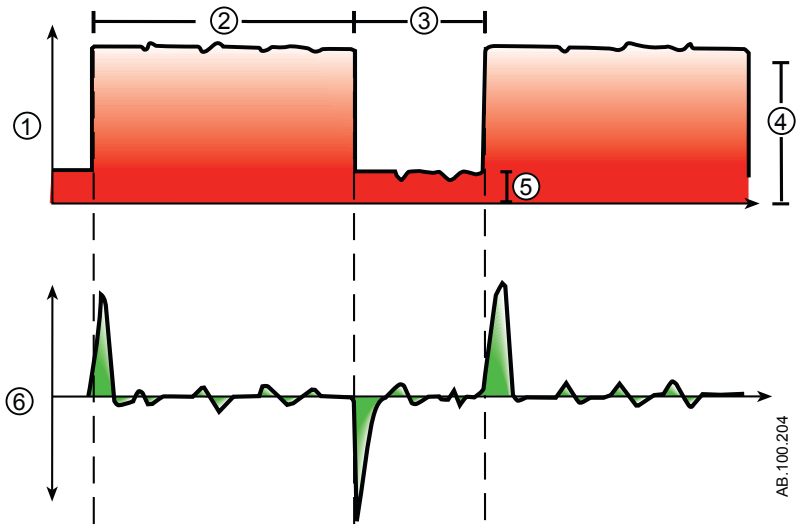


Figure 5-11 • APRV waveforms

1. Airway pressure (Paw) waveform
2. Thigh
3. Tlow
4. Phigh
5. Plow
6. Flow waveform

Volume Support (VS)

Note VS mode is a purchasable option.

VS mode is intended to be used on spontaneously breathing patients. During VS, the patient initiates spontaneous breaths and determines respiratory rate and timing. The ventilator maintains a PEEP level and provides support to deliver the set tidal volume (VT). For each breath, the ventilator adjusts the inspiratory pressure to use the lowest pressure required to deliver the tidal volume.

To determine the patient's lung compliance, the ventilator delivers volume-controlled ventilation for 10 seconds or two inspiratory periods, whichever is longer when the mode is initiated. Based on the patient's lung compliance, the inspiratory pressure is established and used for subsequent breaths.

The ventilator uses the following pressure range when adjusting inspiratory pressure:

- Low limit: PEEP + Pmin
- High limit: Pmax - 5 cmH2O

The difference in inspiratory pressure between breaths does not exceed ±3 cmH2O.

When the Minimum Rate is set during VS, the ventilator will deliver a mechanical breath if the patient's spontaneous respiratory rate is less than the Minimum Rate. The mechanical breath will be delivered at the Backup Pinsp pressure setting for the time duration of the Backup Tinsp setting.

Note If a high airway pressure alarm is active for the current breath, the next breath's pressure target is 0.5 cmH2O lower.

Note Backup ventilation is available in VS mode. To set a Backup Mode, select ***Current Mode*** > ***Mode Settings*** and select ***Backup Mode***.

Note Tube Comp, Leak Comp, and Trigger Comp may be set if desired.

The following settings are available in VS mode:

Category	**Setting**
Main Parameters	FiO2
	VT
	PEEP
Patient Synchrony	Tsupp
	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time

Category	Setting
Safety	Pmax
	Pmin
	Minimum Rate
	Backup Tinsp

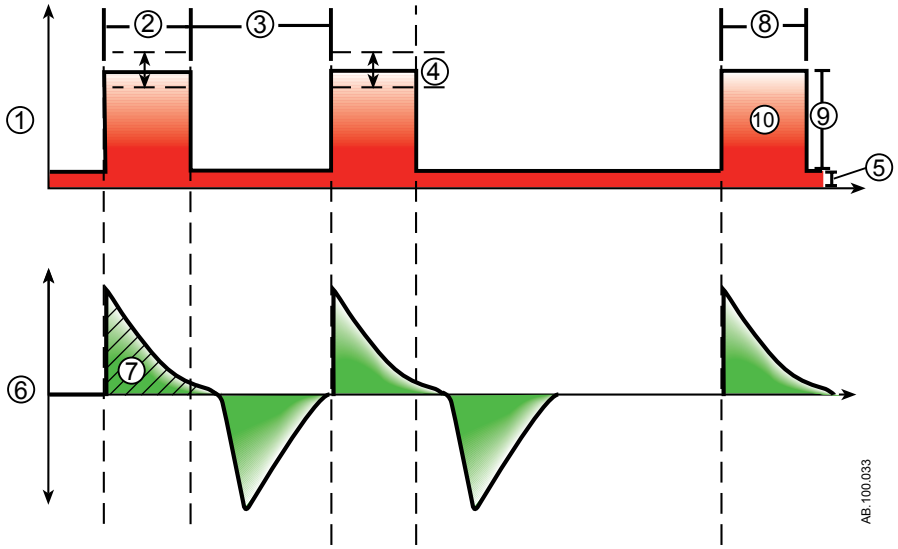


Figure 5-12 • VS waveforms

1. Airway pressure (Paw) waveform
2. Spontaneous inspiratory time
3. Spontaneous breathing period
4. Variable pressure
5. PEEP
6. Flow waveform
7. Tidal Volume (VT)
8. Inspiratory time (Backup Tinsp)
9. Backup Pinsp
10. Minimum rate backup breath

Non-invasive ventilation (NIV)

Note NIV mode is a purchasable option. NIV mode is intended to be used on spontaneously breathing patients.

During NIV mode, the patient draws spontaneous breaths as the ventilator maintains the set PEEP level and provides pressure support (PS).

Because flow triggers are affected by patient circuit leaks, flow and pressure triggers are applied simultaneously in NIV mode. When a flow trigger is set by the user, the ventilator uses a simultaneous pressure trigger to improve trigger detection.

The MVexp low, Apnea Time, and Leak Limit alarms may be disabled to prevent nuisance alarms when large patient circuit leaks are present. A medium priority alarm is active when any of these alarms is disabled. Select Audio Pause to acknowledge and de-escalate this alarm.

WARNING If the Apnea Time, Leak Limit, or MVexp low alarms are disabled, additional monitoring, such as SpO2, ECG, and CO2, is recommended to prevent the patient from hypoventilating.

WARNING If the patient does not meet the set Minimum Rate for spontaneous breaths, the ventilator delivers a backup breath based on the Backup Tinsp and Backup Pinsp settings. If the ventilator does not detect any spontaneous breaths within the set Patient Effort time, a high priority alarm indicates that the patient has stopped triggering breaths.

- While in non-invasive ventilation, the ventilator is to be provided with CO2 monitoring equipment that complies with ISO 80601-2-55 or ISO 21647. If the Apnea Time, Leak Limit, or MVexp low alarms are set to Off, additional monitoring such as SpO2 or ECG is also recommended to protect the patient from hypoventilation.

Note Leak Comp and Trigger Comp may be set if desired.

The following settings are available in NIV mode:

Category	Setting
Main Parameters	FiO2
	PEEP
	PS

Category	Setting
Patient Synchrony	Tsupp
	Insp Trigger
	Exp Trigger
	Bias Flow
	Rise Time
Safety	PMax
	Backup Pinsp
	Minimum Rate
	Backup Tinsp

WARNING Before using NIV mode, the patient should demonstrate all of the following characteristics:

- Is responsive
- Breathes spontaneously
- Has a controlled airway
- Requires pressure support ventilation

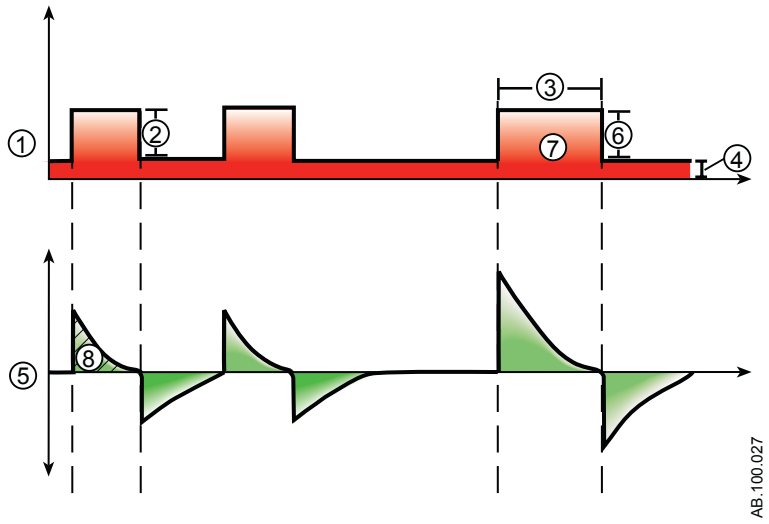


Figure 5-13 • NIV waveforms

1. Airway pressure (Paw) waveform
2. Pressure support (PS)
3. Inspiratory time (Backup Tinsp)
4. PEEP
5. Flow waveform

6. Backup Pinsp
7. Minimum rate backup breath
8. Tidal Volume (VT)

Spontaneous breathing trial (SBT mode)

SBT mode is intended to be used as a part of the procedure to evaluate the patient's ability to breathe spontaneously during a specified duration of time. See "*SBT view*" in the "*Clinical decision support*" section. SBT is not intended to be used for long-term ventilation beyond the set duration time.

Prior to the SBT evaluation, the following setting limits must be entered:

- SBT Duration
- Apnea Time
- High and low MVexp alarm
- High and low RR alarm

During SBT mode, the patient initiates spontaneous breaths as the ventilator maintains the set PEEP level and provides pressure support (PS).

Note To set a pressure support level for spontaneous breaths, select ***Current Mode*** > ***Mode Settings*** and enter a PS value.

Note To evaluate the Spontaneous Breathing Trial, select Clinical Decision Support > SBT.

Category	**Setting**
Main Parameters	FiO2
	PEEP
	PS
Patient Synchrony	Insp Trigger
	Exp Trigger
	Bias Flow
	PS Rise Time
Safety	Pmax
Stop Criteria	RR
	MVexp
	Apnea Time

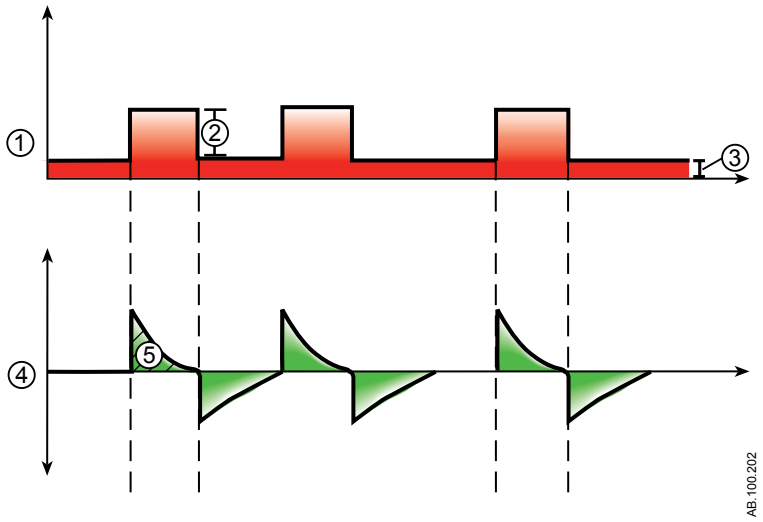


Figure 5-14 • SBT waveforms

1. Airway pressure (Paw) waveform
2. Pressure support (PS)
3. PEEP
4. Flow waveform
5. Tidal Volume (VT)

6 Operation

In this section

Power

Turning on power to the ventilator

1. Plug the power cord into an electrical outlet.
   - The LED indicator illuminates (green) to indicate the main power is connected.
2. Press the power switch on the back of the ventilator to the On position.
   - The start-up screen appears while the system runs a series of automated self tests.
   - When the self tests pass, the system goes into Standby and the display shows the Standby menu.
   - If the self tests fail, the display shows an alarm. See "*List of alarms*" and "*Troubleshooting*" in the "*Alarms and troubleshooting*" section or "*List of alarms – Neonatal*" in the "*Neonatal alarms and troubleshooting*".
3. Listen for two distinctly different audio tones to sound to make sure the primary speaker and backup buzzer are working properly.
4. Watch and verify the alarm light on the top of the display unit cycles through the following colors: blue, red, and yellow.

WARNING If both the primary and backup audio tones do not sound or the alarm lights do not function correctly when the ventilator is powered on, take the ventilator out of service. Contact an authorized service representative to repair the system.

Turning off power to the ventilator

The ventilator may only be turned off when in Standby, Configuration (Super User), or Service. If the ventilator is turned off during ventilation, an alarm sounds and ventilation and monitoring continue. This ensures the ventilator cannot be accidentally shut off during ventilation.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventilation to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.

3. Select ***Pause Ventilation***.

   - Monitoring and ventilation will stop.

4. Press the power switch on the back of the ventilator to the Off position.

Patient Setup

New Patient

Use these instructions for preparing the ventilator for a New Patient. After powering on the ventilator the Standby menu displays.

1. Select ***NEW PATIENT***.
2. Select ***Adult***, ***Pediatric***, or ***Neonatal*** patient type.
3. Select ***Patient ID*** (identification).
   - Enter up to 10 characters and then select ***Confirm***. (Only English alpha-numeric characters may be entered).

WARNING To protect patient privacy, do not use the patient's name when entering the patient ID (identification). Consider the facility's privacy policies when entering the patient ID.

4. Select ***Gender*** (male or female).
5. Select ***Height***.
6. Select ***Weight***.
   - The ventilator calculates and displays the patient weight in kilograms, the BSA (Body Surface Area), IBW (Ideal Body Weight), and a suggested VT (Tidal Volume). See the "*Clinical theory*" section for calculations.
   - IBW is available for adult patients only.
7. Select (Endotrach, Trach, or ---).

   When --- is selected, the ventilator will not compensate for tube resistance.
8. Select ***Tube Diameter***.
9. Verify and confirm settings.

Previous Patient

The Previous Patient button shows upon power up of the ventilator when previous patient data exists. Previous Patient allows the clinician to use the patient settings and alarm limits that were previously used and view trends and historical data. For example, if a patient is extubated, but fails to progress and needs to be re-intubated, the clinician may use the previous patient settings.

From the Standby menu, select ***PREVIOUS PATIENT***.

Important Previous Patient data is only saved when a normal shutdown sequence is performed. Abrupt or unexpected power loss will prevent this data from being saved.

Current Patient

Use this menu to update settings or change patient type from Pediatric to Adult or Adult to Pediatric. If Neonatal is installed, patient types may be changed from Neonatal to Pediatric or Pediatric to Neonatal.

1. Select ***Standby***.
2. Select ***Current Patient***.

   The Current Patient menu shows.
3. Select the desired patient type and adjust settings.

System Check

System Check overview

The ventilator should be fully cleaned and prepared for a patient before performing the System Check.

When started, the System Check runs automatically. Selecting the information icon will show the active progress in the System Check Details menu. The steps will show a green check mark (pass) or a red X (fail). When each check is completed, the next check begins.

A General Warning icon in the System Check indicates that a check has not been performed or completed for the current patient. Both the yellow warning icon and the yellow Start Ventilation button serves as a visual warning that a System Check needs to be performed.

WARNING To help ensure the proper function of the system, it is highly recommended to complete the System Check between patients.

- The patient must not be connected to the ventilator while completing the System Check.
- Complete the System Check with the breathing circuit and accessories that will be used during ventilation.
- If a System Check is not completed for the current patient, the system uses the compliance and resistance data from the last completed system check for the set patient type for all internal compensations. If the current breathing circuit differs significantly from the previous circuit, differences in ventilation parameters due to changes in the compensation process are possible.
- Failure to complete a System Check may result in inaccurate delivery and monitoring. This may result in risk to the patient.

Additional System Check information

- The circuit leak is measured at 25 cmH2O. The resistance is the measured resistance of the inspiratory limb of the patient circuit. If the circuit leak is greater than 0.5 l/min or resistance or compliance measurements cannot be calculated, the Circuit Check will fail.
- If the circuit leak is greater than 0.5 l/min or if the exhalation flow sensor is changed after the System Check, the expiratory tidal volume may have decreased accuracy.

- If the relief valve failure alarm activates after the System Check then the ventilator will not allow ventilation until the relief valve portion of the System Check has passed.

Circuit Setup

Use the Circuit Setup menu to select settings that must be compensated for in patient circuit measurements. The HME and Humidifier (must include a heated expiratory limb) settings are selected in the Circuit Setup. For adult and pediatric patient types the default selection is HME. For the neonatal patient type, the Circuit Setup menu is not available and the Humidifier selection will always be used.

WARNING Changing the Circuit Setup will invalidate the current System Check results. Changing the patient circuit after completion of System Check will affect volume delivery and exhaled volume measurements. If any change is made to Circuit Setup or the patient circuit, repeat the System Check.

Circuit Setup should be checked when setting up a New Patient or a change has been made to the patient's circuit setup.

A yellow warning icon will replace the previous System Check status icon (pass or fail) when a change has been made in the Circuit Setup menu. The yellow warning icon indicates that a System Check should be performed.

1. Select ***Circuit Setup***.

   The Circuit Setup menu displays.
2. Select the check box for the ***HME*** or ***Humidifier***.

   Settings are confirmed when the setting is changed.
3. Select X to close the menu.

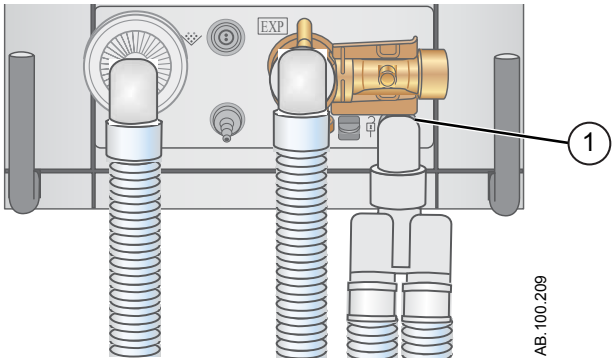
Running a System Check

1. From Standby, select ***SYSTEM CHECK***.

   The Run System Check menu shows.
2. Attach the breathing circuit and all accessories that will be used to ventilate the patient.

   - Complete the System Check using the appropriate flow sensor per patient type. For example, use the neonatal flow sensor when completing a System Check for a neonatal patient.

3. Occlude the patient wye using the occlusion port.



1. Occlusion port

4. Select Start.

   The System Check starts and shows the results of each check.

   The system runs the following checks:

   - Paw transducer check
   - Barometric pressure check
   - Relief valve check
   - Exhalation valve check
   - Expiratory flow sensor check
   - Air flow sensor check
   - Oxygen sensor check
   - O2 flow sensor check
   - Resistance check
   - Circuit measurements check (circuit leak, compliance, and resistance)

Important When performing the Resistance Check, the wye-piece and all breathing accessories such as: D-lite (+)/Pedi-lite(+) sensor and HME should remain on the occlusion port.

5. Select the information icon to see the System Check Details menu.

   The System Check starts and shows the results of each check.

Note Follow all on-screen system check instructions.

As the System Check runs, the results of each check are displayed as a green check mark (pass) or red X (fail). If a check fails, a Help icon displays next to the failed check (red X). Select the Help icon to view possible causes and help for troubleshooting a failure.

When the System Check is complete, the Final Result line will display the patient type icon, a green check mark (pass) or red X (fail), and the date and time of the System Check.

Patient ventilation

Setting the ventilator data source

The data source is used to obtain patient monitoring parameters from either the ventilator or the airway module. See "*Patient monitoring*" for detailed information. See "*Setting the ventilator data source*"in the "*Neonatal Operation*" section.

1. Select ***Menu*** > ***System***.

   The System menu shows.
2. Select ***Data Source***.
3. Select ***Ventilator*** or ***Airway Module*** to confirm settings.

   If Ventilator is selected as the data source the Ventilator Data icon displays in the lower right corner of the display; the internal sensors of the ventilator will be the source for monitored data.

   If Airway Module is selected as the data source and an airway module is installed and warmed up, the Airway Module (Patient) data icon displays in the lowerright corner of the display. The airway module will be the first source for monitored data. If data is not available through the airway module, monitored data will come from the internal ventilator sensors.

Ventilator Data Source Icons	
	
Ventilator data	Airway Module (Patient) data

Note When Airway Module is selected as the data source, the data source icon will not be updated until the module is able to provide data. This may take 2 to 5 minutes when a module is first installed into the module bay. Only data available from the installed airway module will be displayed on the ventilator, all other data will be from the ventilator. For example, if a module capable of measuring CO2 and O2 only is installed, CO2 and O2 data displayed will be from the module, all other data will be from the ventilator.

System menu

The System menu contains settings for data source selection, calibration options, display brightness, and system information.

1. Select ***Menu*** > ***System***.

The Airway Module type and software version number are shown under data source.

2. Select Data Source (***Ventilator*** or ***Airway Module***).

   - For Neonatal; select ***Ventilator*** or ***NFS***. See "*System menu*" in the "*Neonatal Operation*" section.

3. Select Calibrations (***Airway Module***, ***Paux Zero***, or ***Purge Flow***).

   - Select Airway Module to calibrate the airway module.
   - Select Paux Zero. A green check mark indicates Paux Zeroing calibration was successful.
   - Select Purge Flow. The Purge Flow check box may be checked or unchecked when performing a Paux Zero. Continuous purge flow will come from the Paux outlet when the Purge Flow check box is selected. A white check mark indicates Purge Flow is active.

Note See "*Purging the auxiliary pressure tubing*" and "*Zeroing auxiliary pressure*" in the "*Setup and connections*" section.

4. Select ***Display Brightness*** to adjust the brightness level of the user interface.

   Select brightness level of 1 (low) to 5 (high).

5. View system information: software version, service packet version, running hours, altitude, O2 supply pressure, air supply pressure, and battery status.

Setting a ventilation and backup mode

Ventilation modes are selected through the Current Mode button. The selected ventilation mode shows with the corresponding mode settings.

Ventilation modes may be changed in Standby or during ventilation.

Ventilation mode settings should be set prior to connecting a patient to the ventilator.

See "*Backup mode*" in the "*Ventilation modes*" section for additional information.

1. Select ***Current Mode***.
2. Select the desired ventilation mode.

   The title of the vent mode shows in the Mode Settings menu along with the parameters for that mode. See "*Ventilation modes*" section for detailed information on types of modes and settings.

   Depending upon the facility default setup for ventilation modes, the Mode Settings menu may contain two icons. The partial list

icon represents the facility's set ventilation modes and the full list icon represents the full set of ventilation modes available.

Select the appropriate icon to see available ventilation modes.

	
Partial list of ventilator modes	Full list of ventilator modes

3. Select ***Assist Control***, ***Leak Comp***, or ***Trigger Comp*** if desired.
   - Assist Control is only available in the following ventilation modes: A/C VC, A/C PC, and A/C PRVC.
   - See "*Assist control*", "*Leak compensation*", or "*Trigger compensation*" in the "*Ventilation modes*" section for detailed information.
4. Set the desired settings for the ventilation mode and confirm.

   When ventilator settings are confirmed, the Mode Settings menu closes and the selected ventilation mode shows in Current Mode.
5. To set a Backup Mode, select ***Current Mode***.
6. Select ***Backup Settings***.
   - Set the desired settings for the backup mode and confirm.
7. Confirm all ventilation mode settings.

Setting limit indicators

When adjusting ventilation mode settings, yellow and red visual indicators show when parameters are approaching their setting limits. Green visual indicators show the parameters are appropriate for the setting limits.

Starting patient ventilation

WARNING Ventilation will not start until 'Start Ventilation' is selected.

- Ensure that the ventilator battery is fully charged before starting patient ventilation. See "*Battery status*" for additional information.

1. From Standby, select ***START VENTILATION***.

   If the Start Ventilation button is green, a System Check has been completed for the current patient and when selected, will start ventilation.

If the Start Ventilation button is yellow, the Complete System Check warning alert will display the following:

Select Continue to bypass System Checkout and start ventilation. Select Cancel to remain in Standby.

Note It is recommended that System Check is completed prior to starting ventilation.

2. After ventilation has started, connect the breathing circuit to the patient.

Pausing ventilation

WARNING The patient will not be ventilated when in Standby.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventilation to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.
3. Select ***Pause Ventilation***.

   • Monitoring and ventilation will stop.

Park Circuit

Park Circuit allows the patient circuit to be occluded without the ventilator alarming while in Standby. When the patient circuit is positioned on the occlusion port the display activates the PARK CIRCUIT selection.

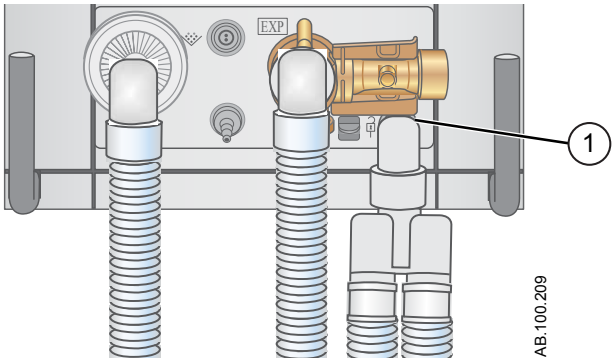
WARNING The patient will not be ventilated while the circuit is parked and in Standby.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventialtion to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.
3. Select ***Pause Ventilation***.

   • Monitoring and ventilation will stop.

4. Occlude the patient circuit using the occlusion port.



1. Occlusion port

5. Select ***PARK CIRCUIT***.

   - The display will show: Patient circuit is occluded and the ventilator is in Standby.

Setting Favorites

Up to four Favorite procedures may be selected to show on the upper-right corner of the user interface.

1. Select ***Menu***.
2. Select ***Procedures***, ***Lung Mechanics***, or ***Suction*** menus.
3. Select ***Assign Favorites***.

   The Assign Favorites menu shows with a list of the following procedures: Increase O2, Suction, Auto PEEP, Inspiratory Hold Expiratory Hold, P 0.1, NIF, Vital Capacity, and Manual Breath.
4. Select up to four Favorites.

   Favorites show in the upper right corner of the display.

Note The following Favorite procedures begin automatically after they are selected: Manual Breath, Suction, and Increase O2.

7 Procedures

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

Suction

Closed Suction: Any ventilation modes and settings may be used with a closed suction catheter. Patient Disconnected, RR low, MVexp low, VTexp low, Apnea, and other alarms may occur during use of a closed suction catheter.

Open Suction: To perform suctioning without nuisance alarms, an open suction procedure is provided by the ventilator.

The Open Suction procedure has three phases:

Suction oxygenation - Phase 1: The ventilator delivers increased oxygen at the current Increase O2 setting (factory default value is +25% for neonatal or 100% for pediatric and adult) for two minutes or until the patient is disconnected.

Suction Standby - Phase 2: The ventilator enters Suction Standby for two minutes or until the patient is reconnected.

Oxygenation - Phase 3: The ventilator resumes ventilating at the current Increase O2 setting delivering the increased oxygen value for two minutes.

CAUTION If the current set value is 1 cmH2O or less, PEEP or Plow will be increased to a minimum value of 1.5 cmH2O to better detect a patient disconnect condition during the Suction procedure.

1. Select as a Favorite - see "*Setting Favorites*" in the Operation section or select ***Menu*** >***Suction***.
2. Select Start.

   The Suction oxygenation, Suction, and Oxygenation general messages show as each phase occurs.
3. Wait for the pre-oxygenation phase and then disconnect the patient at the wye.

   An audible tone sounds to indicate the patient is disconnected and ventilation is paused.
4. Suction the patient.
5. Reconnect the patient to resume ventilation.

   The Suction procedure will end after the oxygenation phase completes, if Stop is selected, or if the Suction Favorite is selected.

Nebulizer treatment

The Aerogen® Professional Nebulizer System is a portable medical device that is intended to aerosolize physician-prescribed solutions and suspensions for inhalation to patients on and off ventilation or other positive pressure breathing assistance.

The ventilator supports the Aerogen Pro and Aerogen Solo (disposable) in-line nebulizers by Aerogen.

The nebulizer time can be set for specific duration delivery times or for the volume of medication that will be delivered to the patient. A general message shows the nebulizer treatment time remaining.

When the nebulizer is in use, gas sampling and monitoring from the airway module is suspended. The addition of nebulizer flow is not included in the FiO2 reading.

CAUTION Only the Aerogen Solo (disposable) may be used for continuous delivery of nebulized medication.

- Use the Aerogen recommended nebulized drug suspension and/or high viscosity solution. Using a solution, suspension or emulsion in the nebulizer different from that, may alter the particle size distribution curve, the mass median aerodynamic diameter, aerosol output and/or aerosol output rate.
- Do not insert an airway module into the module bay until at least one minute after a nebulizer procedure has been completed. Aerosolized medication may damage the D-fend or interfere with the airway module measurements.
- If the patient type is neonatal and a neonatal flow sensor is in use, remove it from the patient circuit during the delivery of nebulized medication and change the data source to ventilator to prevent damage to the neonatal flow sensor.
- To avoid the risk of fire, do not use the nebulizer in the presence of a flammable anesthetic mixture combined with air or with oxygen or nitrous oxide.
- Do not use the nebulizer to aerosolize alcohol-based medications, which can ignite in oxygen-enriched air under pressure.

1. Select ***Menu*** > ***Nebulizer*** > ***Aerogen***.
2. Select ***Time*** or ***Continuous***.

   Selecting Continuous will deliver nebulized medication until medication delivery is stopped or runs out.

   The time and approximate volume of nebulized medication are shown in the table. This calculated volume is based on an

average nebulization rate of 0.38 ml/min, but the actual nebulization rate of each individual nebulizer cannot be guaranteed and may vary significantly

Time (min)	7	8	11	16	21	26	32
Volume (ml)	2.5	3.0	4.0	6.0	8.0	10.0	12.0

3. Select Start.

Note To end a nebulizer treatment before the set time, select Stop.

Pneumatic nebulizer

The ventilator can compensate for additional flow introduced by a pneumatic nebulizer into the patient circuit. The displayed FiO2 measurement does not reflect the additional gas introduced to the patient through the nebulizer.

WARNING Use of an external pneumatic nebulizer may significantly modify the mixture of gas that is delivered to the patient.

- Use of external pneumatic nebulization may significantly impact volume delivery and monitoring, decrease trigger sensitivity, and cause alarms if external flow is introduced and Pneumatic Nebulizer Flow Compensation is not used.
- When the Pneumatic Nebulizer Flow Compensation is On, flow and volume accuracy may be decreased.
- Leaks and flow sensor alarms may not be identified by the ventilator when Pneumatic Nebulizer Flow Compensation is On.

1. Select ***Menu*** > ***Nebulizer*** > ***Pneumatic***.
2. Select the ***Flow*** value.
   - Set the flow value to match the amount of flow that will be introduced into the circuit. Flow setting is patient type dependent: 1.0 to 4.0 l/min for neonatal; 1.0 -12.0 l/min for adult and pediatric.
3. Select Start.

   A general message shows when nebulizer flow compensation is on.
4. Introduce the pneumatic nebulizer into the patient circuit.
   - For best results, introduce the pneumatic nebulizer into the patient circuit within approximately 15 seconds after selecting Start.

Note To end a nebulizer treatment, turn the pneumatic nebulizer flow source off, then select Stop.

Performing an Increase O2 procedure

Increase O2 is used to increase the amount of oxygen delivered to the patient to prevent low oxygen saturation levels.

1. Select as a Favorite (the procedure will start immediately - see "*Setting Favorites*" in the Operation section), or select ***Menu*** > ***Procedures*** > ***Increase O2***, or press the Increase O2 hard key.
2. Use the facility set increase O2% (factory default value is +25% for neonatal or 100% for pediatric and adult) or adjust the O2% to the desired concentration and confirm the setting.
3. Select Start.
    - The oxygenation general message shows along with the progress bar and a 2 minute countdown timer. The progress bar fills in proportion to the amount of time the Increase O2 procedure has completed.
    - The procedure will end when the time has elapsed or when Stop is selected, or when the Increase O2 Favorite is selected, or when the Increase O2 hard key is pressed.

Performing an Inspiratory Hold

The Inspiratory Hold procedure may be used during an x-ray procedure or to determine plateau pressure and static compliance calculations. When Inspiratory Hold is selected the inspiratory and expiratory valves close at the end of the next inspiratory phase. The Inspiratory Hold cannot be repeated until the patient triggers a spontaneous breath or the ventilator delivers a mandatory breath. Inspiratory Hold is not available in non-invasive ventilation modes.

1. Select as a Favorite (the procedure will start immediately) - see "*Setting Favorites*" in the Operation section or select ***Menu*** >***Procedures*** >***Inspiratory Hold***.
2. Select the Inspiratory Hold Time.
   - Use the Trim Knob to select an Inspiratory Hold time: 2 to 40 seconds for adult, 2-15 seconds for pediatric and neonatal.
3. Select Start.
   - A general message shows while the inspiratory hold is in progress.
   - The procedure will end when the Hold Time has elapsed or when Stop is selected.
   - Pplat and Cstat results will display along with a timestamp. If the measurement is not available, a red X will display indicating a failure.

Performing an Expiratory Hold

The Expiratory Hold procedure is used to measure the end breath lung pressure. When Expiratory Hold is selected, the inspiratory and expiratory valves close at the end of the next expiratory phase. The expiratory hold cannot be repeated until the patient triggers a spontaneous breath or the ventilator delivers a mandatory breath. Expiratory Hold is not available in non-invasive ventilation modes.

1. Select as a Favorite (the procedure will start immediately) - see "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Procedures*** > ***Expiratory Hold***.
2. Select the Expiratory Hold time.
   - Use the Trim Knob to select an Expiratory Hold time between 2 to 60 seconds for adult, 2-20 seconds for pediatric and neonatal.
3. Select Start.
   - A general message shows while the expiratory hold is in progress.
   - The procedure will end when the Hold Time has elapsed or when Stop is selected.

Manual breath

The Manual Breath procedure allows the clinician to deliver additional mechanical breaths to the patient. The ventilator requires a 0.25 second pause between delivery of breaths. The breath delivered is based on the settings for the current mode or backup ventilation mode if a rate is not set for the current mode. Manual Breath is not available in non-invasive ventilation modes.

Select as a Favorite (the procedure will start immediately) - see "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Procedures*** > ***Manual Breath*** > ***Add Breath***.

Measuring P 0.1

P 0.1 is a respiratory measurement used to evaluate the patient's readiness to be weaned from the ventilator. P 0.1 is a measurement of the airway occlusion pressure 0.1 second after beginning an inspiratory effort against an occluded airway.

1. Select as a Favorite. See "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Lung Mechanics*** > ***P 0.1***.
2. Select Start.

   - The P 0.1 measurement will display along with a timestamp.
   - The P 0.1 procedure will end when the measurement is completed or when Stop is selected. If the measurement is not available, a red X will display indicating a failure.

Measuring Negative Inspiratory Force (NIF)

Negative Inspiratory Force is a weaning measurement that is used to evaluate the patient's readiness to be weaned from the ventilator. NIF is used to determine the patient's ability to take a deep breath and to generate a cough strong enough to clear secretions.

WARNING The patient will not be ventilated during a NIF procedure.

1. Select as a Favorite - see "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Lung Mechanics*** >***NIF***.
2. Set NIF Time.
   - Use the Trim Knob to select a NIF time up to 30 seconds.
3. Instruct the patient to fully exhale.
4. Select Start and instruct the patient to fully inhale.
   - When the patient inhales the most negative airway pressure is recorded and displayed along with a timestamp.
   - The procedure will end when the measurement is completed or when Stop is selected. If the measurement is not available, a red X will display indicating a failure.

Measuring Vital capacity

Vital Capacity is the measurement of a patient's largest (VTexp) expired Tidal Volume over a 30 second period.

During a Vital Capacity measurement, Pinsp and PS are set to zero. When the Vital Capacity measurement is complete Pinsp and PS return to the previous setting.

During the Vital Capacity procedure, VTinsp and VTexp for each breath will display in the Splitscreen view.

When the Vital Capacity procedure is complete, the largest VTexp value is displayed with a timestamp in the Lung Mechanics window.

WARNING The patient will not be mechanically ventilated during a Vital Capacity procedure.

1. Select as a Favorite - see "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Lung Mechanics*** > ***VC***.
2. Select Start.
3. Instruct the patient to fully inhale and exhale.
    - The procedure will end when the measurement is completed or when Stop is selected. If the measurement is not available, a red X will display indicating a failure.

Measuring Auto PEEP

Auto PEEP or Intrinsic PEEP is a measurement of pressure remaining in the lungs above the PEEP value at the end of a breath. It may be used as an indication of a patient's inability to completely exhale.

1. Select as a Favorite - see "*Setting Favorites*" in the Operation section or select ***Menu*** > ***Procedures*** >***Auto PEEP***.
2. Select Start.

   - The ventilator measures Auto PEEP at the end of each controlled breath during a 30 second time period. If unsuccessful, the measurement procedure is cancelled.
   - Spontaneous patient breath triggers or activation of other procedures may cause an unsuccessful measurement.
   - The effects of breathing circuit compliance are accounted for in the Auto PEEP measurement.
   - The procedure will end when the measurement is completed or when Stop is selected. If the measurement is not available, a red X will display indicating a failure.

PEEPi Volume

Selecting Auto PEEP also calculates the PEEPi Volume. This is the approximate volume of air trapped in the lungs at the time the Auto PEEP procedure is started. PEEPi Volume is calculated from the current lung compliance and PEEPi measurement.

If PEEPi Volume cannot be calculated when Auto PEEP is selected, --- is displayed.

8 Alarms and troubleshooting

In this section

Alarms

WARNING If an alarm occurs, attend to the patient before troubleshooting or doing any repair procedures.

- A hazard can exist if different alarm settings are used for the same parameter for similar equipment in any single area, such as an intensive care unit.
- The ventilator must not be enclosed in a room where the auditory alarm signals cannot be heard by the clinician.

CAUTION Repairs should only be performed by an authorized service representative. See "*Repair policy*" in the "*Cleaning and maintenance*" section for more information.

Important The alarm light can be seen from all sides of the ventilator, but messages can only be viewed from the front of the ventilator using the display.

During ventilation, there are two types of alarms that can occur, parameter and technical. Parameter alarms occur when the measured patient data is not in the range of the set limits. Technical alarms occur when an error condition is detected within the ventilator. A technical alarm may also occur when data cannot be interpreted or data is not available.

When an alarm occurs during ventilation, the ventilator emits an audible tone, flashes a light on the top of the display unit, and shows the alarm message on the screen.

Note The facility must determine the maximum remote alarm signal generation delay for its distributed alarm system.

Note Current alarm settings will be maintained upon main power interruption, when the system operates using the internal battery. The alarm settings will be lost when both main power and battery are lost, and will change to default settings upon restart of the system.

Alarm management

During ventilation, alarms are managed from the alarm bar, which gives a visual indication of the priority and type of alarm. Use the alarm bar to acknowledge alarms and access alarm settings. When a parameter alarm occurs, the measured data can be selected to quickly access the setting that is out of range.

CAUTION Do not set alarm limits to extreme values that can render the alarm system useless.

Alarm bar

The alarm bar gives a visual indication of parameter and technical alarms. The alarm bar includes audio pause, alarm status, and alarm setup.

- If there are no current active alarms or previous alarms requiring user acknowledgement, the alarm status shows No Alarms and the alarm bar is green. The alarm list is not available.
- If there are active alarms, the alarm status shows the alarm message for the most recent alarm with the highest priority. The alarm bar color shows the priority of the alarm.The alarm list contains a list of all active alarms, as well as previous alarms requiring user acknowledgement.
- If the alarm bar is grey, there are no active alarms but a previous alarm requires user acknowledgement.

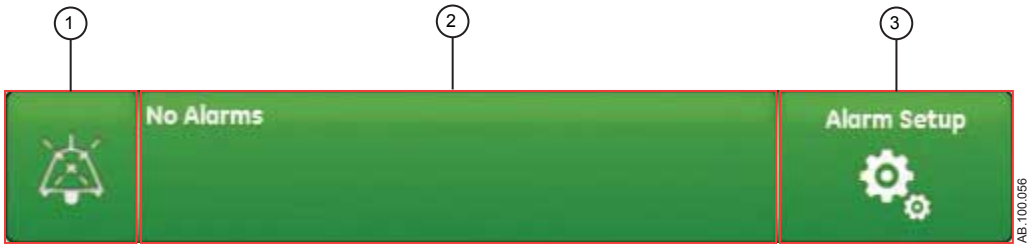


Figure 8-1 • Alarm bar with no active alarms

1. Audio pause
2. Alarm status
3. Alarm setup

Figure 8-2 • Alarm count

1. Audio pause timer
2. Active alarm count

Adjacent to Alarms is a number that shows how many alarms are in the list. Select the alarm status to show the list of alarm messages. The alarm messages are in the order of when the alarm occurred, with the most recent alarm shown at the top of the list. In addition, each alarm in the list has a timestamp to show when it occurred.

When the alarm list is expanded, select the question mark next to an alarm to show details about the alarm. The detailed information gives a description of the cause and what action is necessary to correct the alarm condition. See "*List of alarms*" for more information.

Alarm messages that are grey will show in the list after the condition is corrected and stay until they are viewed in the alarm list. When the list is closed, these messages are removed from the list and are available in the Trend log.

Alarm setup

Alarm limits and other alarm settings can be adjusted in the Alarm Setup menu. Select ***Alarm Setup*** to show the following alarm limits:

- Ppeak - Low and High
- MVexp - Low and High
- VTexp - Low and High
- RR - Low and High
- EtCO2 - Low and High
- EtO2 - Low and High
- FiO2 - Low and High
- PEEPi High
- Paux High
- PEEPe - Low and High
- Leak Limit High
- Apnea Time

- Patient Effort (NIV mode only)
- Tdisconnect (NIV mode only)

Figure 8-3 • Alarm setup menu

Note Alarm limits for EtCO2, EtO2, and PEEPi are only available when an airway module with these measurement capabilities is installed. If the patient type is Neonatal, these alarm limits are not shown.

Select either the low or high alarm limit, and then use the Trim Knob to adjust the setting.

- Alarm setting changes that are not confirmed prior to the end of a timeout period are cancelled.

A Super User can set alarm limit defaults. See the "*System configuration (Super User) and service*" section.

1. Apnea Time — Set Apnea time up to 60 seconds.
2. Alarm Light Brightness — Set the brightness level of the alarm light. The range is 1 (low) to 5 (high).
3. Alarm Volume — Set the volume of the alarm tone. The range is 1 (low) to 5 (high).
4. High Alert Audio — Set the delay time in which a high priority alarm must be resolved or acknowledged before the audio tone pitch and volume increase to the maximum level. The range is 0 to 30 seconds or Off. A general message shows when High Alert Audio is set to off.

5. Alarm Limits — Select the check box to show alarm limits adjacent to the measured data in Basic, Basic Waveforms, Advanced Waveforms, and Splitscreen views. The alarm limit always shows when an alarm occurs for the measured data, even if it is set to Off.
6. Auto Limits — Select to set auto alarm limits based on current measured data.

Auto limits

Use the Auto Limits button to expand current alarm limits. This feature is only available while ventilating a patient, and may be useful when multiple alarms are occurring.

Select ***Auto Limits*** to change the alarm limits for the following measured data values.

- MVexp – Low and High
- VTexp – Low and High
- Rate – Low and High
- EtCO2 – Low and High
- PEEPe – Low and High

The alarm setting change is dependent on the current measured data. An alarm limit set to Off will not change when Auto Limits is selected.

The table shows how the adjusted alarm limit settings are calculated using the current measured data. If the calculated alarm limit is below zero, the alarm limit will be set to the lowest possible value for that particular alarm limit setting. Auto limits will never set an alarm to Off.

Alarm Setting	Low Limit	High Limit
MVexp	current value x 0.5	current value x 2.5
VTexp	current value x 0.5	current value x 2.5
Rate	current value - 2	current value + 30
EtCO2 (% or kPa)	current value - 1	current value + 1
EtCO2 (mmHg)	current value - 6	current value + 6
PEEPe (cmH2O or mbar)	current value - 5	current value + 5
PEEPe (kPa)	current value - 0.5	current value + 0.5

Alarm priority

Audible and visual indicators tell the priority of the alarm.

Priority	Color	Light	Tone
High	Red	Flashes red	Series of five tones, twice
Medium	Yellow	Flashes yellow	Series of three tones
Low	Blue	Solid blue	Single tone

Note For medium and high priority alarms, the alarm tone is repeated until audio pause is selected or the alarm condition is resolved. When high priority alarms are not resolved within the set high alert audio time limit, the pitch and volume of the tone increases to the maximum audio level. See "*Alarm setup*" for information on how to set High Alert Audio.

When more than one alarm occurs at the same time, the alarm bar, alarm light, and audible alarm tone indicates the highest priority alarm.

The color on the right side of the alarm light shows the priority of the alarm. The left side of the alarm light is blue when audio pause is active.

Some medium priority and high priority alarms are de-escalated and change to low priority alarm when audio pause is selected. To see which alarms can be de-escalated, see "*List of alarms - adult and pediatric*" or "*List of alarms – Neonatal*". Until the de-escalated alarm condition is resolved, the low priority alarm stays active.

Audio pause

Audio pause temporarily mutes the audible tone of an alarm for two minutes.

To pause audio, select the audio pause icon on the alarm bar or press the audio pause hard key on the front of the display. When audio pause is selected, a timer above audio pause in the alarm bar starts to count down from two minutes. If the alarm is still active or a new alarm occurs after the timer expires, the alarm tone becomes audible for the highest priority alarm.

Select audio pause while the timer is counting down to cancel audio pause; the alarm tone then becomes audible.

Important The nurse call alert is off while audio pause is active.

The following alarms are always audible, even if they become active during audio pause:

- Battery error
- Battery in use
- Patient circuit occluded
- Patient disconnected

- Sustained airway pressure
- System shutdown in less than 20 (10, 5, and 1) minutes
- Power supply error

Audio pause will not mute the alarm tone for the folowing alarms:

- Patient detected
- Turn off ventilator?

Secondary audio alarm

If the primary audio alarm fails, the ventilator has a secondary audio alarm as a backup. When the ventilator is initially turned on, the primary and secondary audio each emit an audible tone.

Measured data alarms

When an alarm occurs for measured data, the number and alarm limits are shown with a border around them. The color of the border and the alarm limit (when in the Alarm Setup menu) shows the priority of the alarm. Select within the border of the active alarm to open the Alarm Setup menu. If necessary, use the Trim Knob to adjust the setting for the alarm limit.

Figure 8-4 • Select inside of the border to open the Alarm Setup menu.

List of alarms - adult and pediatric

Important If the patient type is Neonatal, see "*List of alarms – Neonatal*" for details.

Note See Alarms and Troubleshooting and Alarm Tests for additional information about alarms and to see a list of general messages.

These notes apply to the alarm messages in the table below:

- A [1] by the priority indicates an alarm that is not enabled when an inspiratory hold is in progress.
- A [2] by the priority indicates an alarm that is not enabled when an expiratory hold is in progress.
- A [3] by the priority indicates an alarm that is not enabled when the P 0.1 or NIF procedures are in progress.
- A [4] by the priority indicates an alarm that is de-escalatable.
- * The removal criteria for an alarm is the removal or reversal of the listed condition.

Alarm	Priority	Condition*	Cause	Action
Air and O2 supply pressure low	High	O2 supply pressure and air supply pressure are less than 24.3 psig for more than 0.5 seconds.	Air supply pressure is low and O2 supply pressure is low.	• Check the Air and O2 connections. • Check the air source. • Check the O2 source. • Prepare to disconnect the patient from the ventilator and manually ventilate.
Air supply pressure high	Low	Air supply pressure is greater than 95 psig for more than 0.5 seconds.	Air supply pressure is high.	• Check the air source. • Set FiO2 to 100%.
Air supply pressure low	Medium[4]	Air supply pressure is less than 24.3 psig for more than 0.5 seconds.	Air supply pressure is low. The ventilator is delivering O2 only. O2 may be leaking into the air supply system.	• Check the Air connection. • Check the air source.
Air supply pressure sensor error	Low	Air supply pressure sensor data is invalid during a non-ventilation state.	The ventilator is not able to measure air supply pressure.	• Perform System Check. • Contact an authorized service representative. • Prepare to disconnect the patient from the ventilator and manually ventilate.
Air temperature high	High	Total flow sensor temperature is above 51° C.	Air supply temperature is high.	• Check the air source. • Clean the compressor filter.

Alarm	Priority	Condition*	Cause	Action
Airway module error	Medium[4]	There is a problem with the installed airway module. Airway module spirometry data is not available while this alarm is active. Some features may not be available.	The airway module is not working. CO2 and O2 data are not available. The airway module data is not valid.	• Replace the airway module.
	Low	Airway module detected is not compatible with system software.	The installed airway module is not compatible with system software.	• Remove the airway module.
Airway module gas sampling error	Medium[4]	Sample gas outlet of the installed airway module is blocked while the nebulizer is not in use.	Occlusion detected in airway module sample gas outlet.	• Check for an occlusion in the airway module sample gas outlet. • Wait 30 seconds, and then press Home to resume gas sampling.
		D-fend module is not detected by the installed airway module while the nebulizer is not in use.	Occlusion detected in airway module gas sampling line or D-fend water trap.	• Empty the D-fend water trap. • Check for an occlusion in the airway module gas sampling line. • Replace the airway module gas sampling line.
		Sample tubing inside or outside the installed airway module is blocked or the water trap is occluded.	The airway module gas sampling line or the D-fend water trap is not installed.	• Install the D-fend water trap. • Check the airway module gas sampling line connection. • Wait 30 seconds, and then press Home to resume gas sampling.
	Low	Residue buildup on the water trap membrane of the installed airway module. Buildup can decrease airflow.	Occlusion detected in airway module D-fend filter.	• Replace the D-fend water trap.
		Airway module sample flow was too low for 20 seconds.	The airway module sample flow is low.	• Check for an occlusion in the patient circuit. • Check the airway module gas sampling line connection. • Check for an occlusion in the airway module gas sampling line.

Alarm	Priority	Condition*	Cause	Action
Airway module sensor error	High	Peak pressure measured by the airway module is below 3 cmH2O, and is also at least 5 cmH2O below the peak pressure measured by the ventilator.	The airway module does not detect pressure or flow.	• Install the airway module spirometry sensor between the patient circuit and the patient. • Check the airway module spirometry tube connection. • Remove the neonatal flow sensor. • Set Data Source to Ventilator.
Airway pressure sensor error	High	The difference between expiratory pressure and inspiratory pressure is greater than 10 cmH2O for more than 350 ms.	Expiratory pressure is greater than inspiratory pressure.	• Check for an occlusion in the expiratory pressure port. • Perform System Check.
		Expiratory pressure sensor data is invalid.	The ventilator is not able to measure expiratory pressure.	• Perform System Check.
		Inspiratory pressure sensor data is invalid.	The ventilator is not able to measure inspiratory pressure.	• Perform System Check.
	Low	Zeroing of expiratory pressure sensor data was out of range for 3 consecutive zeroing attempts.	The ventilator is not able to measure expiratory pressure.	• Perform System Check.
		Zeroing of inspiratory pressure sensor data was out of range for 3 consecutive zeroing attempts.	The ventilator is not able to measure inspiratory pressure.	• Perform System Check.
Alarm light error	Medium[4]	An error was detected with the alarm light.	The alarm light is not working.	• Cycle power. • Contact an authorized service representative.
Apnea	High[1, 2]	No valid breaths were detected for the set Apnea Time.	Expired tidal volume not detected within the set Apnea Time.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the Apnea Time setting in Alarm Setup.
Apnea alarm off	Medium[4]	Apnea Time selection is Off.	Apnea Time is set to Off.	• Review the Apnea Time setting in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
Backup ventilation on	Medium	Apnea has been detected.	Apnea detected.	• Check the status of the patient. • Review the ventilator settings. • Confirm the current mode in Mode Settings to continue using backup ventilation settings. • Select Previous Mode in Mode Settings to end backup ventilation and return to the settings used prior to entering backup ventilation. • Confirm a different mode in Mode Settings to end backup ventilation.
	Medium[1, 2]	Measured expired minute volume is less than 50% of the MVexp low alarm limit.	Low expired minute volume detected.	• Check the status of the patient. • Review the ventilator settings. • Confirm the current mode in Mode Settings to continue using backup ventilation settings. • Select Previous Mode in Mode Settings to end backup ventilation and return to the settings used prior to entering backup ventilation. • Confirm a different mode in Mode Settings to end backup ventilation.
Barometric pressure sensor error	Low	Barometric pressure data is invalid.	The ventilator is not able to measure barometric pressure.	• Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
Battery error	Medium[4]	Battery power is not available due to one of the following issues: • Battery charge failed • Battery failed • Battery missing • Battery not connected • Battery connection is reversed • Power system self-test failed • Battery is degraded • Battery current was too high while the power switch was off	Battery power is not available. Ventilation will stop if main power supply is lost.	• Contact an authorized service representative.
		No battery power is detected due to one of the following issues: • Power system communication error • The battery is not charging properly	No battery power detected. Ventilation may stop if main power supply is lost.	• Contact an authorized service representative.
Battery in use	Medium[4]	The system has been powered by internal battery for more than 3 seconds.	Main power supply is not available. The ventilator is powered by the battery.	• Connect to main power supply.
		Mains power is unavailable and the remaining internal battery time is less than 30 minutes.	Main power supply is not available. The ventilator is powered by the battery.	• Connect to main power supply.
		Batteries are discharging while the ventilator is plugged in.	Main power supply is not available. The ventilator is powered by the battery.	• Check main power supply connections.
Circuit leak	High	Measured leak is greater than the set Leak limit while the patient is connected.	Leak % is greater than the set Leak Limit.	• Check for leaks in the patient circuit or airway. • Review the Leak Limit setting in Alarm Setup. • Clean or replace the expiratory flow sensor.
Circuit leak alarm off	Medium[4]	Leak Limit is set to Off.	Leak Limit is set to Off.	• Review the Leak Limit setting in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
Cooling fan error	High	A power system component has overheated.	Ventilator is overheating. Ventilation may stop.	• Clean the ventilator unit fan filter. • Contact an authorized service representative.
	Medium[4]	There is a problem with the display cooling fan due to one of the following issues: • An internal display board has overheated • Display fan speed is too low	The system detected a display cooling fan error.	• Contact an authorized service representative.
		Power system cooling fan failed.	The system detected a display cooling fan error. The system may overheat and stop ventilation.	• Contact an authorized service representative.
EtCO2 high	High	Airway module end tidal CO2 is greater than the EtCO2 high alarm limit.	End tidal CO2 is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the EtCO2 high alarm limit in Alarm Setup.
EtCO2 low	High	End Tidal CO2 measured by the airway module is less than the EtCO2 low alarm limit.	End tidal CO2 is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway • Check the airway module gas sampling line connection. • Check for an occlusion in the airway module gas sampling line. • Review the ventilator settings. • Review the EtCO2 low alarm limit in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
EtO2 high	Medium	End tidal O2 measured by the airway module is greater than the EtO2 high alarm limit.	End tidal O2 is greater than the high alarm limit.	• Check for additional O2 flow into the patient circuit. • Review the ventilator settings. • Review the EtO2 high alarm limit in Alarm Setup.
EtO2 low	Medium	End Tidal O2 measured by the airway module is less than the EtO2 low alarm limit.	End tidal O2 is less than the low alarm limit.	• Check for leaks in the patient circuit or airway. • Check the airway module gas sampling line connection. • Check for an occlusion in the airway module gas sampling line. • Review the ventilator settings. • Review the EtO2 low alarm limit in Alarm Setup.
Expiratory flow sensor error	High	Expiratory flow sensor communications failed.	The ventilator is not receiving data from the expiratory flow sensor. Flow and volume measurements may not be available.	• Replace the expiratory flow sensor. • Contact an authorized service representative.
		The Expiratory flow sensor is not connected.	The expiratory flow sensor is not detected.	• Install the expiratory flow sensor. • Check the expiratory flow sensor connection. • Replace the expiratory flow sensor.
	Medium[4]	• For an Adult or Pediatric patient, measured expired tidal volume is greater than the measured inspired tidal volume by 20% or 100 ml, whichever is greater for 6 consecutive breaths.	Expiratory flow sensor measurement is high.	• Check for additional flow into the patient circuit. • Clean or replace the expiratory flow sensor.

Alarm	Priority	Condition*	Cause	Action
FiO2 high	High	Measured FiO2% is higher than the FiO2 high alarm limit.	Inspired O2 is greater than the high alarm limit.	• Check for additional O2 flow into the patient circuit. • Review the FiO2 high alarm limit in Alarm Setup. • Perform System Check. • Perform airway module calibration.
FiO2 low	High	Measured FiO2% is lower than the FiO2 low alarm limit.	Inspired O2 is less than the low alarm limit.	• Check the O2 connection. • Check the O2 source. • Review the FiO2 low alarm limit in Alarm Setup. • Perform System Check. • Perform airway module calibration.
FiO2 sensor error	Medium[4]	FiO2 cannot be measured due to one of the following issues: • O2 sensor data is invalid • There is a communication error with the O2 sensor	The ventilator is not able to measure FiO2.	• Perform System Check.
Flow control valve error	High[4]	Insufficient inspiratory flow is being measured by the total flow sensor for 65 seconds.	The ventilator is not delivering flow.	• Prepare to disconnect the patient from the ventilator and manually ventilate. • Check the Air and O2 connections. • Check the air source. • Check the O2 source. • Contact an authorized service representative.
FRC error	Low	An FRC measurement was started for FRC or PEEP INview, but was unable to be completed within the last 5 seconds.	The last attempted FRC measurement could not be completed. Ventilation setting changes will stop an FRC measurement.	• Install the airway module and allow it to warm up. • Stop active procedures. • Start a new FRC measurement.

Alarm	Priority	Condition*	Cause	Action
		Another procedure or condition prevented the FRC series measurement from starting within the last 5 seconds.	The FiO2 setting was changed between FRC measurements. At least a 10% difference must be maintained between the FiO2 setting and the FRC O2 setting to measure FRC.	• Set FRC O2 to be a minimum of 10% higher or lower than the FiO2 setting, and then start the FRC series. • Set FiO2 to be a minimum of 10% higher or lower than the FRC O2 setting, and then start the FRC series.
Hard keys or trim knob error	High	Key pad failed to communicate for greater than 10 seconds.	The system detected a hard key or Trim Knob error.	• Cycle power. • Contact an authorized service representative.
Inspiratory flow sensor error	High[4]	Total flow sensor communications failed.	The ventilator is not receiving data from the total flow sensor. Flow and volume measurements may not be available.	• Contact an authorized service representative.
	Medium[4]	Air Flow sensor communications failed.	The ventilator is not receiving data from the Air flow sensor. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
		O2 Flow sensor communications failed.	The ventilator is not receiving data from the O2 flow sensor. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
Inspiratory temperature sensor error	Low	Air temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure air flow temperature. The delivered FiO2 may not match the set FiO2.	• Set FiO2 to 100%.
		O2 temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure O2 flow temperature. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
		Total flow temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure total flow temperature.	• Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
MVexp high	High	Measured expired minute volume is greater than the MVexp high alarm limit.	Expired minute volume is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the MVexp high alarm limit in Alarm Setup.
MVexp low	High[1, 2]	Measured expired minute volume is less than the MVexp low alarm limit while the patient is connected.	Expired minute volume is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the MVexp low alarm limit in Alarm Setup.
MVexp low alarm off	Medium[4]	MVexp low alarm selection is Off.	MVexp low alarm limit is set to Off.	• Review the MVexp low alarm limit in Alarm Setup.
Nebulizer not connected	Low	The Aerogen Nebulizer procedure is active but the nebulizer is not connected.	The nebulizer cable is not detected.	• Connect the nebulizer and cable.
Negative airway pressure	High[3]	Inspiratory pressure is below -10 cmH2O for more than 50 continuous ms.	The ventilator detected negative airway pressure from the patient.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Review the Insp Trigger setting in Mode Settings.
No patient effort	High	No spontaneous triggers have been detected for the set Patient Effort time.	Patient has not triggered a breath within the set Patient Effort time.	• Check the status of the patient. • Check for leaks in the patient circuit. • Review the Patient Effort time in alarm setup.
O2 supply pressure high	Low	O2 supply pressure is greater than 95 psig for more than 0.5 seconds.	O2 supply pressure is high.	• Check the O2 source. • Set FiO2 to 21%.
O2 supply pressure low	Medium[4]	O2 supply pressure is less than 24.3 psig for more than 0.5 seconds.	O2 supply pressure is low. The ventilator is delivering Air only. Air may be leaking into the O2 supply system.	• Check the O2 connection. • Check the O2 source.

Alarm	Priority	Condition*	Cause	Action
O2 supply pressure sensor error	Low	O2 supply pressure sensor data is invalid while not in therapy.	The ventilator is not able to measure O2 supply pressure.	• Perform System Check. • Contact an authorized service representative.
Patient circuit occluded	High	An occlusion in the patient circuit was detected.	Inspiratory pressure is greater than expiratory pressure.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Replace inspiratory safety guard.
Patient connection leak	High	Leak measured by the neonatal flow sensor is greater than the set leak limit.	Leak % is greater than the set Leak Limit.	• Check for leaks in the patient airway. • Review the Leak Limit setting in Alarm Setup. • Clean or replace the neonatal flow sensor.
Patient detected	High	A patient connection is detected while in Standby with the circuit not parked.	A patient connection is detected.	• Start ventilation if a patient is connected. • Select Park Circuit if a patient is not connected.
Patient disconnected	High	Patient is disconnected.	Low expiratory pressure or flow detected.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the Tdisconnect setting in Alarm Setup.
	Low	Patient is disconnected while in a non-invasive vent mode prior to the Tdisconnect time.	Low expiratory pressure or flow detected.	• Check the status of the patient. • Check for leaks in the patient circuit. • Review the Tdisconnect setting in Alarm Setup.
Paux high	Medium	Auxiliary pressure is greater than the Paux high alarm limit.	Paux is greater than the high alarm limit	• Review the Paux high alarm limit in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
Paux sensor error	Low[3]	Auxiliary pressure sensor data is invalid.	The ventilator is not able to measure auxiliary pressure.	• Remove the auxiliary pressure line from the patient circuit. • Zero the auxiliary pressure sensor.
	Low	Auxiliary pressure sensor zero procedure failed.	The ventilator is not able to measure auxiliary pressure.	• Remove the auxiliary pressure line from the patient circuit. • Zero the auxiliary pressure sensor.
PEEPe high	Medium	Measured PEEPe is greater than the PEEPe high alarm limit.	PEEPe is greater than the high alarm limit.	• Review the ventilator settings. • Review the PEEPe high alarm limit in Alarm Setup.
PEEPe low	High	Measured expiratory pressure is less than the PEEPe low alarm limit for 2 seconds while in nCPAP mode.	Airway pressure is less than the PEEPe low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit. • Review the ventilator settings. • Review the PEEPe low alarm limit in Alarm Setup.
	Medium[2]	Measured PEEPe is less than the PEEPe low alarm limit.	Airway pressure is less than the PEEPe low alarm limit.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the PEEPe low alarm limit in Alarm Setup.
PEEPi high	Medium	PEEPi measured by the airway module is greater than the PEEPi high alarm limit.	PEEPi is greater than the high alarm limit.	• Review the ventilator settings. • Review the PEEPi high alarm limit in Alarm Setup.
Plimit reached	Medium[4]	Peak airway pressure has reached the set Plimit.	Peak airway pressure reached Plimit.	• Review the ventilator settings. • Review the pneumatic nebulizer Flow setting. • Review the Plimit setting in Mode Settings.

Alarm	Priority	Condition*	Cause	Action
Power supply error	High	Power supply is failing.	Main power supply is not available. The ventilator is powered by the battery.	• Prepare to disconnect the patient from the ventilator and manually ventilate. • Check main power supply connections. • Contact an authorized service representative.
Ppeak high	High	Measured airway pressure is greater than Pmax.	Airway pressure is greater than Pmax.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Review the ventilator settings. • Review Pmax or the Ppeak high alarm limit in Alarm Setup.
Ppeak low	High[2]	Measured peak airway pressure is less than the Ppeak low alarm limit.	Peak airway pressure is less than the low alarm limit.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the Ppeak low alarm limit in Alarm Setup.
Primary audio error	High[4]	An error was detected with the speaker.	The primary audio speaker is not working. (The backup buzzer sounds during this alarm.)	• Contact an authorized service representative.
Relief valve opened	High	Valid pressure data reached an extreme level in the patient circuit.	High airway pressure detected. Ventilator opened relief valve to relieve pressure.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Review the ventilator settings. • Review Pmax or the Ppeak high alarm limit in Alarm Setup. • Replace inspiratory safety guard.

Alarm	Priority	Condition*	Cause	Action
RR high	Medium	Measured respiratory rate is greater than the RR high alarm limit.	Respiratory rate is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the RR high alarm limit in Alarm Setup.
RR low	High[1, 2]	Measured respiratory rate from the ventilator is less than the RR low alarm limit.	Respiratory rate is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the RR low alarm limit in Alarm Setup.
		Measured respiratory rate from the airway module is less than the RR low alarm limit.	Respiratory rate is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Check the airway module gas sampling line connection. • Check for an occlusion in the airway module gas sampling line. • Review the ventilator settings. • Review the RR low alarm limit in Alarm Setup.
SBT completed successfully	Low	The SBT time remaining expired.	Spontaneous Breathing Trial has completed successfully. The ventilator has returned to the settings used prior to entering SBT.	• None.
SBT ended	Medium	Apnea was detected during an SBT.	Apnea detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.

Alarm	Priority	Condition*	Cause	Action
		High expired minute volume was detected during an SBT.	High expired minute volume detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		Low expired minute volume was detected during an SBT.	Low expired minute volume detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		High respiratory rate was detected during an SBT.	High respiratory rate detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		Low respiratory rate was detected during an SBT.	Low respiratory rate detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
Secondary audio error	Medium[4]	The backup buzzer did not sound during power-up.	The secondary audio speaker is not working.	• Contact an authorized service representative.
Sustained airway pressure	High[1]	Measured airway pressure is greater than PEEP + 10 cmH2O or Plow + 10 cmH2O for greater than 15 seconds.	High airway pressure detected for greater than 15 seconds.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Replace inspiratory safety guard.

Alarm	Priority	Condition*	Cause	Action
System shutdown in less than 1 minute	High	Mains power is unavailable and the remaining internal battery time is less than 1 minute.	Battery time is less than 1 minute.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 5 minutes	High	Mains power is unavailable and the remaining internal battery time is less than 5 minutes.	Battery time is less than 5 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 10 minutes	High	Mains power is unavailable and the remaining internal battery time is less than 10 minutes.	Battery time is less than 10 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 20 minutes	Medium[4]	Mains power is unavailable and the remaining internal battery time is less than 20 minutes.	Battery time is less than 20 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
Tidal volume not delivered	Medium[4]	Ventilator has delivered 20% less tidal volume than the set tidal volume, or 5 ml (whichever is grater) for 6 breaths.	Delivered tidal volume is less than the set tidal volume for six consecutive breaths.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the pneumatic nebulizer Flow setting.
Turn off ventilator?	High	Power switch is turned Off while ventilation is being delivered.	Power switch is turned Off while ventilation is being delivered.	• Turn ventilator system switch On. • Contact an authorized service representative.
Ventilation not available	High	During the most recent system check, the safety valve could not sufficiently relieve pressure.	Relief valve failed to relieve patient circuit pressure during System Check.	• Perform System Check. • Contact an authorized service representative.
VTexp high	Medium	Measured expired tidal volume is greater than the VTexp high alarm limit.	Expired tidal volume is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the VTexp high alarm limit in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
VTexp low	Medium	Measured expired tidal volume was less than the VTexp low alarm limit for 3 breaths.	Expired tidal volume is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the VTexp low alarm limit in Alarm Setup.
		Measured airway module expired tidal volume was less than the VTexp low alarm limit for 3 seconds.	Expired tidal volume is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Check the airway module spirometry tube connection. • Check for an occlusion in the airway module spirometry tube. • Review the ventilator settings. • Review the VTexp low alarm limit in Alarm Setup.

Alarm filters

When an alarm is active and another similar alarm becomes active, the original alarm may be filtered (or removed) from the alarm list.

Alarm Filters	
Active Alarm	**Filtered (removed) Alarms**
Expiratory flow sensor error	VTexp low
	VTexp high
	MVexp high
	MVexp low
Airway module error	Airway module gas sampling error
System shutdown in less than 1 minute	System shutdown in less than 5 minutes
	System shutdown in less than 10 minutes
	System shutdown in less than 20 minutes
	Battery in use

Alarm Filters	
Active Alarm	**Filtered (removed) Alarms**
System shutdown in less than 5 minutes	System shutdown in less than 10 minutes
	System shutdown in less than 20 minutes
	Battery in use
System shutdown in less than 10 minutes	System shutdown in less than 20 minutes
	Battery in use
System shutdown in less than 20 minutes	Battery in use
Air and O2 supply pressure low	Air supply pressure low
	O2 supply pressure low
	Inspiratory flow sensor error
	Flow control valve error
Apnea	VTexp low
	VTexp high
	MVexp high
	MVexp low
	RR low
Patient Connection Leak	Circuit Leak
Patient Disconnected	No patient effort
	Apnea
	Ppeak low
	VTexp low
	MVexp low
	RR low
	Circuit Leak
	Patient Connection Leak
	FiO2 low
Ppeak high	Ppeak low
Relief valve opened	Ppeak low

Alarm delays

Delay	Alarm
2 seconds upon transition to therapy	Patient disconnect (NIV)
10 seconds after the airway module pump is turned back on	EtCO2 low
	FiO2 High
	FiO2 Low

Delay	Alarm
10 seconds since the last “Backup ventilation on” alarm was active	Backup ventilation on (due to Apnea or MVexp)
10 seconds since the last ventilation mode change	Backup ventilation on (due to Apnea)
10 seconds upon transition to therapy	Patient disconnect
	PEEPe low (nCPAP)
60 seconds after an inspiratory or expiratory hold procedure	Backup ventilation on (due to MVexp)
	MVexp low
	RR low
	FiO2 high
	FiO2 low
	EtO2 high
	EtO2 low
60 seconds since last FiO2 setting change	FiO2 high
	FiO2 low
60 seconds since the last vent mode change	Backup ventilation on (due to MVexp)
60 seconds since the start of the SBT	SBT ended (due to MVexp or RR)
60 seconds upon transition to therapy	Backup ventilation on (due toMVexp)
	FiO2 high
	FiO2 low
	MVexp high
	MVexp low
	PEEPe high
	PEEPe low
	PEEPi high
	RR low
	VTexp high
	VTexp low
90 seconds since last FiO2 setting change	EtO2 high
	EtO2 low
90 seconds upon transition to therapy	EtCO2 high
	EtCO2 low

Alarm tests

To make sure the alarm system works, perform the following tests periodically. After an alarm test is completed, make sure the alarm limits are set to the correct values before using the ventilator on a patient.

Prior to performing an alarm test:

1. Select ***Standby***.
2. Connect a patient circuit and test lung to the ventilator.
3. Follow instructions for alarm tests.

   - Make sure there are no active alarms prior to an alarm test.
   - Only the alarm being tested should become active during the alarm test.

Low O2 alarm test

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Use the quick key to set FiO2 to 50%.

   - Ventilator FiO2 alarms are not active until 60 seconds after an FiO2 change.

4. Select ***Alarm Setup*** and set the FiO2 low alarm limit to 60 and the FiO2 high alarm limit to 70.

   - Verify the high priority FiO2 low alarm sounds.
   - Verify the FiO2 low alarm shows with a red background in the alarm bar.
   - Verify the display unit high priority alarm light flashes red.

5. Select ***Alarm Setup*** and set the FiO2 low alarm limit to 44 and the FiO2 high alarm limit to 56; wait 60 seconds.

   - Verify the FiO2 low alarm no longer sounds.
   - Verify the FiO2 low alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

High O2 alarm test

1. Set the vent mode to ***A/C VC***.

2. Select ***START VENTILATION*** > ***Continue***.
3. Use the quick key to set FiO2 to 50%.
    - Ventilator FiO2 alarms are not active until 60 seconds after an FiO2 change.
4. Select ***Alarm Setup*** and set the FiO2 low alarm limit to 30 and the FiO2 high alarm limit to 40.
    - Verify the high priority FiO2 high priority alarm sounds.
    - Verify the FiO2 high alarm shows with a red background in the alarm bar.
    - Verify the display unit alarm light flashes red.
5. Select ***Alarm Setup*** and set the FiO2 low alarm limit to 44 and the FiO2 high alarm limit to 56.
    - Verify the FiO2 high alarm no longer sounds.
    - Verify the FiO2 high alarm shows with a grey background in the alarm bar.
    - Verify the display unit alarm light no longer flashes.

Low EtO2 alarm test

This test requires an installed and warmed-up airway module with O2 monitoring capabilities.

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Use the quick key to set FiO2 to 50%.
    - Module EtO2 alarms are not active until 90 seconds after an FiO2 change.
4. Select ***Alarm Setup*** and set the EtO2 high alarm limit to 70 and the EtO2 low alarm limit to 60.
    - Verify the medium priority EtO2 low alarm sounds.
    - Verify the EtO2 low alarm shows with yellow background in the alarm bar.
    - Verify the display unit alarm light flashes yellow.
5. Select ***Alarm Setup*** and set the EtO2 high and low limits to Off.
    - Verify the EtO2 low alarm no longer sounds.
    - Verify the EtO2 low alarm shows with a grey background in the alarm bar.
    - Verify the display unit alarm light no longer flashes.

High EtO2 alarm test

This test requires an installed and warmed-up airway module with O2 monitoring capabilities.

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION***.
   - Module EtO2 alarms are not active until 90 seconds after a FiO2 change.
3. Use the quick key to set FiO2 to 50%.
4. Select ***Alarm Setup*** and set the EtO2 low alarm limit to 30 and the ETO2 high alarm limit to 40.
   - Verify the medium priority EtO2 high alarm sounds.
   - Verify the EtO2 high alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
5. Select ***Alarm Setup*** and set the EtO2 low and EtO2 high alarm limits to Off.
   - Verify the EtO2 high alarm no longer sounds.
   - Verify the EtO2 high alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Low EtCO2 alarm test

This test requires an installed and warmed-up airway module with CO2 monitoring capabilities.

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Add CO2 into the inspiratory limb to get an EtCO2 value between 5% and 10%.
4. Select ***Alarm Setup*** and set the EtCO2 low alarm limit to 12 and the EtCO2 high alarm limit to 15.
   - Verify the high priority EtCO2 low alarm sounds.
   - Verify the EtCO2 low alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.

5. Select ***Alarm Setup*** and set the EtCO2 low and EtCO2 high alarm limits to Off.

   - Verify the EtCO2 low alarm no longer sounds.
   - Verify the EtCO2 low alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

High EtCO2 alarm test

This test requires an installed and warmed-up airway module with CO2 monitoring capabilities.

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Add CO2 into the inspiratory limb to get an EtCO2 value between 5% and 10%.
4. Select ***Alarm Setup*** and set the EtCO2 low alarm limit to 1 and the EtCO2 high alarm limit to 4.

   - Verify the high priority EtCO2 high alarm sounds.
   - Verify the EtCO2 high alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.

5. Select ***Alarm Setup*** and set the EtCO2 low and EtCO2 high alarm limits to Off.

   - Verify the EtCO2 high alarm no longer sounds.
   - Verify the EtCO2 high alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

PEEPe low alarm test

1. Set vent mode to ***A/C VC***.
2. Use the quick key to set PEEP to 5 cmH2O.
3. Select ***START VENTILATION*** > ***Continue***.
4. Select ***Alarm Setup*** and set the PEEPe high alarm limit to Off and the PEEPe low alarm limit to 15 cmH2O.

   - Verify the medium priority PEEPe low alarm sounds.
   - Verify the PEEPe low alarm shows with a yellow background in the alarm bar.

- Verify the display unit alarm light flashes yellow.

5. Select ***Alarm Setup*** and set the PEEPe low alarm limit to Off.

   - Verify the PEEPe low alarm no longer sounds.
   - Verify the PEEPe low alarm no longer shows in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

PEEPe high alarm test

1. Set the vent mode to ***A/C VC***.
2. Use the quick key to set PEEP to 20 cmH2O.
3. Select ***START VENTILATION*** > ***Continue***.
4. Select ***Alarm Setup*** and set the PEEPe low alarm limit to 2 and the PEEPe high alarm limit to 5.

   - Verify the medium priority PEEPe high alarm sounds.
   - Verify the PEEPe high alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.

5. Select ***Alarm Setup*** and set the PEEPe low and high alarm limits to Off.

   - Verify the PEEPe high alarm no longer sounds.
   - Verify the PEEPe high alarm no longer shows in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

VTexp low alarm test

1. Set vent mode to ***A/C VC***.
2. Use the quick key to set VT to 500 ml.
3. Select ***START VENTILATION*** > ***Continue***.
4. Select ***Alarm Setup*** and set the VTexp high alarm limit to 700 and the VTexp low alarm limit to 600.

   The VTExp low alarm becomes active after three breaths.

   - Verify the medium priority VTexp low alarm sounds.
   - Verify the VTexp low alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.

5. Select ***Alarm Setup*** and set the VTexp low alarm limit to 300.

- Verify the VTexp low alarm no longer sounds.
- Verify the VTexp low alarm shows with a grey background in the alarm bar.
- Verify the display unit alarm light no longer flashes.

VTexp high alarm test

1. Set vent mode to ***A/C VC***.
2. Use the quick key to set VT to 500 ml.
3. Select ***START VENTILATION*** > ***Continue***.
4. Select ***Alarm Setup*** and set the VTexp low alarm limit to 200 and the VTexp high alarm limit to 300.

   - Verify the medium priority VTexp high alarm sounds.
   - Verify the VTexp high alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.

5. Select ***Alarm Setup*** and set the VTexp high alarm limit to 700.

   - Verify the VTexp high alarm no longer sounds.
   - Verify the VTexp high alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Pmax alarm test

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Select ***Alarm Setup*** and set the Pmax alarm limit less than the measured Ppeak.

   - Verify the high priority Ppeak high alarm sounds.
   - Verify the Ppeak high alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.

4. Increase the Pmax alarm limit to remove the alarm condition.

   - Verify the Ppeak high alarm no longer sounds.
   - Verify the Ppeak high alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

5. Select ***Mode Settings*** and set the Plimit mode setting to a value less than the current measured Ppeak value.
   - Verify the breaths are limited at Plimit.
   - Verify the medium priority Plimit reached alarm sounds.
   - Verify the Plimit reached alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
6. Set the Plimit mode setting to a value greater than the Ppeak alarm limit to remove the alarm condition.
   - Verify the Plimit reached alarm no longer sounds.
   - Verify the display unit alarm light no longer flashes.

O2 supply pressure low alarm test

1. Disconnect the O2 pressure hose from the O2 source.
2. Select ***Menu*** > ***System*** and verify the O2 supply pressure decreases.
   - Verify the medium priority O2 supply pressure alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
3. Reconnect the O2 pressure hose to the ventilator.
   - Verify the O2 supply pressure low alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Air supply pressure low alarm test

1. Disconnect the pressure hose from the Air source.
2. Select ***Menu*** > ***System*** and verify the Air supply pressure decreases.
   - Verify the medium priority Air supply pressure alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
3. Reconnect the Air pressure hose to the ventilator.
   - Verify the Air supply pressure low alarm shows with a grey background in the alarm bar.

- Verify the display unit alarm light no longer flashes.

Sustained airway pressure (Paw) alarm test

1. Set the vent mode to ***A/C VC***.
2. Set the Bias Flow to 2 l/min.
3. Set the PEEP to Off.
4. Select ***Alarm Setup*** and set the Ppeak high alarm limit to the maximum setting.
5. Select ***START VENTILATION*** > ***Continue***.
6. Partially occlude the exhalation flow sensor by applying pressure to the exhalation flow sensor gas exhaust port.
   - If Pmax is reached, the Ppeak high or Relief valve opened alarms may occur. Repeat the test with a lower occlusion pressure or a lower VT.
   - Verify the high priority Sustained Paw alarm sounds after 15 seconds with Paw greater than PEEP + 10 cmH2O.
   - Verify the Sustained Paw alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
7. Remove the occlusion from the exhalation flow sensor.
   - Verify the Sustained Paw alarm no longer sounds.
   - Verify the Sustained Paw alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Minute volume alarm test

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Select ***Alarm Setup*** and set the MVexp low alarm limit to a value higher than the current MVexp value to violate the alarm condition.
   - MVexp alarms are not active until 60 seconds after ventilation.
   - Verify the high priority MVexp low alarm sounds.
   - Verify the MVexp low alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
4. Set the MVexp low alarm limit to remove the alarm condition.

- Verify the MVexp low alarm no longer sounds.
- Verify the MVexp low alarm shows with a grey background in the alarm bar.
- Verify the display unit alarm light no longer flashes.

Breathing circuit occlusion alarm test

1. Set the vent mode to ***A/C VC***.
2. Select ***Alarm Setup*** and set the Ppeak high alarm limit to the maximum setting.
3. Select ***START VENTILATION*** > ***Continue***.
4. Disconnect the breathing circuit from the expiratory port.
5. Occlude the expiratory limb of the patient breathing circuit.

   - Verify the high priority Patient Circuit occluded alarm sounds.
   - Verify the Patient Circuit occluded alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.

Breathing circuit alarm leak test

1. Set the vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** > ***Continue***.
3. Use the quick key to set PEEP to Off.
4. Select ***Alarm Setup*** and set Leak Limit to 10%.
5. Create a small leak by partially disconnecting the expiratory limb hose from the ventilator. (Fully disconnecting the hose may cause the Patient Disconnect alarm.)

   - Verify the high priority Circuit Leak alarm sounds.
   - Verify the Circuit Leak alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.

6. Reconnect the expiratory limb hose to the ventilator.
7. Select ***Alarm Setup*** and set Leak Limit to 50%.

   - Verify the Circuit Leak alarm no longer sounds.
   - Verify the Circuit Leak alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Apnea alarm test

1. Set the vent mode to ***A/C VC***.
2. Use the quick key to set Rate to 3.
   - I:E, Tinsp, VT, and Flow may need to be adjusted to set the Rate to 3.
3. Select ***Alarm Setup*** and set Apnea time to 10 seconds.
4. Select ***START VENTILATION*** > ***Continue***.
   - Verify the high priority Apnea alarm sounds after 10 seconds.
   - Verify the Apnea alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
5. Select ***Alarm Setup*** and set Apnea time to the maximum setting.
   - Verify the Apnea alarm no longer sounds after a breath is detected.
   - Verify the Apnea alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm no longer flashes.

Patient disconnected alarm test

1. Set the vent mode to ***A/C VC***.
2. Use the quick key to set PEEP to 5 cmH2O.
3. Select ***START VENTILATION*** > ***Continue***.
4. Disconnect the inspiratory limb hose from the ventilator.
   - Verify the high priority Patient disconnected alarm sounds.
   - Verify the Patient disconnected alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
5. Reconnect the inspiratory limb hose to the ventilator.
   - Verify the Patient disconnected alarm tone no longer sounds.
   - Verify the Patient disconnected alarm shows with a grey background in the alarm bar.
   - Verify the display unit alarm light no longer flashes.

Nebulizer not connected alarm test

1. Set vent mode to ***A/C VC***.
2. Select ***START VENTILATION*** >***Continue***.
3. Connect an Aerogen Nebulizer to the ventilator and start an Aerogen nebulizer procedure.
4. Disconnect the nebulizer cable.
   - Verify the low priority Nebulizer not connected alarm sounds.
   - Verify the Nebulizer not connected alarm shows with a blue background in the alarm bar.
   - Verify the display unit alarm light is blue.
5. Reconnect the nebulizer cable.

Low internal battery alarm test

Note Depending on the charge status of the batteries being tested, it is possible that some alarms may be skipped.

1. Disconnect the power cord from the main power supply.
2. Set the ventilator mode to ***A/C VC***.
3. Select ***START VENTILATION*** > ***Continue***.
4. Allow ventilation to continue until the Low Internal Battery - 20 min alarm sounds.
   - Verify the medium priority Low Internal Battery - 20 min alarm sounds.
   - Verify the Low Internal Battery - 20 min alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
5. Allow ventilation to continue until the Low Internal Battery - 10 min sounds.
   - Verify the high priority Low Internal Battery - 10 min alarm sounds.
   - Verify the Low Internal Battery - 10 min alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
   - Verify the Low Internal Battery - 20 min alarm no longer shows in the alarm bar.
6. Allow ventilation to continue until the Low Internal Battery - 5 min sounds.

- Verify the high priority Low Internal Battery - 5 min alarm sounds.
- Verify the Low Internal Battery - 5 min alarm shows with a red background in the alarm bar.
- Verify the display unit alarm light flashes red.
- Verify the Low Internal Battery - 10 min alarm no longer shows in the alarm bar.

7. Allow the ventilation to continue until the Low Internal Battery - 1 min sounds.

   - Verify the high priority Low Internal Battery - 1 min alarm sounds
   - Verify the Low Internal Battery - 1 min alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
   - Verify the Low Internal Battery - 5 min alarm no longer shows in the alarm bar.

Important After this test is completed, connect the ventilator to the main power supply for eight hours before it is used on a patient to make sure the batteries are fully charged.

Power failure alarm test

1. With the system switch set to On, unplug the power cord from the AC mains power supply.

   - If the batteries are not fully charged, the System shutdown in less than x minutes alarm may occur instead of the Battery in use alarm.
   - Verify the medium priority Battery in use alarm sounds.
   - Verify the Battery in use alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
   - Verify the main power plug icon changes to a green battery in use indicator icon (located on the lower right corner of the display).

2. Connect the power cord to the electrical outlet.

   - Verify the Battery in use alarm no longer sounds.
   - Verify the display unit alarm light no longer flashes.
   - Verify the green battery in use indicator icon changes to the power plug icon (located on the lower right corner of the display).

Internal errors

The ventilator is able to detect internal hardware or software errors.

If an internal error occurs while ventilating a patient, the ventilator will continue ventilating the patient with the current settings and show this message on the display:

- Ventilator failure. Prepare to disconnect the patient from the ventilator and manually ventilate. Contact an authorized service representative.

If an internal error is detected when the ventilator is initially turned on, one of the following messages is shown:

- No bootable device.
- Watchdog circuit failed.
- CPU data cache.
- RAM memory error.
- System Reset: ECxx xx xx.
- No bootable image available.
- Program load failed – CRC.
- Alarm speaker not detected.
- RTC date/time error.
- CPU Board Supply Voltage Out of Range.
- CMOS battery is weak.

If any of these internal error messages are shown, contact an authorized service representative and do not use the ventilator.

Troubleshooting

The table lists possible problems that could occur when using the ventilator. If a problem occurs that is not listed, see "*Repair policy*" in the "*Cleaning and maintenance*" section for more information.

Symptom	Problem	Solution
The main power indicator is not on.	The electrical power cord is not connected correctly.	• Connect the power cord. • Loosen the power cord retaining clamp and make sure plug is fully seated. Then tighten the retaining clamp.
	The inlet circuit breaker (switch) is off.	Turn the circuit breaker on.
	The power cord is damaged.	Replace the power cord.
	The electrical outlet that the power cord is connected to has no power.	Use a different electrical outlet.
	An internal fuse is open.	Contact an authorized service representative to repair the ventilator.
	The display unit cable is loose.	Turn the ventilator switch off, and then disconnect from the main power. Check and tighten the display unit connectors.
Ventilator cannot be turned off.	The ventilator is not in Standby.	Set the ventilator to Standby, and then turn the system off.
Backup audio alarm turns on.	A system failure has occurred.	Contact an authorized service representative to repair the ventilator.
	The display unit cable is loose.	Turn the ventilator switch off, and then disconnect from the main power. Check and tighten the display unit connectors.
An alarm shows although the data is within range.	The alarm is from the ventilator but the value shown is from the airway module. (Not applicable for neonatal.)	• Calibrate the airway module. • Go to Menu > System and change the selection for Data Source.
	The Ppeak high alarm conditions are checked before the display view is updated.	No action required. In some situations the ventilator will react to a transient high pressure before the data can be sampled and shown on the display.
Ventilator does not deliver set VT in A/C VC or SIMV VC modes.	The Plimit setting prevents the full VT from being delivered in the inspiratory period.	• Change the VT setting. • Change the Plimit setting.
Ventilator does not deliver set VT in A/C PRVC, SIMV PRVC, or BiLevel VG modes.	Pmax alarm limit is limiting delivered inspiratory pressure.	• Change the VT setting. • Change the Pmax setting.
	The ventilator is at minimum allowed delivery.	• Change the VT setting. • Change the Pmin setting.

Symptom	Problem	Solution
Ventilator transitions to Backup mode.	MVexp low, Apnea alarm, RR alarm, and insufficient patient ventilation.	Change ventilation settings.
Short delay in the breath cycle at the PEEP pressure level.	Automatic pressure transducer zeroing interference.	No action required. The situation will be corrected when zeroing is complete.
	Automatic flow sensor zeroing interference.	
Ventilator is automatically triggering a breath.	The breathing circuit leak rate is higher than the flow trigger level.	• Enable Trigger Compensation. • Check the breathing circuit for leaks. • Turn Leak Comp On. • Increase the Flow triggering level or change from Flow triggering to Pressure triggering. • Make sure the correct patient type is selected.
VT, compliance and resistance values are not accurate.	System Check was not done with the current patient circuit.	Complete System Check with the same breathing circuit that will be used on the patient.
	Flow sensors are dirty	• Clean expiratory flow sensor. • Clean neonatal flow sensor. • Replace D-lite flow sensor. • Replace D-lite spirometry sensing lines. • Calibrate gas module.
System Check fails.	Water trap on the exhalation valve is not on tightly.	Make sure the water trap is tightly secured.
	Patient circuit not connected to the ventilator.	Attach the patient circuit to the inspiratory and expiratory ports.
	Patient wye is not occluded correctly.	Make sure the patient wye is occluded completely with the leak test plug.
	Expiratory flow sensor has failed.	Clean or replace the flow sensor. Make sure flow sensor is connected correctly.
	Exhalation valve and seals are not seated correctly.	Remove and replace the exhalation valve.
	A connection port on the patient circuit is open.	Make sure all connection ports are occluded.
	Leak in patient circuit is very large.	Check the breathing circuit for leaks.
	System Check was stopped before it completed.	Do a System Check and let it complete.
Touchscreen does not respond.	The touchscreen is locked.	Press the Lock hard key at the bottom of the display unit.
	The touchscreen requires calibration or repair.	Contact an authorized service representative to repair the ventilator.

NIV Troubleshooting

Symptom	Problem	Solution
Auto-triggering.	Trigger setting is too sensitive.	• Increase the Insp Trigger setting. • Set a pressure Insp Trigger. • Enable trigger compensation. • Check the patient interface. • Check the expiratory flow sensor.
No triggering or missed triggers.	Trigger setting is not sensitive enough.	• Decrease the flow Insp Trigger setting. • Increase the pressure Insp Trigger setting.
Pressure support inspiration is too long.	Exp Trigger setting is too low. Tsupp setting is too high. High leak.	• Increase the Exp Trigger setting. • Decrease the Tsupp setting. • Check the patient interface.
Pressure support inspiration is too short.	Exp Trigger setting is too high. Tsupp setting is too low.	• Decrease the Exp Trigger setting. • Increase the Tsupp setting.
Undesired backup breaths.	Minimum Rate is set too high.	Decrease the Minimum Rate setting.

General messages

General messages show notices, procedures status information, and system status information to the user. General messages show in the lower left corner of the display. The general messages are listed in order of priority from highest to lowest as shown in the table.

A [1] indicates a countdown timer is shown with the general message.

General Message
Inspiratory hold active
Expiratory hold active
Snapshot created
Snapshot deleted
Oxygenation[1]
Nebulizer[1]
Nebulizer flow compensation on
SBT[1]
Suction[1]
Suction oxygenation[1]
Calculating FRC
PEEP INview on
High Alert Audio off
Assist control off
Tube compensation on
Leak compensation on
Bench configuration. Not for patient use.
Calibration required.
NFS calibration required.

9 Patient monitoring

In this section

Patient data and waveforms

Measured data definitions

Patient monitoring views show patient data measured by the ventilator and accessories.

Note Some measured data can be viewed with different units. Set unit preferences on the ***Configuration*** > ***Units*** menu. See "*Configuring units*" in the "*System configuration (Super User) and service*" section.

Note Some data is only available when an airway module with the required capabilities, such as spirometry and metabolics, is installed and warmed up.

Gases Data	Definition	Unit
FiO2	The percentage of oxygen that the ventilator delivers to the patient.	%
EtO2	The percentage of oxygen exhaled, measured at the end of expiration.	%
EtCO2	The percentage of carbon dioxide exhaled, measured at the end of expiration.	%, kPa, or mmHg
FI-ET O2	The difference between inspiratory and expiratory concentrations of oxygen.	%

Pulmonary Data	Definition	Unit
C	The compliance of the patient’s respiratory system measured during the breath cycle.	ml/cmH2O, ml/kPa, or ml/mbar
Cstat	The static compliance of the patient’s respiratory system measured during an inspiratory hold.	ml/cmH2O, ml/kPa, or ml/mbar
Raw	The average inspiratory and expiratory airway resistance measured during the breath cycle.	cmH2O/l/s, kPa/l/s, or mbar/l/s
PEEPe+i	The sum of extrinsic and intrinsic positive end expiratory pressures.	cmH2O, kPa, or mbar

Pulmonary Data	Definition	Unit
Time Constant	The time needed for the lungs to deflate by a certain amount or a percentage of volume. • One Time Constant allows 63% of volume to be exhaled. • Two Time Constants allow for 86% of volume to be exhaled. • Three Time Constants allow for 95% of volume to be exhaled. • Four Time Contants allow for 98% of volume to be exhaled.	ms
Static PEEPi	The pressure above PEEPe that remains in the patient's lungs, measured at the end of the expiratory phase during an expiratory hold.	cmH2O, kPa, or mbar

Mechanical/ Spontaneous Data	Definition	Unit
MVexp spont	The volume of gas the patient exhales per minute with spontaneous breaths.	l/min
RR spont	The number of spontaneous breath cycles the patient completes per minute.	/min
VTexp spont	The volume of gas the patient exhales with a spontaneous breath.	ml
MVexp mech	The volume of gas the patient exhales per minute with mechanical breaths.	l/min
RR mech	The number of mechanical breath cycles the patient completes per minute.	/min
VTexp mech	The volume of gas the patient exhales with a mechanical breath.	ml
RSBI	The rapid shallow breathing index is calculated by dividing the spontaneous breath rate by the tidal volume, averaged over one minute. The RSBI reflects the frequency and depth of the patient's breath cycles. A high RSBI value indicates that patient's breath cycles are more frequent and shallow. RSBI is calculated in spontaneous breathing modes (CPAP/PS, VS, NIV, and SBT).	/min/l

Per Weight Data	Definition	Unit
Weight	The calculated ideal body weight for adult patients. The entered weight of the patient for pediatric patients.	kg
MVexp/kg	The volume of gas the patient exhales per minute per the patient's ideal body weight.	l/min/kg
VTexp/kg	The volume of gas the patient exhales in a breath per the patient's ideal body weight.	ml/kg

Per Weight Data	Definition	Unit
MVexp spont/kg	The volume of gas the patient exhales per minute with spontaneous breaths per the patient's ideal body weight.	l/min/kg
VTexp spont/kg	The volume of gas the patient exhales in a spontaneous breath per the patient's ideal body weight.	ml/kg
C/kg	The dynamic compliance of the patient's lungs per the patient's calculated ideal body weight.	ml/kPa/kg, ml/cmH2O/kg, or ml/mbar/kg
VO2/kg	The volume of oxygen a patient inhales (consumes) per minute per the patient's set weight.	ml/min/kg
VCO2/kg	The volume of carbon dioxide a patient exhales (produces) per minute per the patient's set weight.	ml/min/kg

Metabolics Data	Definition	Unit
EE	The amount of energy the patient expends per day in calories.	kcal/d or kJ/d
RQ	The ratio between the amount of carbon dioxide the patient produces and oxygen the patient consumes.	N/A
VO2	The volume of oxygen a patient inhales (consumes) per minute.	ml/min
VCO2	The volume of carbon dioxide a patient exhales (produces) per minute.	ml/min
VO2/m2	The volume of oxygen a patient inhales (consumes) per minute per square meter of body surface area.	ml/min/m2
VCO2/m2	The volume of carbon dioxide a patient exhales per minute per square meter of body surface area.	ml/min/m2

Spirometry Data	Definition	Unit
Ppeak	The highest pressure level measured during the inspiratory phase.	cmH2O, kPa, or mbar
Pplat	The pressure level measured after the inspiratory phase and before the expiratory phase (during an inspiratory pause).	cmH2O, kPa, or mbar
Pmean	The average pressure level measured during the breath cycle.	cmH2O, kPa, or mbar
PEEPe	The pressure on the patient's airway at the end of the expiratory phase.	cmH2O, kPa, or mbar
PEEPi	The pressure that remains on the patient's airway at the end of the expiratory phase due to incomplete expiration. PEEPi is measured above PEEPe.	cmH2O, kPa, or mbar
VTinsp	The volume of gas the patient inhales per breath.	ml
MVinsp	The volume of gas the patient inhales per minute.	l/min
VTexp	The volume of gas the patient exhales per breath.	ml
MVexp	The volume of gas the patient exhales per minute.	l/min

Spirometry Data	Definition	Unit
Leak	The percentage of volume leaked from the patient circuit.	%

Timing Data	Definition	Unit
I:E	The ratio of inspiratory time to expiratory time.	N/A
Tinsp	The duration of the inspiratory phase of the breath cycle.	s
Texp	The duration of the expiratory phase of the breath cycle.	s
RR	The number of breath cycles a patient completes per minute.	/min
Cycle Time	The sum of the duration of inspiratory and expiratory phases.	s

Waveform settings

Access waveform settings

All waveforms and spirometry loops are configured by selecting the Settings icon located in the right-hand corner of the waveform.

1. Select the waveform or spirometry loop.

   The settings menu displays with the Settings icon in the upper right-hand corner.
2. Select the Settings icon.
3. Configure or adjust the desired settings.

Waveform Settings	
Style	Solid or Outline
Speed	Fast or Slow
Color	White, Green, Red, Yellow, or Blue
Scaling	Auto or Manual

Spirometry Loop Settings	
Scaling	Auto or Manual

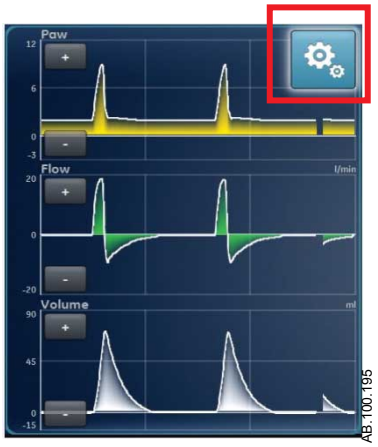


Figure 9-1 • Select the Settings icon to access waveform settings

Waveform configuration

On the Waveform Settings menu, Basic Waveforms, Advanced Waveforms, and Splitscreen views can be customized to show up to four waveforms with measured data specified in the following table.

Wave Field	Options
Fields 1 and 2	Paw
	Volume
	Flow
	Paux
Fields 3 and 4	Off
	Paw
	Volume
	Flow
	Paux
	CO2
	O2

Note An airway module must be installed and set as the data source to monitor CO2 or O2 in Wave Field 3 or 4.

Waveform style

On the Waveform Settings menu, waveforms can be set as one of the following styles:

- Solid: the waveform curve or loop is filled with the set color.
- Outline: the waveform curve or loop is shown as a line in the set color.

Waveform speed

On the Waveform Settings menu, waveform curves and loops can be set to Fast or Slow. The Fast setting travels at twice the speed of Slow.

Waveform color

On the Waveform Settings menu, measured data can be set to show as one of the following colors:

- White
- Green
- Red
- Yellow
- Blue

Waveform and spirometry loop scaling

The range of values shown for each waveform can be set automatically or manually.

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.
- Manual: Adjust the scaling controls to increase or decrease the scale of the waveform.

Manual adjustments to waveform scaling can be made when scaling is set to Auto. When a manual adjustment is made, the scaling setting changes to Manual.

Note Paw, Flow, and Volume scaling settings are available in both the Waveform Settings and Spirometry Settings menus. When set in either menu, they apply to both waveforms and spirometry loops.

Spirometry settings

Configure spirometry loops

On the Spirometry Settings menu, the Splitscreen view can be customized to display up to two spirometry loops or sets of measured data with data specified in the following table.

Wave Field	Options
Fields 1 and 2	P-V
	F-V
	P-F
	Spirometry

Wave Field	Options
	Mech/Spont
	Per Weight
	Pulmonary
	Breath Timing
	Gases
	Metabolics

Configure splitscreen view

On the Spirometry Settings menu, the Splitscreen view can be customized to display a spirometry loop or sets of measured data with data specified in the following table.

Wave Field	Options
Fields 1 and 2	P-V
	F-V
	P-F
	Gases
	Pulmonary
	Mech/Spont
	Per Weight
	Metabolics
	Spirometry
	Breath Timing

Reading waveforms

Waveforms are dynamic illustrations of patient respiratory data received by the ventilator, airway module, or neonatal flow sensor.

- The Y-axis represents the range of values for the data shown.
- The X-axis represents time.

Waveform curves show data collected during the breath cycle. As the ventilator or patient initiates a breath, a waveform curve appears on the graph. In the following figure, the periods between breaths show a lack of flow as the system maintains the set PEEP level.

Note If an airway module is installed and warmed up and the data source is set to Airway Module, waveform data shown is collected by the airway module. If no airway module is installed or it is not warmed up, waveform data shown is collected by the ventilator.

Paw and Flow waveforms are colored orange when an inspiratory trigger is detected.

- When a patient draws a spontaneous, patient-controlled breath, Paw and Flow waveform curves are colored orange from the Insp trigger until the end of the inspiratory phase (Exp trigger).
- When a patient initiates a system-controlled breath, Paw and Flow waveform curves are colored orange for a short time following the inspiratory trigger.

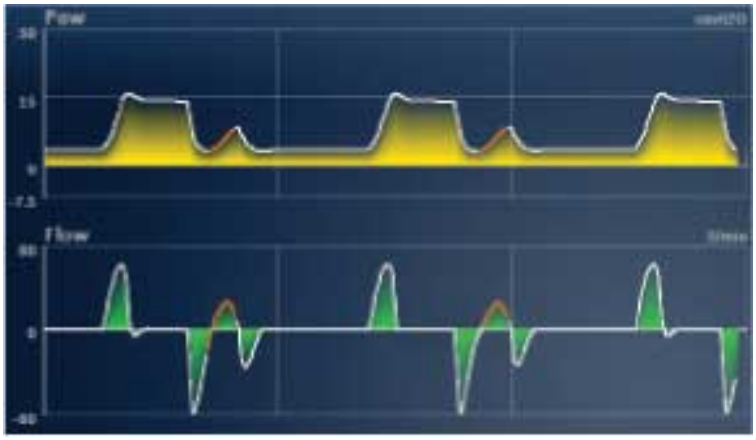


Figure 9-2 • Paw and Flow waveforms

Possible units for the measured data are shown in the following table. See "*Configuring units*" in the "*Configuration menu (Super User)*" section.

Measured Data	**Unit**
Airway Pressure (Paw)	cmH2O
	mbar
	kPa
Volume	ml
Flow	l/min
Auxiliary Pressure (Paux)	cmH2O
	mbar
	kPa
Oxygen (O2)	%
Carbon dioxide (CO2)	%
	mmHg
	kPa

Reading spirometry loops

Spirometry curves are drawn on the graph as loops. A spirometry loop shows two types of measured data on the Y and X axes. The graph can show three different types of loops:

- Paw-Volume (P-V): Volume is shown on the Y axis and pressure on the X axis.
- Flow (P-F): Flow is shown on the Y axis and volume on the X axis.
- Pressure-Flow (Paw Flow): Flow is shown on the Y axis and pressure on the X axis.

Figure 9-3 • Splitscreen view

Important When the data source is set to airway module, the data shown may not be accurate if the sensor type is not set correctly. Make sure the correct sensor type (D-Lite(+) or Pedi-Lite(+) is set. See "*System menu*" in the "*Navigation*" section.

Trends workspace

Use the Trends workspace to view patient data trends.

The following trends views are available:

- Graphical trends
- Numerical trends
- Trend log
- Snapshot trends

Figure 9-4 • Graphical trends view

1.	Trends timeline	Shows the past 72 hours of data. See "*Trends timeline*" for more information.
2.	Guide setting	When set, shows MVexp, RR, Ppeak data, or EtCO2 (adult/ped) plotted on the timeline.
3.	Timeline cursor	Highlights the set period on the timeline. The timeline cursor range can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours.
4.	Trends list	Shows data based on the selected trends view. The trends list shows the period of trending data highlighted by the timeline cursor.
5.	Trends list cursor	Can be moved throughout the period shown to specific data points.

Review trends

1. Access one of the trends views.
   - Graphical trends
   - Numerical (Measured data) trends
   - Trends log
   - Snapshot trends
2. Set a time period on the trends timeline cursor.
3. Position the timeline cursor to highlight the time period to show on the trends list.
4. Move the trends list cursor to review the data at specific points in time.

Trends timeline

In the Graphical, Numerical, and Trends log views, the trends timeline shows the past 72 hours of data. The Guide setting plots data points on the timeline for one of the following data sets when available and selected:

- MVexp
- RR
- EtCO2
- Ppeak

Figure 9-5 • Trends timeline with RR data plotted

The timeline cursor can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours. The period highlighted on the timeline is the period shown in the trends list.

When alarms have occurred during the period shown on the timeline, the alarm priority color is displayed for the duration of the alarm.

- Data curves are colored red for the duration of active high priority alarms.
- Data curves are colored yellow for the duration of medium priority alarms.

- If medium and high priority alarms overlap, the data curve is colored red for the duration of the overlap.

Graphical trends view

The Graphical trends view shows plotted data for the period selected on the timeline. A dashed line extends from the cursor and intersects the data plotted on the Graphical trends view and Snapshot trends view > Waveforms tab. At the points of intersection, data values are shown. If an alarm is active at the point of intersection, the data value is colored for the alarm priority. Move the trends list cursor to the desired time on the plotted data shown in the trends list. Scroll through the trends list to view the following data plotted in the Graphical trends view.

- MVexp
- RR
- Ppeak
- EtCO2
- PEEPe
- FiO2
- Pplat
- C
- Cstat
- Raw
- Leak
- MVexp spont
- MVexp mech
- RR spont
- RR mech
- VTexp
- VTexp/kg
- VTinsp
- PEEPi
- Pmean
- Paux Peak
- VO2
- VCO2
- RQ
- EE

Numerical trends view

The Numerical trends view has three tabs: the Mode tab, Measured tab, and Alarms tab.

- The Mode tab shows ventilation mode settings.
- The Measured tab shows measured patient data measured by the ventilator or airway module.
- The Alarms tab shows alarm settings.

Move the trends list cursor to view measured data or ventilation mode or alarm settings at the desired point in time. Use the Measured tab and Mode tab to compare the measured data to the ventilator settings.

Measured data trends

The Measured tab shows the following patient data.

Volumes	Pressures	Rate	Gases	Metabolics	SpiroDynamics
VTexp	Ppeak	RR	FiO2	EE	C 5-15
VTexp spont	Pplat	RR spont	EtO2	RQ	C 45-55
VTexp mech	Pmean	RR mech	FI-ET O2		C 85-95
VTexp/kg	Paux Peak	I:E	VO2		
VTexp spont/kg	PEEPe	Tinsp	VO2/kg		
VTinsp	PEEPi	Texp	VO2/m2		
Leak	Static PEEPi	RSBI	EtCO2		
MVexp	C	Time Constant	VCO2		
MVexp spont	Cstat	Cycle Time	VCO2/m2		
MVexp mech	C/kg		VCO2/kg		
MVexp/kg	Raw				
MVexp spont/kg					
MVinsp					

Vent mode and settings trends

Vent Mode	Main Parameters	Breath Timing	Safety	Patient Synchrony	Vent Preferences
A/C PC	FiO2	Rate	Pmax	Bias Flow	Backup Mode
A/C PRVC	PEEP	Tinsp	Plimit	Rise Time	Assist Control
A/C VC	Pinsp	I:E	Pmin	Insp Trigger	Leak Comp
APRV	VT	Tpause	Minimum Rate	Exp Trigger	Trigger Comp

Vent Mode	Main Parameters	Breath Timing	Safety	Patient Synchrony	Vent Preferences
BiLevel	Flow	Insp Pause	Backup Tinsp	PS Rise Time	Tube Comp
BiLevel VG	PS	Thigh	Backup Pinsp	Tsupp	
CPAP/PS	Phigh	Tlow			
NIV	Plow				
SBT					
SIMV PC					
SIMV PRVC					
SIMV VC					
VS					

Alarm settings trends

The Alarms tab shows the alarm trends data for the following parameters:

- Apnea Time
- Patient Effort
- Tdisconnect

Parameter	Low	High
EtCO2	X	X
EtO2	X	X
FiO2	X	X
Leak Limit		X
MVexp	X	X
Paux		X
PEEPe	X	X
PEEPi		X
Ppeak	X	X
RR	X	X
VTexp	X	X

Trends log view

The Trends log view shows a list of alarms and events that occurred during the period selected on the timeline. The log updates once a minute, therefore alarms may not appear immediately. Log entries are listed in the order they occurred with the most recent entry at the top. Each entry is labeled with the date and time of its occurrence.

- Alarms: Low, medium, and high priority alarms are shown as they occur.
- Events: Ventilation procedures and patient type changes are shown as they occur.
- Setting changes: Settings changes are shown as they occur.

The Trends log view can be filtered to show or hide alarms, events, and setting changes.

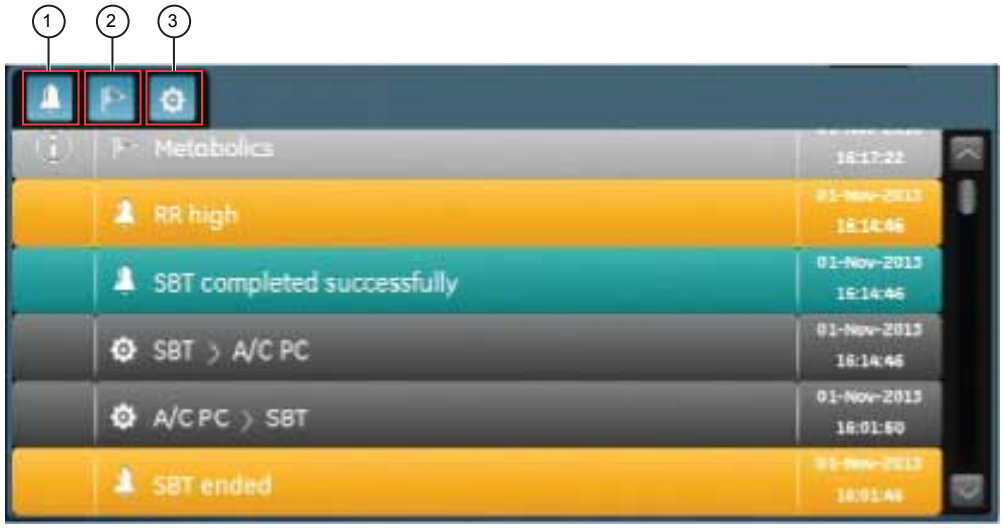


Figure 9-6 • Trends log with all filters selected

1. Alarms filter
2. Events filter
3. Settings filter

Figure 9-7 • Trends log with settings filter selected

Snapshot trends view

The Snapshot trends view shows a collection of data saved at selected times within the past 72 hours. Up to ten snapshots can be saved. When more than ten snapshots are saved, the oldest snapshot is deleted. A general message shows when a snapshot is deleted.

Note To create a snapshot, press the Snapshot hard key on the Display Unit. The data is saved and can be reviewed on the Snapshot trends view.

A general message shows when a snapshot is created. Data is included in a snapshot and presented on the following tabs on the Snapshot trends view:

- Mode
- Measured
- Waveforms
- Alarms

In the Snapshot trends view, the trends timeline shows blue vertical lines to represent snapshots. Press the left or right arrow to navigate between snapshots.

Figure 9-8 • Snapshot trends view

Mode snapshots

The Mode tab shows ventilation mode settings that were set when the snapshot was saved.

Vent Mode	Main Parameters	Breath Timing	Safety	Patient Synchrony	Vent Preferences
A/C PC	FiO2	Rate	Pmax	Bias Flow	Backup Mode
A/C PRVC	PEEP	Tinsp	Plimit	Rise Time	Assist Control
A/C VC	Pinsp	I:E	Pmin	Insp Trigger	Leak Comp
APRV	VT	Tpause	Minimum Rate	Exp Trigger	Trigger Comp
BiLevel	Flow	Insp Pause	Backup Tinsp	PS Rise Time	Tube Comp
BiLevel VG	PS	Thigh	Backup Pinsp	Tsupp	
CPAP/PS	Phigh	Tlow			
NIV	Plow				
SBT					
SIMV PC					
SIMV PRVC					
SIMV VC					
VS					

Measured patient data snapshots

The Measured tab shows measured patient data that was available when the snapshot was saved.

Volumes	Pressures	Rate	Gases	Metabolics	SpiroDynamics
VTexp	Ppeak	RR	FiO2	EE	C 5-15
VTexp spont	Pplat	RR spont	EtO2	RQ	C 45-55
VTexp mech	Pmean	RR mech	FI-ET O2		C 85-95
VTexp/kg	Paux Peak	I:E	VO2		
VTexp spont/kg	PEEPe	Tinsp	VO2/m2		
VTinsp	PEEPi	Texp	VO2/kg		
Leak	Static PEEPi	RSBI	EtCO2		
MVexp	C	Time Constant	VCO2		
MVexp spont	Cstat	Cycle Time	VCO2/m2		
MVexp mech	C/kg		VCO2/kg		
MVexp/kg	Raw				
MVexp spont/kg					
MVinsp					

Waveform snapshots

On the Waveforms tab, Paw, Flow, Volume, Paux, CO2, and O2 waveforms are shown if data was available when the snapshot was saved. Move the trends list cursor to show waveform data values.

When a snapshot is taken, the duration of the waveform is based on the set speed.

- If speed is set to Slow, 15 seconds of waveform data is shown.
- If speed is set to Fast, 30 seconds of waveform data is shown.

Waveforms are shown in the color and scale set in the Waveform Settings menu.

Alarms snapshots

The Alarms tab shows any low, medium, or high priority alarms that were active when the snapshot was saved.

Review snapshot trends

1. Access Trends > Snapshot Trends.
2. On the snapshot timeline, select the snapshot to show on the trends list.
3. Access the following tabs to review snapshot data:
    - Mode
    - Measured
    - Waveforms
    - Alarms

10 Clinical decision support

In this section

SBT view

During an SBT (Spontaneous Breathing Trial), a patient is spontaneously breathing with the assistance of Pressure Support (if desired) for a set period of time. The patient is monitored with specific clinician selected alarm settings during the SBT. The ventilator will use these alarm settings as pass/fail criteria to decide if the mode of ventilation should be changed back to the previous mode. During a spontaneous breathing trial, the SBT view shows graphical and numerical data and trends related to the ongoing trial. This data may be used to see the progress of a patient during the SBT and evaluate SBT data. Data from a previous SBT may also be reviewed if it was obtained within the past 12 hours.

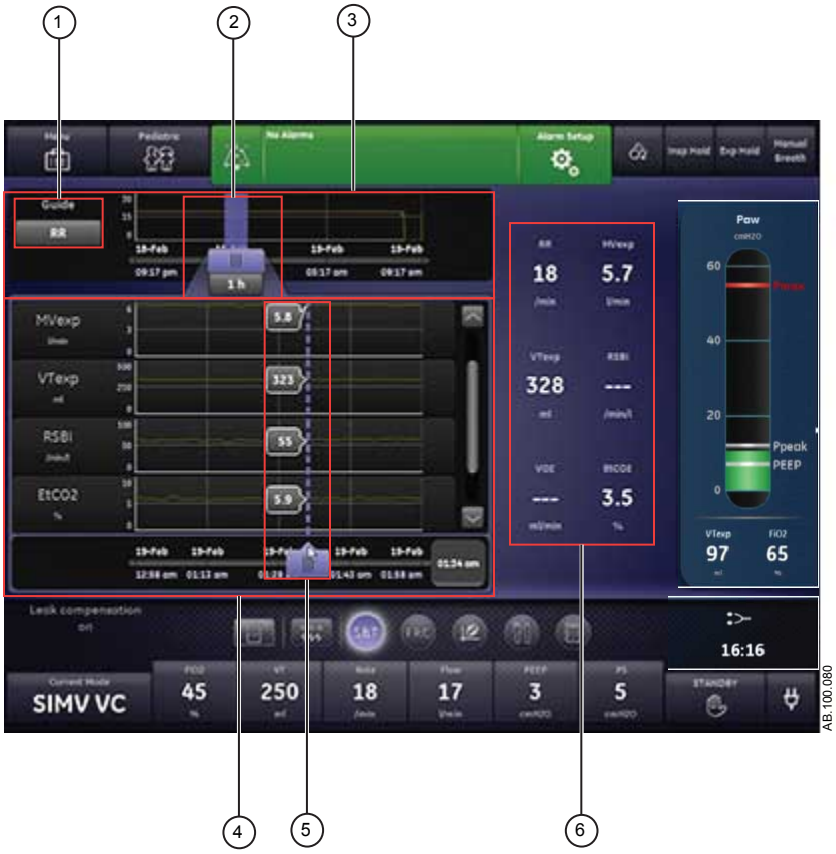


Figure 10-1 • SBT view

1.	Guide setting	When set, shows RR, MVexp, VTexp, RSBI, EtCO2, or VO2.
2.	SBT timeline cursor	Highlights the set period on the timeline. The timeline cursor range can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours.
3.	SBT timeline	Shows the past 12 hours of data.

4.	SBT trends list	Shows the period of SBT trending data highlighted by the SBT timeline cursor.
5.	SBT trends list cursor	Can be moved throughout the period shown to specific data points.
6.	Measured data	Shows numerical data for RR, MVexp, VTexp, RSBI, EtCO2, and VO2.

Review spontaneous breathing trial data

Review measured data on the SBT view to evaluate the patient after the completion or during a spontaneous breathing trial.

1. Access Clinical Decision Support > SBT.
2. If desired, select ***Guide*** and select one of the following data to plot on the timeline:
   - ***RR***
   - ***MVexp***
   - ***VTexp***
   - ***RSBI***
   - ***EtCO2***
   - ***VCO2***
3. Select the SBT timeline cursor and select a time period.
4. Position the SBT cursor to highlight the desired time period on the timeline.
5. Review the SBT trends data in the trends list.
6. Move the SBT trends list cursor as needed to view specific data points.
7. As desired, repeat steps 3-6.

Perform a spontaneous breathing trial

While transitioning from a ventilation mode to an SBT, it may take a period of time for the patient to meet the criteria for the new set of alarms.

1. Select ***Current Mode***.
2. Select ***SBT***.
3. If desired, select the following features:
   - ***Tube Comp*** (Not applicable for neonatal.)
   - ***Leak Comp***
   - ***Trigger Comp***
4. Set the Stop Criteria limits:

- ***RR low***, ***RR high***
- ***MVexp low***, ***MVexp high***
- ***Apnea Time***

5. Set the ventilation mode settings:

   - ***FiO2***
   - ***PEEP***
   - ***PS***
   - ***Bias Flow***
   - ***Exp Trigger***
   - ***Insp Trigger***
   - ***PS Rise Time***
   - ***Pmax***

6. Select ***Time*** and select a duration for the Spontaneous Breathing Trial.
7. Select ***Start SBT***.

   The SBT general message shows along with the procedure countdown timer and progress bar. The progress bar fills in proportion to the amount of time the SBT procedure has been running.

Note Access Clinical Decision Support > SBT to evaluate the data relevant to the Spontaneous Breathing Trial.

Note The Spontaneous Breathing Trial lasts for the set Time unless it is terminated by the Stop Criteria limits. After the Spontaneous Breathing Trial is complete, the ventilator resumes the previous ventilation mode. If needed, select Stop to return to the previous mode.

Note If any Stop Criteria limits are reached, an alarm occurs and the ventilator changes to the previous ventilation mode.

8. Select ***Current Mode*** and do one of the following:

   - Select ***Resume SBT*** to resume the Spontaneous Breathing Trial.
   - Select ***Confirm*** to end the Spontaneous Breathing Trial and continue ventilation in the current ventilation mode.

Functional residual capacity view

Note Functional Residual Capacity (FRC) is measured on non-ventilated patients. For ventilated patients with elevated PEEP, the parameter is defined as End Expiratory Lung Volume (EELV). Throughout this manual, the term FRC is used instead of EELV for simplicity.

The ventilator provides the ability to measure FRC in adult and pediatric patients.

The FRC view has three tabs.

- On the Evaluate tab, review respiratory data, including waveforms and measured data to determine if the patient is in steady state for optimal FRC results.
- On the FRC INview tab, perform an FRC INview procedure to measure the patient's FRC.
- On the PEEP INview tab, perform a PEEP INview procedure to determine the PEEP that optimizes the patient's FRC.

FRC procedures

FRC procedure requirements

To perform the FRC and PEEP INview procedures, the following is required.

- Airway module with metabolics capabilities
- D-lite(+) or Pedi-Lite(+) sensor

To perform a Lung INview procedure, an intratracheal pressure sensor is required.

Important It is recommended that the airway module be warmed up for 30 minutes before performing an FRC procedure.

Important Adding a 5-ml spacer between the D-lite(+) sensor and the patient wye will prevent the bias flow from adversely affecting the gas exchange measurements.

Important Do not change any ventilation settings, perform any procedures that alter ventilation settings, perform a nebulization procedure, or remove an airway module during this procedure. These actions stop the current measurement, resulting in invalid data shown as dashes. To attain a valid FRC measurement, the patient's gas exchange must be stable for at least 10 minutes.

Important A constant level of delivered O2 is needed to capture an accurate baseline N2 concentration for the nitrogen washout process. The first FRC measurement may be inaccurate if the delivered O2 is changed within 5 minutes of starting an FRC measurement. Consecutive FRC measurements require a 5 minute stabilization period between measurements.

Important If an FRC procedure being performed as part of a PEEP INview procedure is ended early due to a setting change or measurement error, the PEEP INview is also ended.

FRC INview procedure

The FRC INview procedure can be performed as a single procedure or as a series of procedures. When FRC INview is performed in a series, the measurements continue at the set interval until the user stops the series. Measurements are displayed numerically and graphically. Two volume curves show in the graph and three measurements are listed in the data area below the graph. When the next FRC INview procedure is performed:

- The two curves from the previous FRC INview procedure are averaged into one single reference curve.
- The measurements from the previous FRC INview procedure move one column to the right. The values from the most recent five procedures are shown.

Note The reference curve from the most recent procedure is shown. The numerical measurements from the most recent five procedures are shown below the graph.

Perform a FRC INview procedure

1. Access Clinical Decision Support > FRC > FRC INview tab.
2. Select ***FRC O2*** and set the FRC O2 value.

Note The FRC O2 is adjustable to within plus or minus 10% of the set FiO2 value. The FRC O2 setting is the value used for the nitrogen washout calculation.

3. Select ***Interval*** and do one of the following:
   - Select ***Single*** to perform one FRC procedure
   - Select between 1 and 12 hours to perform a series of FRC procedures.
4. Select Start.
   - The FiO2 changes to the FRC O2 setting.
   - As data is collected, the FRC curve is plotted on the graph.
   - When available, numerical FRC data is shown.
   - After the first FRC measurement is complete at the FRC O2 level, the O2 level returns to the initial FiO2 setting.
   - As data is collected, the FRC curve is plotted on the graph.
   - At the end of the FRC procedure, the ventilator initiates an inspiratory hold and measures Cstat.
   - When available, FRC, PEEPe+i, and Cstat data are shown.

- A general message shows when the FRC measurement is being calculated.
- If running a series of FRC procedures, the next FRC procedure begins at the set interval. FRC procedures continue at the set interval until the user stops the series.

Note Select Stop to end a FRC procedure.

Note FRC curves display with the time and date of the most recent FRC procedure.

PEEP INview procedure

The PEEP INview procedure can be used to evaluate how a change in the PEEP value affects the FRC value. A series of FRC measurements are taken at set PEEP levels. The first measurement is taken at the Start PEEP value; the last measurement is taken at the End PEEP value. The measurements in between are taken at levels spaced evenly across the Start PEEP to End PEEP range. Up to five PEEP measurements can be taken during a PEEP INview procedure. Measurements are displayed numerically and graphically.

Perform a PEEP INview procedure

1. Access Clinical Decision Support > FRC > PEEP INview tab.
2. Select ***FRC O2*** to set the FRC O2 value.
3. Select ***Start PEEP*** to set the first PEEP value.
4. Select ***End PEEP*** to set the final PEEP value.

Note When setting the Start PEEP and End PEEP, the values are checked against the constraints from other ventilation settings. If the settings conflict, a message is displayed.

5. Select ***Steps*** to set the number of measurements to be taken.
   - The maximum setting is 5. This is the default setting.
   - If the number of steps set between the Start PEEP and End PEEP can not be completed, the value will change to the maximum steps possible when the procedure is started.
6. Select ***Step Time*** and set the duration of the period between PEEP level changes and measurements at that level.

Note A longer Step Time allows more time for VO2 and VCO2 to stabilize but prolongs the procedure.

7. Select Start.
   - The PEEP setting changes to the set Start PEEP.
   - The FiO2 changes to the set FRC O2, then returns to the set FiO2 to calculate FRC at the start PEEP. FiO2 will

alternate between original set FiO2 and FRC O2 with each PEEP change.

- As data is collected, the FRC and Cstat curves are plotted on the graph.
- When the FRC calculation has completed at the Start PEEP setting, PEEP changes to the next setting based on the step level.
- When available, numerical FRC data is shown for each step.
- A general message shows during the PEEP Inview procedure.

Note Select Stop to end a PEEP INview procedure.

Note FRC and Cstat curves display with the time and date of the most recent PEEP INview procedure.

Lung INview procedure

The Lung INview option combines the PEEP INview procedure with SpiroDynamics measurements to provide an enhanced view of the patient's lung function.

Perform a Lung INview procedure

Note To perform a Lung INview procedure, an intratracheal pressure sensor, an airway module with gas exchange capabilities, and a D-Lite(+) or Pedi-Lite(+) sensor are required. Before you begin, review the Instructions for Use provided with the intratracheal pressure sensor.

1. Attach the intratracheal pressure sensor to the auxiliary pressure port on the ventilator.
2. Access ***Menu*** > ***System***.
3. Select ***Purge Flow***.

Note A continuous purge flow of approximately 35 ml/min prevents the buildup of mucous inside of the sensor.

4. Select ***Paux Zero*** to zero the pressure sensor. When completed, a green check mark appears next to indicating success.
5. Insert the sensor into the endotracheal tube according to the Instructions for Use provided with the sensor.
6. Access Clinical Decision Support > FRC > PEEP INview tab.
7. Select ***FRC O2*** and set the FRC O2 value.
8. Select ***Start PEEP*** and set the first PEEP value.
9. Select ***End PEEP*** and set the final PEEP value.

Note When setting the Start PEEP and End PEEP, the values are checked against the constraints from other ventilation settings. If the settings conflict, a message is displayed.

10. Select ***Steps*** and set the number of measurements to be taken.
    - The maximum setting is 5. This is the default setting.
    - If the number of steps set is not possible between the Start PEEP and End PEEP, the value will change to the maximum steps possible when the procedure is started.
11. Select ***Step Time*** and set the duration of the period between PEEP level changes and measurements at that level.
12. Select the ***Lung INview*** check box.
13. Select Start.
    - The PEEP setting changes to the set Start PEEP.
    - FiO2 will alternate between the original set FiO2 and the set FRC O2 with each step change.
    - When the FRC calculations are complete at the Start PEEP setting, the PEEP setting changes to the next setting based on the step level.
    - At each PEEP, the FRC and airway resistance is measured and a SpiroDynamics loop is saved.
    - The dynostatic curve from the measurement at the current PEEP setting is compared to the dynostatic curve taken from the previous PEEP setting. This value is displayed as the Gain.

	
FRC Change	Dynostatic curve volume

- FRC and Cstat curves for the completed Lung INview procedure can be viewed by unchecking the Lung INview check box.
- When available, numerical FRC, PEEPe+i, Cstat, FRC Change, Dynostatic Curve Volume, and Dynostatic Curve Difference data are shown.

Note Select Stop to end a Lung INview procedure.

Note FRC and Cstat curves display with the time and date of the most recent PEEP INview procedure.

FRC tabs

Evaluate tab

The Evaluate tab shows waveforms, measured data, and trends.

For accurate FRC measurements, the patient's gas exchange should be stable for at least 10 minutes prior to the measurement. The following may be used to evaluate patient's gas exchange stability:

- CO2 waveform indicating that the patient's breathing is synchronized with the ventilator
- Consistent VT
- Stable VO2 and VCO2 trend data

As a quality check, compare the tidal volumes measured by the airway module to those measured by the ventilator. If these values differ, it may be a result of condensation in the D-lite(+) sensor or sampling tubes. If this is detected, dry or change the sensor and the sampling tubes prior to an FRC measurement.

Figure 10-2 • Evaluate tab

1. Waveform - Review the CO2 waveform.
2. Measured data - Review VTinsp and VTexp from the ventilator and airway module.
3. Trends - Review VO2 and VCO2 graphical trends.

FRC INview tab

Use the FRC INview tab to perform FRC procedures and review the resulting measured data. Measurements for up to 5 FRC procedures can be displayed.

Figure 10-3 • FRC INview tab displaying three completed FRC measurements

1. FRC O2 - Enter the FiO2 percentage for the FRC procedure.
2. Interval - Enter the pause time between FRC measurements during the FRC procedure.
3. FRC Chart - Review the FRC measurements taken at each breath during an FRC procedure.
4. Start/Stop - Press Start to start the FRC procedure. During an FRC procedure, press Stop to end the procedure.
5. Measured Data - Review measured data for FRC, PEEPe+i, and Cstat. Up to five measurements are displayed during an FRC procedure.

PEEP INview tab

Use the PEEP INview tab to perform PEEP INview procedures and review the measured data. FRC may be reviewed at each PEEP

level to evaluate which PEEP level may be the most appropriate for the patient.

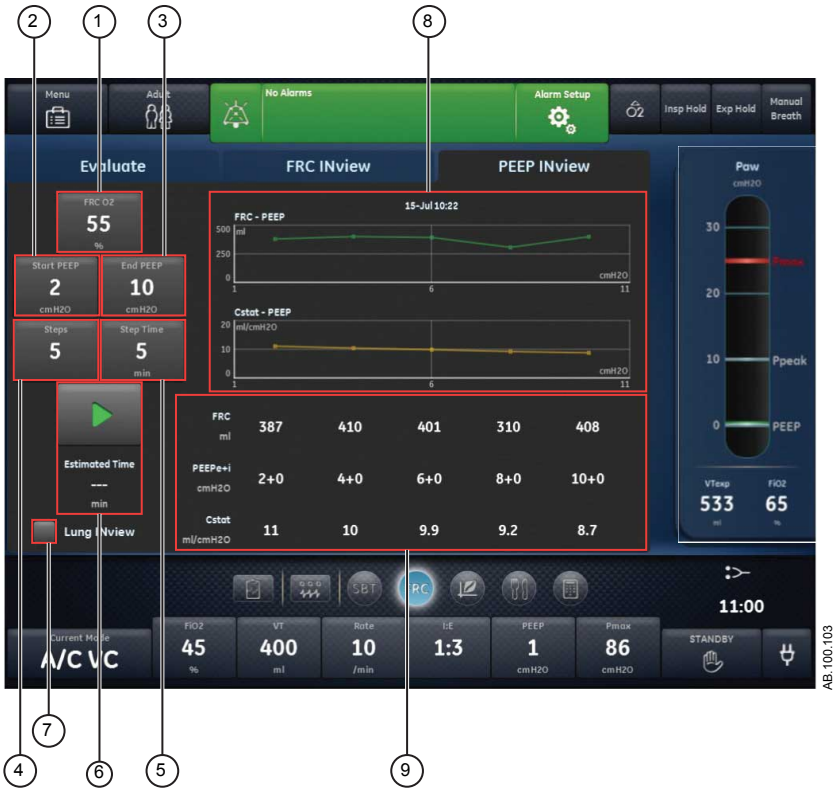


Figure 10-4 • PEEP INview tab

1. FRC O2 - Enter the FiO2 percentage for the PEEP INview procedure.
2. Start PEEP - Enter the first PEEP level for the PEEP INview procedure.
3. End PEEP - Enter the last PEEP level for the PEEP INview procedure.
4. Steps - Enter the number of PEEP levels the PEEP INview procedure will use to take FRC measurements.
5. Step Time - Enter the duration of time between PEEP level changes and measurement at that level.
6. Start/Stop - Press Start to start the PEEP INview procedure. Press Stop to end the procedure. Estimated Time provides an estimation of the duration of the entire PEEP INview procedure.
7. Lung INview - Select Lung INview to use the intratracheal pressure sensor to measure data.
8. FRC chart and Cstat chart- Review FRC and static compliance measurements plotted on the charts taken at each step of the PEEP INview procedure. When Lung INview is selected, these charts are not shown.

9. Measured Data - The following data is shown during a PEEP INview procedure:

   - FRC
   - PEEPe+i
   - Cstat

   When Lung INview is selected, the following measured data is also shown:

   - FRC delta (FRC change)
   - Dynostatic curve volume
   - Gain

   Up to five measurements can be shown during a PEEP INview procedure. Measurements are displayed for each step; the maximum number of steps is five.

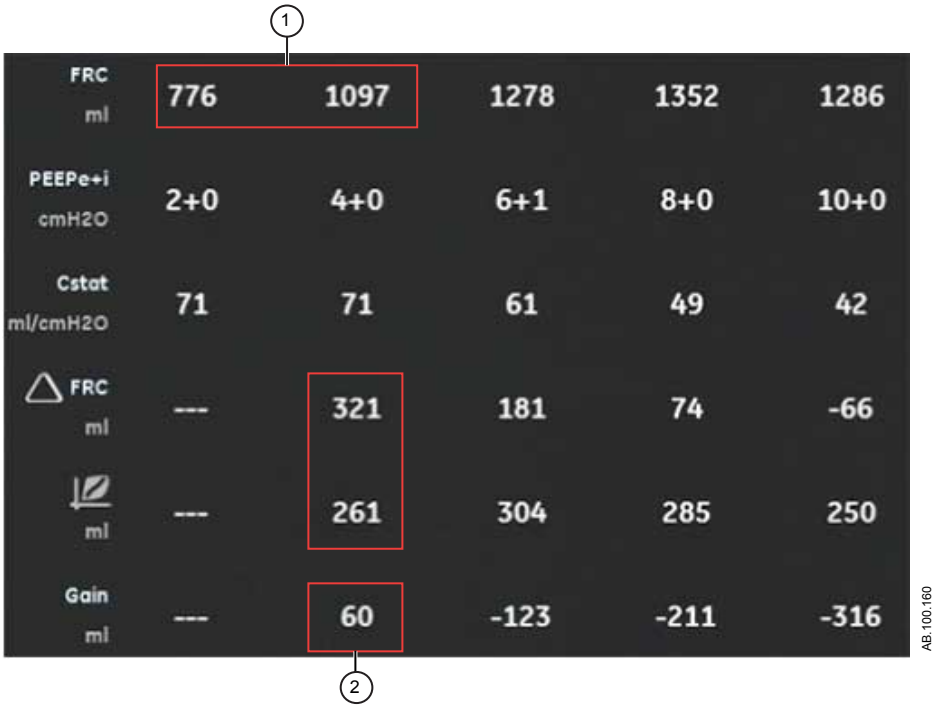


Figure 10-5 • Lung INview measured data

1. FRC delta (FRC change) is the difference between two consecutive FRC measurements. Example: 1097-776=321
2. Gain is a measurement reflecting the change in volume of the two consecutive FRC measurements minus the volume seen in the dynostatic curve between the two PEEP settings. Example: 321-261=60

Spirometry view

The Spirometry view shows spirometry loops and measured data. The Spirometry view contains two tabs:

- Spirometry
- SpiroDynamics

Note An intratracheal pressure sensor is required for valid data to be displayed on the SpiroDynamics tab.

Use the Spirometry view to evaluate patient lung function.

Spirometry tab

The Spirometry tab shows spirometry loops and related measured data. The spirometry loops shown can be customized on the spirometry analysis settings menu.

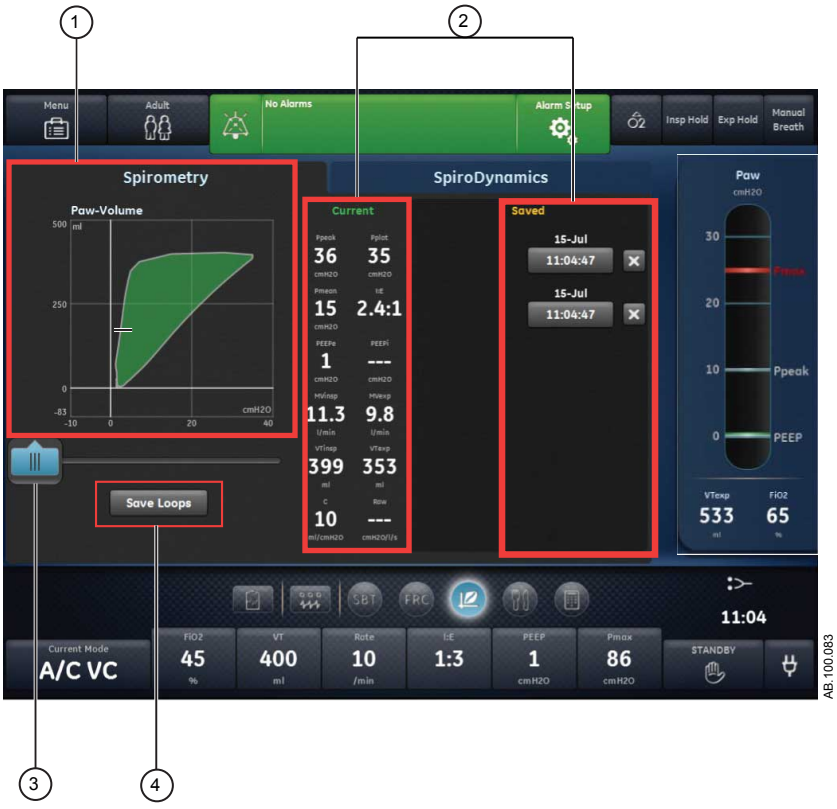


Figure 10-6 • Spirometry tab

1.	Spirometry loops	Shows the spirometry loops.
2.	Measured data	Shows measured data and saved data for the current breath.
3.	Spirometry cursor	Move the cursor in the period shown to view specific data points.
4.	Save loops button	Select to save the trend data to Historical Trends.

Spirometry settings menu

Select the spirometry loop field. The Settings icon appears in the upper right-hand corner. Select the Settings icon to access the Settings menu and select which loop type to show and how the loop is scaled.

The following loop types are available:

- Paw-Volume (P-V)
- Flow-Volume (F-V)
- Paw-Flow (P-F)

The following scaling options are available:

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.
- Manual: Select the scaling controls to increase or decrease the scale of the waveform.

Spirometry loops

The Spirometry tab can be set to show the following loops:

- Pressure-Volume (P-V): Volume is shown on the Y axis and pressure on the X axis.
- Flow-Volume (F-V): Flow is shown on the Y axis and volume on the X axis.
- Pressure-Flow (P-F): Flow is shown on the Y axis and pressure on the X axis.

Spirometry loops are drawn every other breath. Up to six spirometry loops can be saved simultaneously. When six sets of reference data have been saved, subsequent saves overwrite the oldest set of reference data. The current loop is colored green. Reference loops are colored yellow. Move the cursor to view specific data points on the spirometry loops shown. When using the cursor to view specific data points on the loop, loops are not drawn.

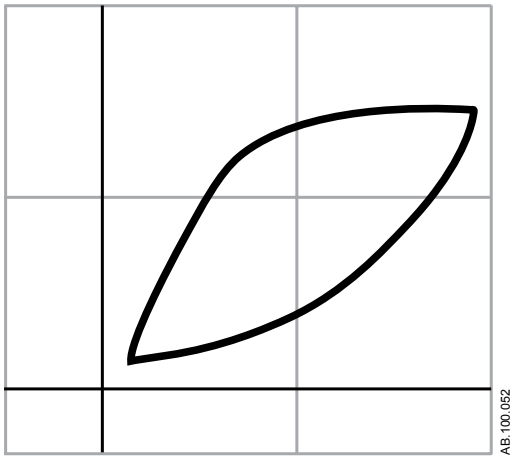


Figure 10-7 • Spirometry loop

Spirometry measured data

The Spirometry tab shows the following data:

- Ppeak
- Pplat
- Pmean
- I:E
- PEEPe
- PEEPi
- MVinsp
- MVexp
- VTinsp
- VTexp
- C
- Raw

This data is shown for the current breath and reference breaths when selected. Review this data to evaluate lung function.

Note PEEPi, compliance, and airway resistance may not be available for all breaths.

SpiroDynamics tab

SpiroDynamics uses the intratracheal pressure catheter connected to the Paux port to measure pressure inside the patient's trachea.

Important The intratracheal pressure catheter is only for pressure sensing. It cannot be used for suctioning the patient or for sampling gases. The catheter is for use only with endotracheal tubes having an internal diameter equal to or larger than 6.5 mm. Refer to the Instructions for

Use supplied with the intratracheal pressure catheter for more information on the use and placement of the catheter.

The SpiroDynamics tab shows pressure-volume (P-V) SpiroDynamics and spirometry loops and related measured data. The SpiroDynamics and spirometry loops shown can be customized on the SpiroDynamics settings menu.

Figure 10-8 • SpiroDynamics tab

1.	Spirometry loops	Shows the spirometry loops.
2.	Measured data	Shows measured data and saved data for the current breath.
3.	Spirometry cursor	Move the cursor in the period shown to view specific data points.
4.	Save loops button	Select to save the trend data to Historical Trends.

The measurements are captured using an intratracheal pressure catheter that is guided down a standard endotracheal tube. The catheter is connected to the auxiliary pressure port of the ventilator and attached to the patient airway. This single-patient-use catheter is purged using a bias flow to help ensure that it remains open.

The catheter provides a more accurate measurement of pressure delivery to the lungs by removing the resistance of the endotracheal tube from the spirometry loop. After a breath, a dynostatic curve is calculated from the loop providing an estimate of the alveolar pressure and volume. This curve is an estimate of the pulmonary compliance during a breath.

The following illustrations show the difference between a P-V spirometry loop and a P-V SpiroDynamics loop. The SpiroDynamics loop shows a more accurate pressure measurement.

- The catheter measures pressure from inside the trachea.
- The pressure shown excludes added pressure from the endotracheal tube.

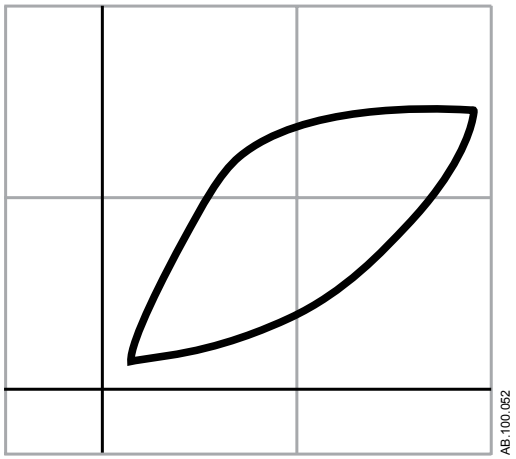


Figure 10-9 • Standard P-V spirometry loop

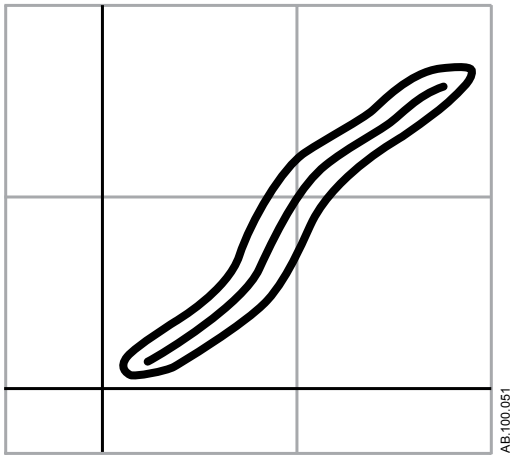


Figure 10-10 • P-V SpiroDynamics loop

Lung mechanics and a graphical tracheal P-V loop are shown on the display. Compliance values are calculated at three points along the dynostatic curve and displayed:

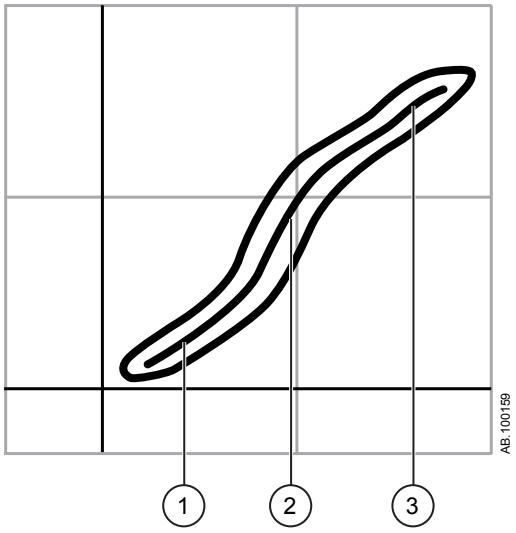


Figure 10-11 • Compliance measurements

1. C 5-15: Compliance measured between 5 and 15% of the volume range.
2. C 45-55: Compliance measured between 45 and 55% of the volume range.
3. C 85-95: Compliance measured between 85 and 95% of the volume range.

SpiroDynamics settings menu

Select the SpiroDynamics loop field. The Settings icon appears in the upper right-hand corner. Select the Settings icon to access the Settings menu and select which loop type to show and how the loop is scaled.

The following scaling options are available:

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.
- Manual: Select the scaling controls to increase or decrease the scale of the waveform.

SpiroDynamics loops

The SpiroDynamics loop and the Spirometry loop can be viewed simultaneously by selecting Spirometry in the SpiroDynamics settings menu.

SpiroDynamics loops are drawn every other breath. Up to six SpiroDynamics loops can be saved simultaneously. When a loop is saved in SpiroDynamics, the Spirometry loop is also saved. When six sets of reference data have been saved, subsequent saves

overwrite the oldest set of reference data. The current loop is colored green. Reference loops are colored yellow. Move the cursor to view specific data points on the SpiroDynamics loops shown. When using the cursor to view specific data points on the loop, loops are not drawn.

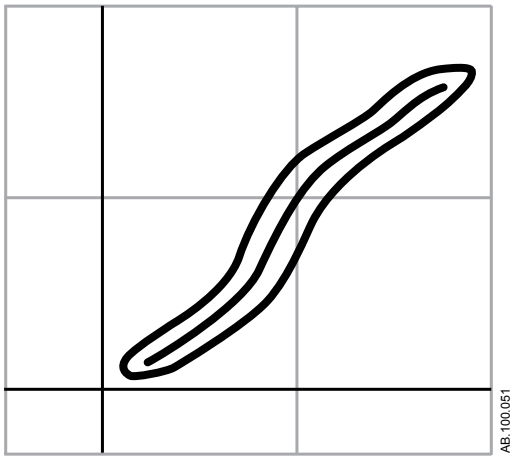


Figure 10-12 • SpiroDynamics loop with dynostatic curve

SpiroDynamics measured data

The SpiroDynamics tab shows the following data collected by the intratracheal pressure sensor:

- Ppeak
- Pmean
- PEEP
- C 5-15
- C 45-55
- C 85-95

This data is shown for the current breath and reference breaths when selected. Review this data to evaluate lung function.

Set up and view SpiroDynamics

Set up SpiroDynamics

Note Before you begin, review the Instructions for Use provided with the intratracheal pressure sensor.

1. Attach the intratracheal pressure sensor connector to the auxiliary pressure port on the ventilator.
2. Access ***Menu*** > ***System*** menu.
3. Select ***Purge Flow***.

Note A continuous purge flow of approximately 35 ml/min prevents the buildup of mucous inside of the sensor.

4. Select ***Paux Zero*** to zero the pressure sensor. When completed, a green check mark appears next to ***Paux Zero*** indicating success.
5. Insert the sensor into the endotracheal tube according to the Instructions for Use provided with the sensor.

View SpiroDynamics data

1. Access Clinical Decision Support > Spirometry view > SpiroDynamics tab.
2. The current SpiroDynamics and Spirometry data is shown based on the SpiroDynamics settings. See "*SpiroDynamics settings menu*" for more information.
3. To save the current data as reference data, press ***Save Loops***.

Note Up to six sets of SpiroDynamics data can be saved. When six sets of reference data have been saved, subsequent saves overwrite the oldest set of reference data.

4. To show a specific set of reference data in the loop graph, select the set of reference data.
5. Select and move the SpiroDynamics loop cursor to view specific data points.
6. To remove a specific set of reference data from the loop graph, select the set of reference data.

Metabolics view

Note An airway module with the capability to measure metabolic data is required to use the Metabolics view.

The Metabolics view shows measured data trends and values related to patient metabolics. The following data is shown:

- Carbon dioxide production (VCO2)
- Oxygen consumption (VO2)
- Respiratory quotient (RQ)
- Energy expenditure (EE)

Review this data to aid in the evaluation of the patient's metabolism and nutritional requirements.

Figure 10-13 • Metabolics view

1. Metabolics timeline cursor — Highlights the set period on the timeline.

2. Metabolics (averaged data)	Shows the averaged numerical data for VCO2, VO2, RQ, and EE corresponding to the averaging cursor.
3. Metabolics trends list	Shows the set period of Metabolics trending data.
4. Averaging cursor	Select the cursor to set the averaging time (5 min to 6 hours) and confirm. Slide the cursor and observe the averaged metabolic data.
5. Save Metabolics button	Select to save the averaged metabolics data.

Steady state ventilation

Metabolics data, also known as Indirect Calorimetry data must be obtained during a steady state to be accurate. A steady state is a sustained period of rest during which ventilation settings remain unchanged and patient stimuli are minimal. Do the following to increase the likelihood of steady state ventilation:

- Maintain ventilation settings for 1-2 hours prior to the Metabolics study. Changes to minute volume, PEEP, and FiO2 affect EE and RQ calculations.
- Avoid measurements or procedures such as bronchial suction that may cause patient discomfort and change respiratory status.

Perform a Metabolics measurement

Perform the following steps to prepare for steady state ventilation, which is required for a Metabolics (Indirect Calorimetry) study.

1. Do the following to ensure the accuracy of the metabolics measurement.
    - Set the ***FiO2*** to less than 85% (ideally less than 60%).
    - Set the ***Rate*** to less than 35 bpm.
    - Set the ***Bias Flow*** to less than 10 l/min.
    - Make sure the ***VT*** is greater than 200 ml for D-Lite(+) or 50 ml for Pedi-Lite(+).
    - Make sure there are no leaks in the patient circuit.
    - Make sure the patient is not undergoing any blood filtration therapies, such as hemodialysis or peritoneal dialysis.
2. Do the following to maximize conditions to achieve steady state ventilation:
    - Make sure ventilator settings remain unchanged.

- Make sure there are no recent or planned nursing activities.
- Make sure the patient has a stable temperature and is hemodynamically stable.

3. Do the following to make sure the airway module measurements are accurate:

   - Make sure that the airway module is calibrated.
   - Allow the airway module to warm up for 30 minutes.
   - Use the appropriate sensor (D-lite(+) or Pedi-lite(+) based on the patient type, set tidal volume, and humidification in use.
   - Make sure the D-lite(+) or Pedi-lite(+) sensor is placed at a 20 – 45° tilt to minimize chances of condensation entering the sampling tubes.

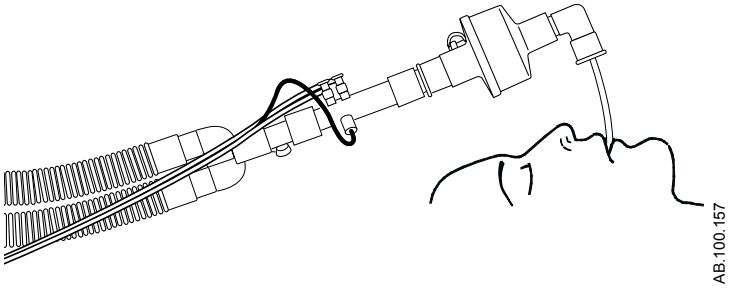


Figure 10-14 • D-Lite(+) sensor at 45° angle

   - Check for patient circuit leaks and eliminate if present.

4. During steady state ventilation, do the following to make sure that humidity and condensation do not affect measurements.

   - Verify that there is no moisture in the airway module sample line.
   - Compare airway module inspiratory and expiratory tidal volumes with the ventilator tidal volume settings and measurements.

Review Metabolics data

1. Access Clinical Decision Support > Metabolics.
2. Select the timeline cursor and select a period of steady state ventilation.
3. Review the Metabolics trends data in the trends list.
4. Move the Metabolics trends list averageing cursor as needed to view specific data points.
5. Review the Metabolics average numerical data and coeffiicient of variation in the trends list.

Note Use the Save Metabolics button to save Metabolics averaged data to Trends log.

6. As needed, repeat steps 2-5.

Calculations view

The Calculations view shows calculated data based on ventilator measured data and laboratory blood gas data. The ventilator measured data is available in one-minute increments for the past 72 hours. Enter blood gas data and the time of collection from within the past 72 hours to perform the calculations.

The time of the lab data entered will be used to select the required ventilator data for the calculations performed. Lab data can only be entered for time periods with valid trended ventilator data.

The ventilator saves up to 45 calculations. When the number of calculations exceeds 45, the oldest calculation is deleted.

Figure 10-15 • Calculations view

1. Lab Data — Enter blood gas data under Lab Data.
2. Input tab — Review the blood gas data entered under Lab Data.
3. Ventilation tab — Analyze ventilation calculations.

4.	Oxygenation tab	Analyze oxygenation calculations.

Lab data

Set and confirm input data. Enter the Sample Time and blood gas values.

Enter blood gas data

1. Access Clinical Decision Support > Calculations.
2. Select and enter the ***Sample Time***.

Note Make sure that the time entered is the time the blood sample was collected and valid ventilator data is available for that time period.

   - Select ***Sample Date*** and enter the date on which the sample was collected.
   - Select ***Sample Hour*** and enter the hour at which the sample was collected.
   - Select ***Sample Minute*** and enter the minute at which the sample was collected.

3. Select ***Confirm***.
4. Use the Trim Knob to enter the following lab data:

   - ***Hb***
   - ***SaO2***
   - ***SpO2***
   - ***SvO2***
   - ***PaO2***
   - ***PvO2***
   - ***PaCO2***

5. Select ***Calculate***.
6. Review the data on the following tabs:

   - ***Input***
   - ***Ventilation***
   - ***Oxygenation***

Input tab

The Input tab shows the data entered under Lab Data.

Data	Definition
Hb	Hemoglobin
SaO2	Arterial oxygen saturation level (of hemoglobin)
SpO2	Peripheral oxygen saturation level (of hemoglobin)
SvO2	Venous oxygen saturation level (of hemoglobin)
PaO2	Arterial pressure of oxygen
PvO2	Venous partial pressure of oxygen
PaCO2	Arterial partial pressure of carbon dioxide

Ventilation tab

The Ventilation tab shows the following calculations based on manually entered blood gas data and data collected by the ventilator.

Data	Definition	Equation
Pa/FiO2	Oxygenation ratio	PaO2/FiO2 *100
AaDO2	Alveolar arterial oxygen gradient	PAO2 - PaO2
CO	Cardiac output	VO2/(CaO2 - CvO2)
Vd/Vt	Dead space to Tidal Volume ratio	(PaCO2 - ExpCO2 Wet)/(PaCO2 - FiCO2 Wet) *100
Vd	Dead space volume	(Vd/Vt /100) * VTexp
VA	Alveolar ventilation	For blood gas unit mmHg: (VCO2/1000)/(PaCO2/(atmospheric pressure in mmHg - 47)) * 1.212 For blood gas unit kPa: (VCO2/1000)/(PaCO2/(atmospheric pressure in mmHg - 47)*0.1333) * 1.212

Oxygenation tab

The Oxygenation tab shows the following calculations based on manually entered blood gas data and data from the ventilator.

Data	Definition	Equation
PAO2	Alveolar partial pressure of Oxygen	For blood gas unit mmHg: ((FiO2/100) * (atmospheric pressure in mmHg - 47)) - (PaCO2 * ((FiO2/100) + ((1 - (FiO2/100))/RQ))) For blood gas unit kPa: ((FiO2/100) * (atmospheric pressure in mmHg - 47) * 0.1333) - (PaCO2 * ((FiO2/100) + ((1 - (FiO2/100))/RQ)))

Data	Definition	Equation
PaO2/PAO2	Alveolar arterial oxygen pressure gradient	(PaO2/PAO2) * 100
OI	Oxygenation index	(Pmean * FiO2)/PaO2
SpO2/FiO2	Peripheral oxygen saturation level (of hemoglobin) to fraction of inspired oxygen ratio	SpO2/(FiO2/100)

11 System configuration (Super User) and service

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

Configuration menu (Super User)

Use the Configuration menu to set facility configuration defaults and system setting defaults per patient type. Setting changes should only be made by the person (Super User) responsible for the configuration of the ventilator. The password for entering the Configuration menus is provided during training.

WARNING Do not enter Configuration menu when a patient is connected to the ventilator.

CAUTION Changes made in the Configuration menu affect the system configuration. All changes made are permanent and preserved until changed again.

Access the Configuration menu

1. Power on the ventilator or enter Standby.

   The Standby menu displays.
2. Select the Setup icon.

   The keypad displays.
3. Enter the Super User password. (This password is provided during training).

   The Configuration menu displays with the alarm management bar and Standby quick key colored orange.
4. Select the desired Configuration tabs to change or set facility defaults.
5. Select Exit to leave the Configuration tabs.

Configuring units

Use the Units tab to select the unit facility defaults for the ventilator.

Important All patient data will be deleted when a change is made in this tab. All changes made are permanent and preserved immediately until changed again.

1. Select Units.

   The corresponding setting options show.
2. Select the unit setting.

   The setting is immediately set.
3. Select Exit to leave the menu.

Menu Item	Setting	Default
Paw	kPa, cmH2O, mbar	cmH2O
CO2	%, kPa, mmHg	%
Height	cm, in	cm
Weight	kg, lb	kg
Energy Expenditure	kcal/d, kJ/d	kcal/d
Gas Supply Pressure	kPa, psi, bar	kPa
Blood Gases	kPa, mmHg	mmHg
Hb	g/l, g/dl, mmol/l	g/l
Exit	Exit menu	
Assign Defaults	Access menus to assign system defaults	

Configuring time and date

Use the Time and date tab to select the clock format, time, and date for the ventilator facility defaults.

Important All patient data will be deleted when a change is made in this menu. All changes made are permanent and preserved immediately until changed again.

1. Select the clock format, time, or date setting.

   The corresponding setting options show.
2. Change settings.

   The setting is immediately set.
3. Select Exit to leave the menu.

Menu Item	Setting	Default
Clock format	12 h, 24 h	24 h
Time	hh:mm:ss	
Date	day (1-31) month (XXX) year (XXXX)	
Exit	Exit menu	
Assign Defaults	Access menus to assign system defaults	

Configuring ventilator settings

Use the Ventilator settings tab to select default patient type (adult, pediatric, or neonatal), Timing, Flow, CPAP Rate, and System Configuration.

Important All patient data will be deleted when a change is made in this menu. All changes made are permanent and preserved immediatley until changed again.

1. Select patient type (adult, pediatric, or neonatal) for the facility default.

   When the ventilator is powered on, the selected patient type will be the default.
2. Select Timing.

   Tpause is only available when Flow is set to On.
3. Select Flow (On or Off).
4. Select CPAP Rate (On or Off).
5. Select System Configuration (Clinical or Bench).

   The Clinical setting is used for patient use only and the Bench setting is used for research only.

   The setting is immediately set. After exiting Configuration menu (Super User), a general message shows to indicate that the ventilator is in the bench configuration.
6. Select Exit to leave the menu.

Menu Item	Settings	Default
Default patient type	adult, pediatric, neonatal	adult
Timing	I:E, Tinsp, Tpause	I:E
Flow	On, Off	Off
CPAP Rate	On, Off	Off
System Configuration	Clinical, Bench	Clinical
Exit	Exit menu	
Assign Defaults	Access menus to assign system defaults	

Assign mode favorites

Use the Assign mode favorites tab to select ventilation modes that will show in the Current Mode list.

1. Select the modes to be used for facility defaults.

Select a partial list or select the full list of vent modes as determined by the facility.

	This icon designates the facility set ventilation modes that are listed in the Current modes menu.
	This icon designates the full set of ventilation modes that are available on the system.

2. The setting is immediately set. Select Exit to leave the menu.

Calibrations

Super User and Service personnel may use the Calibrations tab to calibrate the Air FCV (flow control valve), O2 FCV (flow control valve), Exhalation valve, and Airway module. The last calibration time and date are shown next to each item.

1. Select the desired calibration and follow the on-screen instructions.

   The date and time of the calibration shows when the calibration is complete.
2. Check the Calibration Flag if desired.

   The Calibration Flag check box is used by the factory to activate the “Calibration required” general message. It is set as a reminder that calibrations must be performed when the machine is set up for operation at its permanent location. After completing calibration, set the Calibration Flag to Off.
3. Select Exit to leave the menu.

Calibrating the airway module

1. Power on the ventilator or select Standby.
2. Select the Setup icon, enter the Super User password and confirm.
3. Allow the gas module to warm up before starting calibration.

   - 2 to 5 minutes, if module has previously been powered on for at least 30 minutes
   - 30 minutes, if module has not been previously powered on for at least 30 minutes

4. Attach the regulator to the calibration gas cylinder.
5. Attach a new sampling line to the water trap. Connect the loose end of the sampling line to the regulator on the calibration gas cylinder.
6. Select ***Calibrations*** >***Airway Module***.
7. Follow the on-screen instruction and select Start.

   - Calibration will begin as soon as the menu item is selected.

- If an airway module is active during calibration, “Calibration not available. Make sure no airway module alarms are active." displays.

8. Wait until “Feed Gas” appears after each gas.
9. Open the regulator and feed calibration gas until the message “Ok” or “Adjust” displays.

   - If an error occurs during calibration or no gas is fed, “Calibration error occurred. Select Start to recalibrate.” displays.
   - Select Start to perform a new calibration.

10. If adjustments are needed:

    - Select the gas to be adjusted.
    - Use the Trim Knob to change the value until it matches the calibration gas cylinder value.
    - Push the Trim Knob to confirm the change.
    - Repeat for each gas requiring adjustment.
    - Select Standby to exit.

Copy configuration

Use the Copy Configuration menu to save ventilator settings to USB media, copy settings from USB media, or reset system default settings to the original Factory default settings. Only Super User level configurations may be saved to USB media or copied from USB media. For example, the language configuration option cannot be saved.

1. Select ***Save to USB***, ***Copy from USB***, or ***Factory Reset***.
2. Select Exit to leave the menu.

Assign facility default settings

Set the facility default setting for each patient type using the Assign Default button on the bottom of the Configuration menus. Setting changes should only be made by the person (Super User) responsible for the configuration of the ventilator. The password for entering the Configuration (Super User) menus is provided during training.

Note Facility default settings will be reset to the factory default settings after a Factory Reset of the ventilator.

If already in Super User mode, start with step 4.

1. Power on the ventilator or enter Standby.

   The Standby menu displays.
2. Select the Setup icon.

   The alpha-numeric key pad displays.
3. Enter the Super User password. (This password is provided during training).

   The Configuration (Super User) menu displays. The alarm bar and the Standby quick key are colored orange.
4. Select ***Assign Defaults*** to change or set facility default settings.

   The currently set default view in the Present workspace displays. If no default view has been set, the Basic view displays.
5. Select the patient type for which you would like to change facility default settings.

   Each patient type must have defaults assigned individually. The patient type selected is displayed in the Current Patient menu. The default settings will be applied to this patient type.

   Examples of settings and views that may be configured:

   - Data source
   - Settings for Procedures such as Lung Mechanics, Nebulizer, and Suction
   - Alarm limit settings
   - Current/Backup ventilation mode settings
   - Default ventilation modes
   - Waveform settings
   - Default and home views (See "*Assign facility default views*" for specific instructions on setting default views.)
6. Select ***Standby*** to exit Assign Defaults.

   A warning message displays:

   “Save changes to patient type settings?”

- Select Yes to save as defaults and go to Standby
- Select No to discard changes and go to Standby
- Select Cancel to return to Setup

Assign facility default views

Default views can be assigned for each workspace. The default view for a particular workspace is the last view that was displayed before exiting Assign Defaults or changing the patient type. It is recommended to assign facility default views after assigning all other facility default settings for a patient type.

1. Enter Assign Defaults.

   See "*Assign Facility Defaults*" for instructions on entering Assign Defaults in the Configuration (Super User) menu.
2. Select the patient type for which you would like to change facility default settings.

   Each patient type must have the defaults assigned individually.

   The patient type selected is displayed in the Current Patient menu. The default settings will be applied to this patient type.
3. Select the Past/Historical Trends workspace.
4. Select the desired default Past/Historical Trends view.
5. Select the Future/Clinical Decision Support workspace.
6. Select the desired default Future/Clinical Decision Support view.
7. Select the Present/Patient Status workspace.
8. Select the desired Present/Patient Status view.

Note The default Present/Patient Status view is the Home view that will be displayed when the Home hard key is pressed.

9. Select Standby to confirm default views.

   A warning message displays:

   “Save changes to patient type settings?”

   - Select Yes to save as defaults and go to Standby
   - Select No to discard changes and go to Standby
   - Select Cancel to return to Setup

Factory default settings

The table lists the entire parameter list available for ventilator factory defaults.

Current Mode Factory Default Settings			
	Adult	**Pediatric**	**Neonatal**
Setting	Adult	Pediatric	Neonatal
Vent mode	A/C PC	A/C PC	A/C PC
Backup mode	On	On	On
FiO2	50	50	50
VT	500	100	10
Pinsp	10 cmH2O (10 mbar, 1.0 kPa)	7 cmH2O (7 mbar, 0.7 kPa)	5 cmH2O (5 mbar, 0.5 kPa)
Rate	10	15	25
I:E	1:2	1:2	1:2
Tinsp	1.7	1.7	0.4
Tpause	0	0	0
PEEP	Off	Off	Off
PS	5 cmH2O (5 mbar, 0.5 kPa)	3 cmH2O (3 mbar, 0.3 kPa)	0
Pmax	30 cmH2O (30 mbar, 3.0 kPa)	30 cmH2O (30 mbar, 3.0 kPa)	12 cmH2O (12 mbar, 1.2 kPa)
Plimit	100 cmH2O (98 mbar, 9.8 kPa)	100 cmH2O (98 mbar, 9.8 kPa)	100 cmH2O (98 mbar, 9.8 kPa)
Insp pause	0	0	0
Phigh	10 cmH2O (10 mbar, 1.0 kPa)	7 cmH2O (7 mbar, 0.7 kPa)	5 cmH2O (5 mbar, 0.5 kPa)
Plow	Off	Off	Off
Thigh	1.7	1.7	0.4
Tlow	4.25	2.3	0.8
Flow	40 l/min	20 l/min	1.5 l/min
Rise Time	100 ms	100 ms	100 ms
PS Rise Time	50 ms	50 ms	0 ms
Pmin	2 cmH2O (2 mbar, 0.2 kPa)	2 cmH2O (2 mbar, 0.2 kPa)	2 cmH2O (2 mbar, 0.2 kPa)
Inspiratory Trigger	2 l/min	1 l/min	0.5 l/min
Expiratory Trigger	25%	25%	25%
Bias Flow	3 l/min	2 l/min	2 l/min
Assist control	On	On	On
Leak comp	Off	Off	Off
Trigger comp	Off	Off	Off
Minimum Rate	10	15	25
Tsupp	4 s	1.5 s	0.8 s
Sweep speed	Fast	Fast	Fast

Current Mode Factory Default Settings			
	Adult	**Pediatric**	**Neonatal**
Tube comp	Off	Off	NA

Backup Mode Factory Default Settings			
	Adult	**Pediatric**	**Neonatal**
Backup mode	A/C PC	A/C PC	A/C PC
Backup VT	500	100	10
Backup Pinsp	10 cmH2O (10 mbar, 1.0 kPa)	7 cmH2O (7 mbar, 0.7 kPa)	5 cmH2O (5 mbar, 0.5 kPa)
Backup rate	12	12	25
Backup I:E	1:2	1:2	1:2
Backup Tinsp	1.7	1.7	0.4
Backup Tpause	0	0	0
Backup Insp Pause	0	0	0
Backup Pmin	2 cmH2O (2 mbar, 0.2 kPa)	2 cmH2O (2 mbar, 0.2 kPa)	2 cmH2O (2 mbar, 0.2 kPa)
Backup flow	40 l/min	20 l/min	1.5 l/min
Backup rise time	100 ms	100 ms	100 ms

Alarm Factory Default Settings			
	Adult	**Pediatric**	**Neonatal**
Low FiO2	44%	44%	44%
High FiO2	56%	56%	56%
Low Ppeak	4 cmH2O (4 mbar, 0.4 kPa)	4 cmH2O (4 mbar, 0.4 kPa)	4 cmH2O (4 mbar, 0.4 kPa)
High Ppeak	30 cmH2O (30 mbar, 3 kPa)	30 cmH2O (30 mbar, 3 kPa)	12 cmH2O (12 mbar, 1.2 kPa)
Low MVexp	2 l/min	1 l/min	0.2 l/min
Low VTexp	Off	Off	Off
Low RR	Off	Off	Off
High RR	Off	Off	Off
Low ETO2	Off	Off	NA
High ETO2	Off	Off	NA
Low ETCO2	3% (3 kPa, 23 mmHg)	3% (3 kPa, 23 mmHg)	NA
High ETCO2	8% (8 kPa, 60 mmHg)	8% (8 kPa, 60 mmHg)	NA
High MVexp	10 l/min	5 l/min	0.4 l/min
High VTexp	Off	Off	Off
Low PEEPe	Off	Off	Off
High PEEPe	Off	Off	Off
High PEEPi	Off	Off	NA
High Paux	30 cmH2O (30 mbar, 3 kPa)	30 cmH2O (30 mbar, 3 kPa)	30 cmH2O (30 mbar, 3 kPa)
Apnea time	30 s	30 s	15 s

Alarm Factory Default Settings			
	Adult	**Pediatric**	**Neonatal**
Tdisconnect	30 s	30 s	NA
Patient Effort	50 s	50 s	NA
Leak Limit	50%	50%	50%
Show alarm limits	On	On	On
Alarm volume	3	3	3
High alert audio	30 s	30 s	30 s

Service menus

The Service level menus support Calibration, Service, and Service Log menus. Service settings should only be changed by authorized service personnel or by the person responsible for the configuration of the ventilator. A separate password for entering the service menus is provided to service-level users during training.

When the service mode is entered the date and time is entered into the Event log.

WARNING Do not enter the Service menu when a patient is connected to the ventilator. The ventilator must be powered down in order to exit the Service menus and resume ventilation.

Localization

Use the Localization tab to select the decimal marker, software language, altitude units, and altitude.

Important Cycle power to exit the service menus.

Menu Item	Setting	Default
Decimal Marker	0.01, 0,01	0.01
Language	Brazilian Portuguese	
	Chinese (simplified)	
	Czech	
	Danish	
	Dutch	
	English	English
	Finnish	
	French	
	German	
	Greek	
	Hungarian	
	Italian	
	Japanese	
	Norwegian	
	Polish	
	Portuguese	
	Russian	
	Spanish	
	Swedish	
	Turkish	
Altitude Units	m, ft	m
Altitude	• -400 to 3000 (100 m increments) • -1200 to 9900 (300 ft increments)	300 m

Optional features

Use the Optional Features tab to upgrade software, view software options that are currently loaded on the ventilator, access Current key and Control Board ID.

Important Cycle power to exit the service menus.

See CARESCAPE R860 Technical Reference Manual for detailed information.

Menu Item	Description
Optional Features	Select the optional features
Current Key	Select and enter the key code
Control Board ID	Show control board identification number
USB Upgrade	Select to upgrade software and options

Service log

Service log history is represented by the Main, Error log, Event log, Alarm log, and SW/HW (software and hardware) tabs.

Main

The Main tab shows the total Running Hours, the ventilator serial number, model code, and the date when maintenance was last performed.

Use the Copy Logs button to copy logs to USB media.

Important Cycle power to exit the Service menu.

When logs are saved to USB media; the ventilator's serial number, date, and time are saved along with the current contents of the logs.

Menu Item	Description
Total Running Hours	Shows the total number of hours the ventilator has run
Serial Number	Shows the serial number for the ventilator
Model Code	CARESCAPE R860
Maintenance Performed	Shows the date and time of last maintenance
Copy Logs	Copies all Error, Event, Alarm logs with the software and hardware configuration to a text file on USB media

Error log

The Error log tab lists the last 200 errors logged, starting with the most recent. The system stores the last 1,000 errors logged. The last 1,000 logs can be copied to a USB device using the Copy Log Function on the Service menu > Main tab.

Important Cycle power to exit the Service menus.

Alarm log

The Alarm log tab lists the last 200 alarms starting with the most recent. The alarm log stores the last 1,000 entries. The alarm log is maintained after a power cycle and after the ventilator experiences a total loss of power (including internal system battery loss).

Important Cycle power to exit the Service menus.

Event log

The Event log records the service history of the ventilator. This includes: service calibrations, Super User calibration, checkout results, entry into the service mode, options enabled, and software installation. In the event of a board replacement, this log like all others could be lost.

The Event log lists the last 200 events logged starting with the most recent. The Event log stores the last 1,000 events. The Event log can not be reset.

Important Cycle power to exit the Service menus.

SW/HW (software and hardware)

The Software and hardware tab shows the software and hardware for the ventilator (System, VCB, VMB, DU, BIOS, Front panel, and PMB).

12 Cleaning and maintenance

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

Repair policy

WARNING With the exception of removing and replacing the expiratory flow sensor or calibrating the neonatal flow sensor, do not perform any service while the ventilator is in use with a patient.

CAUTION Repairs should only be performed by a trained GE Healthcare service representative or by persons having completed GE Healthcare approved service training.

Do not use the ventilator if it malfunctions. Replace damaged parts with components manufactured or sold by GE Healthcare. After repairing the ventilator, test it to make sure the parts function correctly and comply with the published specifications from the manufacturer.

If repairs cannot be done by an authorized service representative, replacement and maintenance of the parts listed in this manual may be done by a competent, trained individual with experience in the repair of devices of this type.

Circuit diagrams, parts lists, and calibration instructions used to assist qualified personnel to repair the ventilator are in the Technical Reference Manual (TRM). Contact an authorized service representative for service assistance.

Approved service

At a minimum of every 12 months, an authorized service representative should complete the scheduled service maintenance checks, tests, calibrations, and parts replacements as specified in the Technical Reference Manual.

To see the hours of run-time for the ventilator, select ***Menu*** > ***System***.

Storing the ventilator

CAUTION Keep the ventilator connected to the main power even when it is not in use. It is recommended that the ventilator remain connected to the main power to prevent battery discharge and degradation. Use only Datex-Ohmeda recommended batteries.

The green LED on the lower left side of the display unit is on when the ventilator is connected to the main power source.

To see the battery status, select ***Menu*** > ***System***.

Disposal

Dispose of the ventilator, accessories, and packaging according to local, state, or country disposal and recycling laws at the end of their expected service life.

System data

The System menu shows data used for maintenance and service.

Select ***Menu*** > ***System*** to see the following system information:

- Software Version
- Service Pack Version
- Running Hours
- Altitude
- O2 Pressure
- Air Pressure
- Battery Status

When an airway module is installed, the System menu shows the airway module data:

- Module Type
- Module Version
- Last Passed Calibration

Important The Last Passed Calibration data does not show until after the airway module is warmed up. See "*Airway modules*" in the "*Setup and connections*" section for more information.

Testing battery performance

WARNING Perform the battery test every 6 to 12 months to make sure battery capacity is at least 30 minutes. Replace the batteries when necessary. See "*User maintenance*" for more information.

Only use batteries recommended by GE Healthcare. If the batteries need to be replaced, contact an authorized service representative to install them. Dispose of used batteries in accordance with local regulatory requirements in effect at the place of disposal.

Important If the ventilator is used more than once a month on battery power, such as to transport a patient within the facility, it is recommended that the battery performance test be completed every six months.

1. Connect the ventilator to the main power source for eight hours to make sure the batteries are fully charged.

   To see battery status, select ***Menu*** >***System***.
2. Connect a patient circuit and test lung to the ventilator.
3. Set the following parameters:

   - Mode: A/C PC

- Rate: 12 /min
- I:E: 1:2
- Pinsp: 20 cmH2O
- PEEP: 5 cmH2O
- Bias Flow: 4 l/min

4. Start ventilation.
5. Disconnect the power cord from the main power source.

   - If the batteries continue to power the ventilator for 45 minutes or longer, the batteries have sufficient charge.
   - If the batteries do not continue to power the ventilator for 45 minutes, contact an authorized service representative and have the batteries replaced.

Important After this test is completed, connect the ventilator to the main power source for eight hours before it is used on a patient to make sure the batteries are fully charged.

Maintenance summary and schedule

The maintenance schedules in this section show the minimum intervals recommended by GE Healthcare. Refer to local regulations, which can have more maintenance requirements. GE Healthcare encourages compliance with local regulations that meet or exceed the minimum level of maintenance.

User maintenance

Calibrate the system when any one of these occurs:

- Performance is questionable, such as a System Check failure.
- Internal components are serviced or replaced.
- Every six months.

For best performance of the system, calibrate more frequently.

Do the scheduled maintenance as shown in the table. Processing and disassembly instructions are available later in this section.

Minimum Frequency	Maintenance
During cleaning and setup	• Inspect the parts for damage and replace or repair, as necessary.
As necessary	• Empty the water trap on the exhalation valve housing. • Empty the water trap on the air pipeline inlet fitting and replace the filter. • Clean and replace the expiratory flow sensor. • Clean or replace the neonatal flow sensor.
Monthly	• Remove and clean fan filters for the display unit, vent housing, airway module, and compressor.
Every two months	• Calibrate the airway module, if one is installed.
Every six months	• Calibrate the O2 Flow Control Valve* • Calibrate the Air Flow Control Valve* • Calibrate the Exhalation Valve* • Check performance of internal battery. **

Minimum Frequency	Maintenance
Annually	• Schedule an annual service and maintenance check for the ventilator, airway module, and compressor.

Important *If the ventilator is moved from the facility, calibrate the O2 Flow Control Valve, Air Flow Control Valve, and Exhalation Valve.

Important **If the ventilator is used more than once a month on battery power, such as to transport a patient within the facility, it is recommended that the battery performance test be completed every six months.

Airway module maintenance

For best performance of the airway module, do the maintenance as shown in the table. For calibration instructions, see "*Airway module calibration*".

CAUTION Do not disinfect or open the water trap cartridge. Do not touch the water trap membrane. The hydrophobic membrane will become damaged if any cleaning is attempted other than rinsing with water.

Minimum Frequency	Maintenance
Daily	Empty the D-fend water trap
Every two months	Calibrate the airway module
Annually	Schedule annual service

Compressor maintenance

Contact an authorized GE Healthcare service representative and have preventative maintenance done to the compressor every 5000 hours of operation or annually, whichever occurs first. The hours of operation are shown on the screen on the compressor. Use the navigation buttons on the compressor control panel to change screens.

Refer to the EVair Medical Air Compressor User Manual (2066030-001) for more information about compressor maintenance.

CAUTION The weight of the compressor is approximately 33 kg (73 lbs). Do not try to remove the compressor from the ventilator cart without the correct service tools.

Component replacement schedule

This table indicates the minimum recommended maintenance. Replace the component at the frequency or number of reprocessing cycles, whichever occurs first.

*Visually inspect components to determine if cleaning or replacement is needed. Look for deformation, cracks, or discoloration.

Component	Minimum Frequency	Reprocessing Cycles
Exhalation Valve Assembly • Exhalation Valve Diaphragm	12 months	50
Expiratory flow sensor	6 months	50
Neonatal flow sensor	6 months	25
Cart-mounted water trap • Water trap connector tubing (hytrel tubing)	*As needed	50
D-lite sensor	*As needed	50
Pedi-lite sensor	*As needed	50
Inlet filter bowl	*As needed	*As needed
Display and ventilator fan filters	*As needed	*As needed
Compressor air inlet filter	*As needed	*As needed

See "*Aeroneb Pro Nebulizer*" or "*Inspiratory safety guard*" in this section for component replacement information.

Component processing compatibility

The table shows the compatibility of component material with reprocessing agents.

Important If a cell contains an x, the processing method is compatible with the corresponding component. If a cell is blank, the processing method is not compatible with the component.

Component	Mild detergent solution	70% Denatured ethyl alcohol	10% Bleach solution	Sporox II	Cidex OPA	Auto washer	Autoclave at 132° C or 134° C
Neonatal flow sensor	x	x		x	x		x
Expiratory flow sensor	x	x		x	x		x
Exhalation valve assembly	x	x	x	x	x	x	x
Cart-mounted water trap	x	x	x	x	x	x	x
D-lite sensor	x	x	x	x	x	x	x
Pedi-lite sensor	x	x	x	x	x	x	x

External surfaces processing compatibility

This table shows the compatibility of external sufaces with reprocessing agents.

Important If a cell contains an x, the processing method is compatible with the corresponding surface. If a cell is blank, the processing method is not compatible with the surface.

Component	Mild detergent solution	70% Denatured ethyl alcohol	10% Bleach solution	Sani-cloth or Protex wipes
External surfaces (including display unit surfaces, display cables, neonatal flow sensor cable, nebulizer cable, module rack cables, and power cords.)	x	x	x	x

Follow the manufacturer’s instructions for processing using a soft cloth.

CAUTION Do not allow chemical agent(s) to drip onto system or into system openings and connections.

Fan filters

Clean both the display and ventilator fan filters as follows:

1. To access the display unit fan filter, slide the filter holder downward on the back of the display housing, and then remove the fan filter.

2. To access the ventilator housing fan filter, insert a thin bladed tool into the groove of the filter cover on the back of the housing and pry it off.

Note Do not remove the screws that hold the fan filter in place.

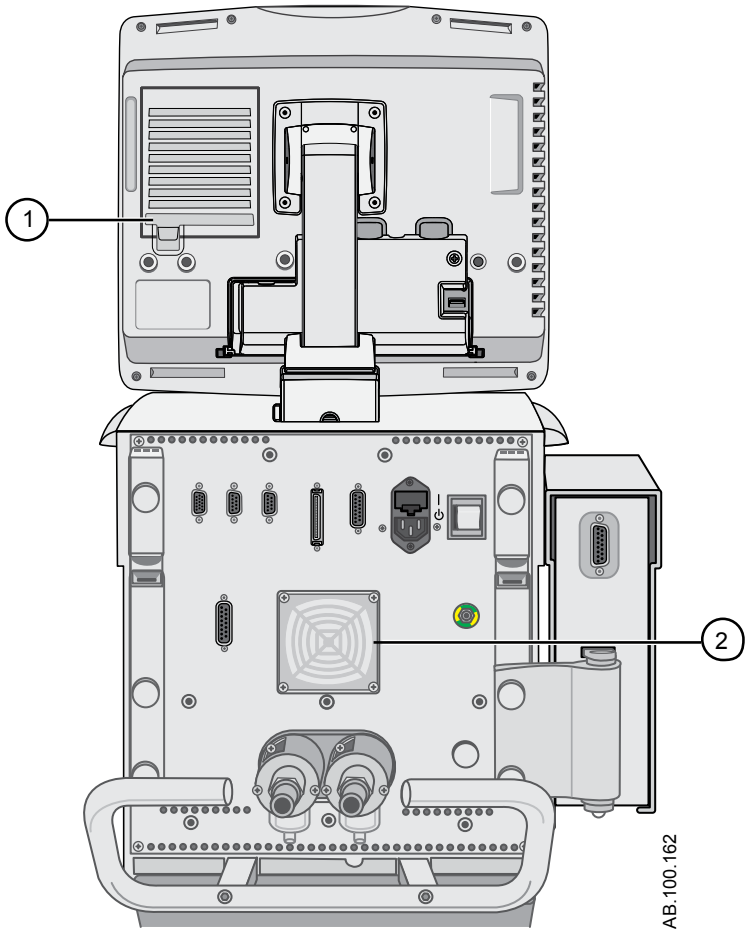


Figure 12-1 • Display and ventilator housing fan filters

1. Display fan filter
2. Ventilator housing fan filter

3. Rinse the filters with potable water until visibly clean and allow them to dry.
4. Before re-assembling the fan filters, do the following:
   - Replace any worn component

Note Re-assemble the fan filters in reverse order.

Compressor filter

The filter is located on the side of the compressor. Pull out the filter through the opening on the side to remove it. Refer to the EVair Medical Air Compressor User Manual (2066030-001) for more information.

WARNING Failure to maintain the air inlet filter may cause the compressor to overheat and shut down.

Before re-assembling or using the compressor filter, do the following:

- Replace filter if soiled

Note Re-assemble the filter in reverse order.

ISO 17664 compliance

The manual cleaning, automated cleaning, disinfection, and sterilization instructions provided in the following sections have been validated by the manufacturer of the medical devices as being capable of preparing a medical device for reuse.

According to ISO 17664, “It remains the responsibility of the processor to ensure that the reprocessing as actually performed using equipment, materials, and personnel in the reprocessing facility achieve the desired result. This requires validation and routine monitoring of the process.”

Component processing

The inspiratory safety guard, nebulizer, nebulizer tees, neonatal flow sensor, D-lite and Pedi-lite airway module spirometry adapters, cart-mounted water trap, exhalation valve assembly, and exhalation flow sensor are parts that can become contaminated with bodily fluids or expired gases.

It is recommended that the ventilator components are processed between patients. Single use components should be replaced and not processed. Refer to the current facility guidelines for cleaning, disinfection, and sterilization policies. Use the methods in this section when processing ventilator components. Do not autoclave or submerse a component unless instructed to do so.

Organic, halogenated or petroleum-based solvents, anesthetic agents, glass cleaners, acetone, and other harsh cleaning agents are not recommended.

WARNING Do not attempt to clean, disinfect, or sterilize components while ventilating a patient.

CAUTION Always clean, disinfect, and sterilize in accordance with current facility protocols.

- Process the ventilator and ventilator components only as instructed using the methods and products provided in this manual. Use of non-validated methods or products may damage components and void part warranties.
- Do not use abrasives, sharp tools, or any methods that can damage the surface of the components.
- Do not exceed 134° C during sterilization.

Inspiratory safety guard

The inspiratory safety guard cannot be cleaned. It is used to prevent patient gas from contaminating the inspiratory gas path of the ventilator. The inspiratory safety guard does not have to be replaced between patients; it must be replaced when patient gas has passed through the safety valve. This can occur in the following situations:

- Excess or sustained pressure in the system, as indicated by the following alarm messages: Relief valve opened, Patient circuit occluded, Sustained airway pressure.
- Failure of the Air and O2 supply gases while connected to the ventilator.
- When the ventilator is ventilating and an internal error message displays; see "*Internal errors*" in the "*Alarms and troubleshooting*" section for a detailed list of error messages.

Disassemble for processing

In this section are the instructions to take apart assemblies prior to processing.

Neonatal flow sensor (NFS)

To remove the neonatal flow sensor:

1. Disconnect the flow sensor from the patient circuit.
2. Disconnect the flow sensor from the flow sensor cable.
3. Disconnect the flow sensor cable from communications port 1 on the back of the vent.

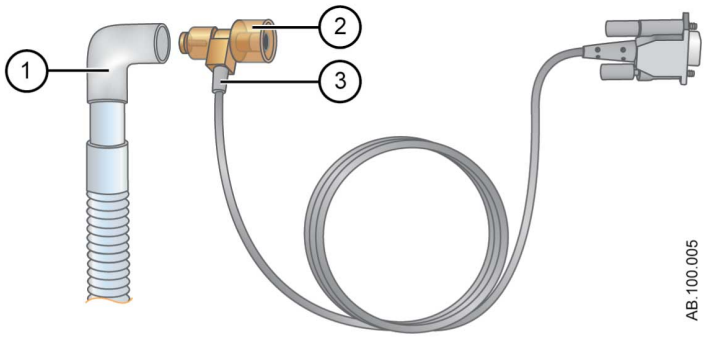


Figure 12-2 • Disconnecting the NFS (neonatal flow sensor)

1. Patient circuit
2. Neonatal flow sensor
3. Flow sensor cable

Note See the shared "*Cleaning and maintenance*" section for more information on cleaning. See "*Calibrating the neonatal flow sensor*" in "*Neonatal Cleaning and Maintenance*" for calibration information.

Pedi-lite(+) and D-lite(+) sensors

See "*Connecting the Pedi-lite(+) and D-lite(+) sensors*" in "*Setup and connections*".

Before re-assembling or using the Pedi-lite(+) or D-lite(+) sensor, do the following:

- Check for visible cracks, discoloration, or other degradation
- Check for leaks before use
- Replace any worn components
- Perform System Check

Expiratory flow sensor

If the expiratory flow sensor is removed during ventilation, the ventilator will alarm, volume and flow measurements will not be shown, and flow triggering will not be available until the flow sensor is replaced.

CAUTION Do not use an automated washer to clean flow sensors.

- Do not use compressed air or a water jet to clean the expiratory flow sensor.
- Do not insert anything into the flow sensor to clean internal surfaces. Damage may occur to the flow sensor.

To remove the expiratory flow sensor:

1. Pull the flow sensor away from the ventilator as shown.

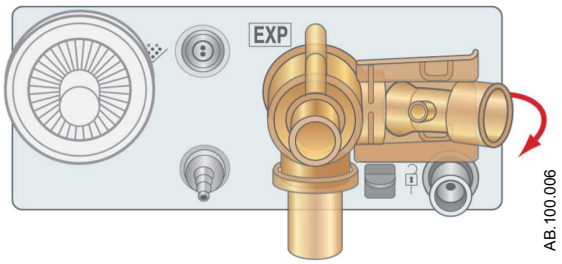


Figure 12-3 • Expiratory flow sensor

2. Before re-assembling or using the expiratory flow sensor, do the following:
   - Check for visible cracks, leaks, discoloration, or other degradation of the sensor and the silicone flap
   - Replace any worn components
   - Perform a System Check

Note Replace the sensor by positioning it back in place; listen for an audible click to ensure it is securely installed.

Exhalation valve assembly

WARNING Obey infection control and safety procedures when handling water traps. Infectious hazard might be present.

To remove the exhalation valve assembly:

1. Remove the expiratory flow sensor from the exhalation valve assembly.
2. Push down on the latch, as shown below, and then pull the exhalation valve assembly away from the ventilator.

Important Do not try to remove the exhalation valve assembly without first pushing down on the release latch. Damage might occur to the housing.

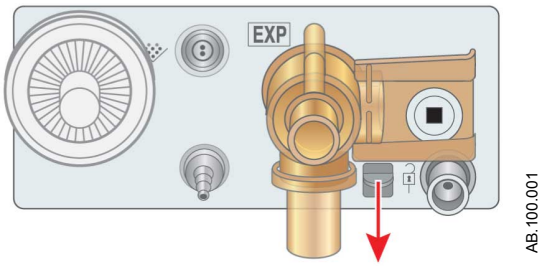


Figure 12-4 • Exhalation valve assembly

3. Remove the water trap and empty it. Make sure to save the o-ring from the water trap.

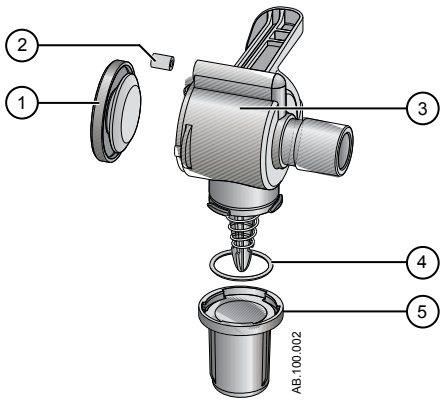


Figure 12-5 • Exhalation valve disassembly

1. Diaphragm

2. Seal
3. Exhalation valve housing (side view)
4. O-ring
5. Water trap

4. Lift the edge of the diaphragm to remove it from the exhalation valve housing. Make sure to save the seal.
5. Before re-assembling or using the exhalation valve assembly, do the following:

   - Check for visible cracks, discoloration, or other degradation
   - Replace any worn components
   - Perform System Check

Note Re-assemble the exhalation flow sensor in reverse order.

Water trap (cart mounted)

WARNING Obey infection control and safety procedures when handling water traps. Infectious hazard might be present.

The humidifier and water trap are attached to the accessory mounting rail.

1. Disconnect the water trap and connector tubing from the patient circuit.
2. If necessary, remove the water trap assembly from the mounting bracket. Otherwise, empty the water from the water trap housing.

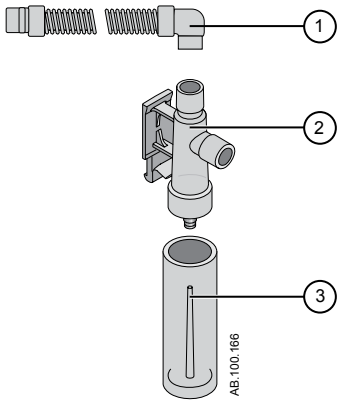


Figure 12-6 • Cart-mounted water trap

1. Water trap connector tubing

2. Water trap housing
3. Water trap

3. Before re-assembling or using the water trap and connector tubing, do the following:

   - Check for visible cracks, discoloration, or other degradation
   - Check for leaks before use
   - Replace any worn components
   - Perform System Check

Note Re-assemble the water trap in reverse order.

Manual cleaning

Soaking

The following parts can be cleaned manually with the soaking method:

- Neonatal flow sensor
- Expiratory flow sensor
- Exhalation valve assembly
- Cart-mounted water trap and tubing
- D-lite sensor
- Pedi-lite sensor

1. Create a mild detergent solution by doing the following:
   - Dilute Neodisher Mediclean solution with warm potable tap water (less than 40° C) to form a 2% solution.
   - Create a homogenous solution by agitating the mixture.
2. Wash and soak the part(s) in the mild detergent solution for a minimum of 30 minutes in a clean soaking tray at temperatures up to a maximum of 40° C.
   - Ensure that all the surfaces of the part(s) are submerged and no air bubbles are visible.
   - Gently agitate the parts under solution to remove and dislodge any debris.
   - Use a soft, plastic brush to remove stubborn debris from external surfaces.

CAUTION Do not use a brush, abrasives, sharp tools or any methods that may damage the inside or surface of the parts.

   - Submerge exhalation valve assembly or cart-mounted water trap in solution, and push down on the spring loaded plunger repeatedly.

3. Rinse the part(s) thoroughly for two minutes in cold potable tap water (25° C); then rinse for two minutes with warm potable tap water (40° C).
   - Repeat steps 2 and 3 as necessary until parts are visually clean.
4. Remove the part(s) from solution allowing cavities to drain and dry in room air.
   - Parts must be fully dry before disinfecting, sterilizing, or re-assembling into the ventilator.

- Do not wipe parts surfaces during the drying process.

5. Check the part(s) for deterioration such as deformation or cracking.

Manual disinfection

Hydrogen peroxide

It is recommended that the Sporox II solution be tested according to manufacturer instructions before use.

The following parts can be disinfected manually with the soaking method in hydrogen peroxide (Sporox II):

- Neonatal flow sensor
- Expiratory flow sensor
- Exhalation valve assembly
- D-lite sensor
- Pedi-lite sensor

1. Use the Soaking method to manually clean the part(s).
2. Soak the cleaned part(s) in Sporox II solution for a minimum of 30 minutes at 20° C in a clean soaking tray.
    - Ensure that all the surfaces of the part(s) are submerged and no air bubbles are visible.
    - Submerge the exhalation valve assembly in solution and push down on the spring loaded plunger repeatedly.
3. Rinse the part(s) thoroughly for two minutes in cold potable tap water (25° C); flush all surfaces. Rinse all surfaces for two minutes with sterile or potable tap water (40° C); flush all surfaces. Finish rinsing with a 70% isopropyl solution to aid in drying.
4. Remove the part(s) from solution allowing cavities to drain and dry in room air.
    - Do not wipe the parts during the drying process.
5. Check the part(s) for deterioration such as deformation or cracking.

Ortho-phthaldehyde

It is recommended that the Cidex OPA solution be tested according to manufacturer's instructions before use.

The following parts can be disinfected manually with the soaking method in ortho-phthaldehyde solution (Cidex OPA):

- Neonatal flow sensor
- Expiratory flow sensor
- Exhalation valve assembly
- D-lite sensor
- Pedi-lite sensor

1. Use the Soaking method to manually clean the part(s).
2. Soak the cleaned part(s) in Cidex OPA solution for a minimum of 12 minutes at 20° C in a clean soaking tray.
    - Ensure that all the surfaces of the part(s) are submerged and no air bubbles are visible.
    - Submerge the exhalation valve assembly in solution and push down on the spring loaded plunger repeatedly.
3. Thoroughly rinse the part(s) by completely immersing them in at least 2 gallons of sterile or potable water for a minimum of 1 minute. Finish rinsing using a 70% isopropyl alcohol solution.
4. Repeat step 3 two times.
5. Remove the part(s) from solution allowing cavities to drain and dry in room air.
    - Do not wipe the parts during the drying process.
6. Check the part(s) for deterioration such as deformation or cracking.

Automated cleaning

WARNING Use only qualified and validated equipment for automated cleaning of components to ensure proper temperatures are reached.

CAUTION Do not use an automated washer with the neonatal flow sensor and expiratory flow sensor.

The following parts can be cleaned automatically with Prolystica Ultra Concentrate Neutral detergent (active ingredient(s): Disodium ethylhexliminod ipropionate, Triethanolamine, Sodium tolyltriazole).

- Exhalation valve assembly
- Cart-mounted water trap and tubing
- D-lite sensor
- Pedi-lite sensor

1. Place the components in the washer tray and load into an automatic washer. Use Prolystica Ultra Concentrate Neutral Detergent as the cleaning agent, dispensed at 0.2 ml per liter of water.
2. Follow the automated washer operation procedure.
    - Prewash I with cold tap water; Set Hold time to 4 minutes.
    - Empty/drain water.
    - Prewash II with cold tap water; Set Hold time to 4 minutes.
    - Empty/drain water.
    - Clean with warm water for 4 minutes at 45° C.
    - Empty/drain water.
    - Rinse for 5 minutes.
    - Rinse an additional 5 minutes.
    - Set the thermal disinfection for 10 minutes at 90° C (A0=600 s).
    - Empty/drain water.
    - Dry for 25 minutes with hot air at 110° C. (If components are not dry after completion of the automatic washing program, they should be left to dry in open air).
3. After the completion of the wash cycle, unload the parts from the washer.
4. Allow the parts to cool in room air.
    - Do not wipe the parts during the drying process.
5. After the parts have completely cooled and dried, check the parts for deterioration such as deformation or cracking.

Sterilization

WARNING Use only qualified and validated equipment for sterilization of components to ensure proper temperatures for sterilization are reached.

Autoclave

The following parts can be sterilized automatically with an autoclave machine:

- Neonatal flow sensor
- Expiratory flow sensor
- Exhalation valve assembly
- Cart-mounted water trap and tubing
- D-lite sensor
- Pedi-lite sensor

1. Use the manual Soaking method or the Automated method (as applicable) to clean the parts.
2. Place the parts in a legally marketed sterilization pouch.
3. Load the pouches into the autoclave machine.
4. Follow the autoclave machine's instructions for use to program it with the following settings:

Temperature	Time	Dry Time
132° C	4 minutes	20 minutes
134° C	3 minutes	20 minutes

5. After the completion of the sterilization cycle, unload the parts.
6. Allow the parts to cool in room air inside the sterilization pouch.
7. Store the parts in the sterilization pouch until they are ready to use.
8. Prior to use, check the parts for deterioration such as deformation or cracking.

Aerogen Pro Nebulizer

The following cleaning, disinfection, and sterilization instructions are according to Aerogen, the manufacturer of the Aerogen Pro Nebulizer. Follow the manufacturer's instructions for processing.

Component replacement schedule - nebulizer

Component	Minimum Frequency	Reprocessing Cycles
Aerogen Pro nebulizer and T adapters	12 months	26

Disassemble for processing - nebulizer

Follow these instructions to disassemble the nebulizer before processing.

1. Remove the nebulizer from the T-adapter.
2. Firmly insert a plug into the T-adapter.
3. Disconnect the cable from the nebulizer.
4. Remove the filler cap from the nebulizer.

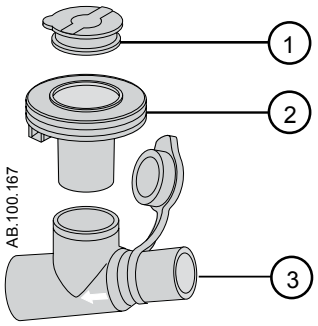


Figure 12-7 • Aerogen Pro nebulizer

1. Filler cap
2. Nebulizer
3. T-adapter

5. Before re-assembling or using the nebulizer, do the following:
   - Check for visible cracks, discoloration, or other degradation
   - Check for leaks before use
   - Replace any worn components

- Perform System Check

Note Follow the instruction for "*Assembling the nebulizer*" in "*Setup and connections*" to reassemble the nebulizer after reprocessing.

Manual cleaning - nebulizer

This section includes cleaning of the nebulizer unit, T-pieces, and adapters.

CAUTION Do not use abrasive or sharp tools to clean the nebulizer unit.

1. Make sure there is no medication remaining in the device.
2. Remove the nebulizer unit from the T-piece and then remove filler cap from the nebulizer unit.
3. Clean all parts with warm potable water (40° C) and mild liquid detergent in accordance with current hospital protocols.
4. Rinse parts with sterile water.
5. Shake excess water from parts and allow parts to fully air dry.

Manual disinfection - nebulizer

This section includes cleaning of the nebulizer unit, T-pieces, and neonate adapters.

Note Aerogen approves the following disinfection solutions for use with its Aerogen Pro Nebulization System regarding material compatibility . With respect to microbiological effectiveness, please ask the manufacturer. Refer to the product labeling for specific instructions regarding activation, safe use, and disposal of these solutions.

- Isopropyl (70%)
- CIDEX
- NU-CIDEX
- CIDEX OPA
- Hexanios G+R

CAUTION Do not use abrasive or sharp tools to clean the nebulizer unit.

1. Make sure there is no medication remaining in the device.
2. Remove the nebulizer unit from the T-piece and then remove filler cap from the nebulizer unit.
3. Clean all parts with warm potable water (40°C) and mild liquid detergent in accordance with current hospital protocols.

4. Completely immerse parts in appropriate disinfecting agent in accordance with current hospital protocols and disinfectant agent manufacturer guidelines.
5. Shake excess water from parts and allow parts to fully air dry.

Automatic cleaning and disinfection

The Aerogen Pro Nebulizer System has been validated with the Automated Washing Cycles One and Two.

WARNING Use only qualified and validated equipment for sterilization of nebulizer components to ensure proper temperatures for sterilization are reached.

Automated Cycle One

- Detergent: Liquid alkaline cleaner (diluted according to manufacturer's instructions)
- Water quality: Mains water
- Method:

1. Load the components in the automated washer.
2. Pre-rinse the components for 3 minutes.
3. Clean the components with liquid alkaline cleaner at 55° C (131° F) for 10 minutes.
4. Rinse for 1 minute.
5. Rinse using thermal disinfection cycle at 93° C (199.4° F) for 10 minutes.

Automated Cycle Two

- Detergent: Cycle Two was validated without the use of detergent
- Water quality: Mains water
- Method:

1. Load the components in the automated washer.
2. Wash components at 91° C (195.8° F) for 10 minutes.
3. Drain the machine for 40 seconds.
4. Rinse at 90° C (194° F) for 1 minute.
5. Drain the machine for 40 seconds.
6. Rinse at 90° C (194° F) for 1 minute.
7. Drain the machine for 40 seconds.
8. Dry at 90° C (194° F) for 15 minutes.

Sterilization - nebulizer

WARNING Use only qualified and validated equipment for sterilization of nebulizer components to ensure proper temperatures for sterilization are reached.

1. Disassemble nebulizer and components.
2. Remove the filler cap from the nebulizer unit.
3. Clean all parts with warm water (40° C) and mild liquid detergent in accordance with current hospital protocols. Rinse thoroughly and air dry.
4. Check for cracks or damage and replace if any defects are visible.
5. Place the disassembled components into appropriate sterilization wrapping.

CAUTION Do not reassemble parts prior to autoclaving.

Sterilize components; Steam sterilization can be performed using the following three methods:

- I: Autoclave wrapped parts using steam sterilization pre-vacuum cycle, a minimum of 134° C (270-275° F) for 3.5 minutes with drying cycle (134° C wrapped cycle).
- II: Autoclave wrapped parts using steam sterilization pre-vacuum cycle, a minimum of 121° C (250° F) for 20 minutes with drying cycle (121° C wrapped cycle).
- III: Autoclave wrapped parts using steam sterilization pre-vacuum cycle, a minimum of 134° C (270° F) for 20 minutes with drying cycle (sometimes referred to as “Prion cycle”).

Note Sterilization using the long autoclave cycle (III above), may cause some areas of the nebulizer to become discolored. This is not indicative of the performance of the nebulizer unit. To sterilize with hydrogen peroxide gas plasma, place wrapped parts in STERRAD System and use the long cycle.

CAUTION Refer to the product labeling for the STERRAD 100S Sterilization System for specific instructions regarding its proper operation.

6. Store the parts in the sterilization wrapping until they are ready to use.

13 Specifications

In this section

Overview

This section contains general ventilator specification information.

- Gas volumes and flows delivered by the ventilator to the patient along with ventilator leakage measurements are expressed at BTPS (Body Temperature Pressure Saturated). All other gas volumes, flows and leakage measurements are expressed at STPD (Standard Pressure Temperature Dry).
- The measurement uncertainty for each disclosed tolerance is included within the range of the specification.
- Unless stated otherwise, measured data is available 60 seconds after startup is initiated.

Physical specifications

All physical specifications of the ventilator are approximate and can change without notice.

The following physical specifications are for the CARESCAPE R860 with a cart.

Height (display up)	152 cm
Height (display down)	127 cm
Width	53 cm
Depth	81 cm
Weight without a compressor	78 kg (171 lbs) +/-10%
Weight with a compressor	107 kg (235 lbs) +/-10%

WARNING The ventilator is heavy. Use caution when lifting.

The following physical specifications are for the CARESCAPE R860 without a cart.

Height (display up)	74 cm
Height (display down)	49 cm
Width	38 cm
Depth	36 cm
Weight	31 kg (68 lbs) +/-10%

Alarm sound pressure

Measurements of Volume of Auditory Alarm Signals (dB)			
Alarm Priority	**Volume Setting**		
	1	**3**	**5**
Low	61	69	77
Medium	61	69	77
High	62	69	77
High Alert	77	77	77
Note: High Alert is always set at the maximum setting level.			

Environmental specifications

The following are environmental specifications for the CARESCAPE R860 ventilator.

	Thermal	**Humidity**	**Barometric Pressure**
Operating range	10° to 40° C	15 to 95% RH, non-condensing	525 to 800 mmHg
Storage range	-20° to 60° C	15% RH (-20°C) to 95% RH (50°C) 15% RH (-20°C) to 75% RH (60°C) Non-condensing	375 to 800 mmHg

	Sound Pressure	**Sound Power**
Ventilator without compressor	Less than or equal to 59 dBA when measured in accordance with ISO 3744.	Less than or equal to 63 dBA when measured in accordance with ISO 3744.
Ventilator with compressor	Less than or equal to 59 dBA when measured in accordance with ISO 3744.	Less than or equal to 63 dBA when measured in accordance with ISO 3744.

Pneumatic specifications

WARNING This ventilator is a high flow device and should only be connected to a pipeline installation that allows for the indicated required flow at the terminal outlets, in order to avoid exceeding the pipeline flow capabilities and to minimize the risk that the ventilator interferes with adjacent equipment operation.

The following are the pneumatic specifications for the CARESCAPE R860 ventilator:

Supply gas*	**Medical air and oxygen**
Supply pressure – maximum	6.5 bar, 94 psi, 650 kPa
Supply pressure – minimum	2.4 bar, 35 psi, 240 kPa
Supply gas flow – peak All values have an additional +/- 5% tolerance.	• 208 Sl/min, two supply gases (adult) • 160 Sl/min, single supply gas (adult) • 100 Sl/min (pediatric) • 30 Sl/min (neonatal)
Maximum limited pressure	125 cmH2O
Internal compliance	0.229 - 0.425 ml/cmH2O
Maximum working pressure range	7 to 100 cmH2O
Maximum transient input flow averaged for 3 s for each gas at 280 kPa	<90 lpm
10 s average input flow for each gas at 280 kPa	<90 lpm
*Refer to the CARESCAPE R860 Technical Reference Manual for the recommended Medical-grade air specifications.	

The ventilator cannot produce negative pressure during the expiratory phase.

Electrical specifications

WARNING To avoid the risk of electrical shock, the ventilator must only be connected to main power with protective earth (ground). Use the battery if the integrity of the protective earth (ground) conductor is in doubt.

Supply voltage	85 to 132 Vac 190 to 264 Vac	47 to 63 Hz
Electrical power consumption	less than 200 VA	
Fuses – type and rating	Mini blade	15 A
	5x20 mm time delayed	2 A, 250 V

Battery information

The ventilator can operate on battery power:

- A minimum of 30 minutes when the batteries are maintained in accordance to the battery performance procedure. See "*Testing battery performance*" for more information.
- Up to 85 minutes when the batteries are new and fully charged.

WARNING Do a battery test every 6 to 12 months to make sure battery capacity is at least 30 minutes. Replace the batteries when necessary.

Important The ventilator is not intended for use during the transport of patients between facilities or emergency transport. The batteries are intended for use as backup power in case of a main power failure. Transition to battery is done automatically by the system.

The ventilator uses two internal 12 Vdc sealed lead-acid batteries, the Enersys NP4-12 or NP5-12 to provide backup power when main power is not available.

Ventilator Battery	
Ampere-hour rating	4 Ah or greater
Voltage requirement	12 Vdc
Current requirement	7.5 A
Recharge time	Eight hours (full discharge to full charge)
Estimated life	Four years; 250 full discharge cycles

Actual operating time on battery power depends on the ventilator settings, battery age, and level of battery charge. The battery

capacity time is approximate. To maximize battery life, maintain a full charge and minimize the number of discharges.

When the ventilator is on battery power, the battery icon shows at the bottom right-hand side of the display. See "*Battery status*" in the "*Specifications*" section for more information.

Battery status

The following icons indicate what type of power the ventilator is operating on. These icons show in the bottom right-hand side of the display.

		
Main power	Battery power	No battery available or battery error

The battery icon shows when the ventilator is not connected to the main power. The color of the battery icon shows the approximate amount of time remaining on battery power.

Select the battery icon to see a status bar of the approximate battery charge. The color of the status bar shows the approximate amount of time remaining on battery power.

Use the following table to define the color of the battery icon and the status bar:

Color	**Time remaining on battery power**
Green	More than 20 minutes
Yellow	Between 10 and 20 minutes
Red	Less than 10 minutes

- The “No battery” icon shows when there is a battery error or battery power is not available.

  The Battery in use alarm becomes active when the ventilator changes from main power to battery power. If the ventilator continues to operate on battery power, it alarms to signal that approximately 20, 10, 5, and 1 minute of battery power is available. See "*List of alarms*" or "*List of alarms – Neonatal*" in the Alarms and Troubleshooting section for more information on battery alarms.

Low internal battery alarm test

Note Depending on the charge status of the batteries being tested, it is possible that some alarms may be skipped.

1. Disconnect the power cord from the main power supply.
2. Set the ventilator mode to ***A/C VC***.
3. Select ***START VENTILATION*** > ***Continue***.
4. Allow ventilation to continue until the Low Internal Battery - 20 min alarm sounds.
   - Verify the medium priority Low Internal Battery - 20 min alarm sounds.
   - Verify the Low Internal Battery - 20 min alarm shows with a yellow background in the alarm bar.
   - Verify the display unit alarm light flashes yellow.
5. Allow ventilation to continue until the Low Internal Battery - 10 min sounds.
   - Verify the high priority Low Internal Battery - 10 min alarm sounds.
   - Verify the Low Internal Battery - 10 min alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
   - Verify the Low Internal Battery - 20 min alarm no longer shows in the alarm bar.
6. Allow ventilation to continue until the Low Internal Battery - 5 min sounds.
   - Verify the high priority Low Internal Battery - 5 min alarm sounds.
   - Verify the Low Internal Battery - 5 min alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
   - Verify the Low Internal Battery - 10 min alarm no longer shows in the alarm bar.
7. Allow the ventilation to continue until the Low Internal Battery - 1 min sounds.
   - Verify the high priority Low Internal Battery - 1 min alarm sounds
   - Verify the Low Internal Battery - 1 min alarm shows with a red background in the alarm bar.
   - Verify the display unit alarm light flashes red.
   - Verify the Low Internal Battery - 5 min alarm no longer shows in the alarm bar.

Important After this test is completed, connect the ventilator to the main power supply for eight hours before it is used on a patient to make sure the batteries are fully charged.

Testing battery performance

WARNING Perform the battery test every 6 to 12 months to make sure battery capacity is at least 30 minutes. Replace the batteries when necessary. See "*User maintenance*" for more information.

Only use batteries recommended by GE Healthcare. If the batteries need to be replaced, contact an authorized service representative to install them. Dispose of used batteries in accordance with local regulatory requirements in effect at the place of disposal.

Important If the ventilator is used more than once a month on battery power, such as to transport a patient within the facility, it is recommended that the battery performance test be completed every six months.

1. Connect the ventilator to the main power source for eight hours to make sure the batteries are fully charged.

   To see battery status, select ***Menu*** >***System***.
2. Connect a patient circuit and test lung to the ventilator.
3. Set the following parameters:

   - Mode: A/C PC
   - Rate: 12 /min
   - I:E: 1:2
   - Pinsp: 20 cmH2O
   - PEEP: 5 cmH2O
   - Bias Flow: 4 l/min
4. Start ventilation.
5. Disconnect the power cord from the main power source.

   - If the batteries continue to power the ventilator for 45 minutes or longer, the batteries have sufficient charge.
   - If the batteries do not continue to power the ventilator for 45 minutes, contact an authorized service representative and have the batteries replaced.

Important After this test is completed, connect the ventilator to the main power source for eight hours before it is used on a patient to make sure the batteries are fully charged.

Equipotential stud

The equipotential stud is used to connect the ventilator system to an equipotential grounding system by attaching a potential equalization conductor. Equipotential grounding is used in some hospitals to enhance electrical safety in critical care areas by attempting to keep the conductive surfaces of all equipment in the patient care area at the same ground potential, thereby minimizing unwanted current flow. Refer to IEC 60601-1:2005 for ME Systems.

Ventilation specifications

Ventilation settings

This table shows the ventilation settings with the available range and resolution for each setting when the patient type is Adult. For neonatal patient type, see "*Neonatal ventilation settings*" in the "*Neonatal specifications and settings*" section for more information.

Setting	Range	Resolution
Backup Pinsp (NIV)	1 to 98 cmH2O (1 to 30 cmH2O)	1 cmH2O
Backup Tinsp (NIV)	0.25 to 15 s(0.25 to 5 s)	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Bias Flow (NIV)	2 to 10 l/min (8 to 20 l/min)	0.5 l/min
Exp Trigger	5 to 80%	5%
FiO2	21 to 100%	1%
Flow	2 to 160 l/min	2 to 40 by 1 l/min 40 to 160 by 5 l/min
I:E	1:9 to 4:1	0.1
Insp Pause	0 to 75%	5%
Insp Trigger	-10 to -0.25 cmH2O	-10 to -3 by 0.5 cmH2O -3 to -0.25 by 0.25 cmH2O
	1 to 9 l/min	1 to 3 by 0.1 l/min 3 to 9 by 0.5 l/min
Minimum Rate (NIV)	Off, 1 to 60 /min (Off, 1 to 40 /min)	1 /min
PEEP (NIV)	Off, 1 to 50 cmH2O (2 to 20 cmH2O)	1 cmH2O
Phigh	1 to 98 cmH2O	1 cmH2O
Pinsp	1 to 98 cmH2O	1 cmH2O
Plimit	7 to 100 cmH2O	1 cmH2O
Plow	Off, 1 to 50 cmH2O	1 cmH2O
Pmax (NIV)	7 to 100 cmH2O (9 to 100 cmH2O)	1 cmH2O
Pmin	2 to 20 cmH2O	1 cmH2O
PS (NIV)	0 to 60 cmH2O (0 to 30 cmH2O)	1 cmH2O
PS Rise Time	0 to 500 ms	50 ms

Setting	Range	Resolution
Rate (BiLevel-VG and SIMV only)[1]	3 to 120 /min (1 to 60 /min)	1 /min
Rise Time	0 to 500 ms	50 ms
Thigh	0.25 to 15 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Tinsp	0.25 to 15 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Tlow	0.25 to 18 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 18 by 0.25 s
Tpause	0 to 11 s	0 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 11 by 0.25 s
Tsupp	0.25 to 4 s	0.25 to 1.0 by 0.05 s 1 to 4 by 0.1 s
VT	100 to 2000 ml	100 to 300 by 5 ml 300 to 1000 by 25 ml 1000 to 2000 by 50 ml
Weight	20 to 200 kg	20 to 100 by 1 kg 100 to 200 by 2 kg
Height	15 to 250 cm	1 cm
Tube Diameter	5 to 10 mm	0.5 mm
[1]The range for Rate in backup for these modes is 3 to 60 /min		

This table shows the ventilation settings with the available range and resolution for each setting when the patient type is Pediatric.

Setting	Range	Resolution
Backup Pinsp (NIV)	1 to 98 cmH2O (1 to 30 cmH2O)	1 cmH2O
Backup Tinsp (NIV)	0.25 to 15 s (0.25 to 5 s)	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Bias Flow (NIV)	2 to 10 l/min (8 to 20 l/min)	0.5 l/min
Exp Trigger	5 to 80%	5%
FiO2	21 to 100%	1%
Flow	2 to 72 l/min	2 to 40 by 1 l/min 40 to 72 by 2 l/min
I:E	1:9 to 4:1	0.1
Insp Pause	0 to 75%	5%

Setting	Range	Resolution
Insp Trigger	-10 to -0.25 cmH2O	-10 to -3 by 0.5 cmH2O -3 to -0.25 by 0.25 cmH2O
	1 to 9 l/min	1 to 3 by 0.1 l/min 3 to 9 by 0.5 l/min
Minimum Rate (NIV)	Off, 1 to 60 /min (Off, 1 to 40 /min)	1 /min
PEEP (NIV)	Off, 1 to 50 cmH2O (2 to 20 cmH2O)	1 cmH2O
Phigh	1 to 98 cmH2O	1 cmH2O
Pinsp	1 to 98 cmH2O	1 cmH2O
Plimit	7 to 100 cmH2O	1 cmH2O
Plow	Off, 1 to 50 cmH2O	1 cmH2O
Pmax (NIV)	7 to 100 cmH2O (9 to 100 cmH2O)	1 cmH2O
Pmin	2 to 20 cmH2O	1 cmH2O
PS (NIV)	0 to 60 cmH2O (0 to 30 cmH2O)	1 cmH2O
PS Rise Time	0 to 500 ms	50 ms
Rate (SIMV and BiLevel-VG only)[1]	3 to 120 /min (1 to 60 /min)	1 /min
Rise Time	0 to 500 ms	50 ms
Thigh	0.25 to 15 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Tinsp	0.25 to 15 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 15 by 0.25 s
Tlow	0.25 to 18 s	0.25 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 18 by 0.25 s
Tpause	0 to 11 s	0 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 11 by 0.25 s
Tsupp	0.25 to 1.5 s	0.25 to 1.0 by 0.05 s 1 to 1.5 by 0.1 s
VT	20 to 300 ml	20 to 50 by 0.5 ml 50 to 100 by 1 ml 100 to 300 by 5 ml
Weight	4 to 60 kg	4 to 7 by 0.1 kg 7 to 15 by 0.5 kg 15 to 60 by 1 kg
Height	15 to 250 cm	1 cm
Tube Diameter	5 to 10 mm	0.5 mm

Setting	Range	Resolution
[1]The range for Rate in backup for these modes is 3 to 60 /min		

Alarm settings

This table shows the range for each parameter alarm and the factory default setting.

Note The actual default may be different from the factory default if the setting has been changed by the Super User.

Alarm	Range	Resolution
Apnea Time (NIV)	5 to 60 s (Off, 5 to 60 s)	5 to 20 by 1 s 20 to 60 by 5 s
Leak Limit	Off, 10 to 90%	5%
Ppeak Low	1 to 97 cmH2O	1 cmH2O
Ppeak High (NIV)	7 to 100 cmH2O (9 to 100 cmH2O)	1 cmH2O
MVexp Low (NIV)	0.01 to 40 l/min (Off, 0.01 to 40 l/min)	0.01 to 1.0 by 0.01 l/min 1.0 to 10 by 0.1 l/min 10 to 40 by 1 l/min
MVexp High	0.02 to 99 l/min	0.02 to 1.0 by 0.01 l/min 1.0 to 10 by 0.1 l/min 10 to 99 by 1 l/min
VTexp Low	Off, 1 to 1950 ml	1.0 to 20 by 0.5 ml 20 to 100 by 1 ml 100 to 350 by 5 ml 350 to 1000 by 25 ml 1000 to 1950 by 50 ml
VTexp High	Off, 3 to 2000 ml	3.0 to 20 by 0.5 ml 20 to 100 by 1 ml 100 to 350 by 5 ml 350 to 1000 by 25 ml 1000 to 2000 by 50 ml
RR Low	Off, 1 to 99 /min	1 /min
RR High	Off, 2 to 150 /min	1 /min
EtCO2 Low	Off, 0.1 to 14.9%	0.1%
EtCO2 High	Off, 0.2 to 15%	0.1%
EtO2 Low	Off, 10 to 99%	1%
EtO2 High	Off, 11 to 100%	1%
FiO2 Low	18 to 99%	1%

Alarm	Range	Resolution
FiO2 High	Off, 24 to 100%	1%
PEEPe Low	Off, 1 to 20 cmH2O	1 cmH2O
PEEPe High	Off, 5 to 50 cmH2O	1 cmH2O
PEEPi High	Off, 1 to 20 cmH2O	1 cmH2O
Paux	12 to 100 cmH2O	1 cmH2O
Patient Effort (NIV only)	40 to 120 s	10 s
Tdisconnect (NIV only)	0 to 60 s	10 s

Alarm Option	Range	Factory Default
Alarm Light Brightness	1 to 5	4
Alarm Volume	1 to 5	3
High Alert Audio	Off, 0 to 30 s	30 s
Show Alarm Limits	Set or clear	Set

Waveform specifications

The waveform specifications table shows the type of filtering used when showing waveforms on the ventilator display.

Waveform	Filtering Technique
Paw	40 ms low pass filter
Flow	40 ms low pass filter
Volume	40 ms low pass filter
CO2	Less than 400 ms rise time
O2	Less than 400 ms rise time

Nebulizer

The Aerogen Professional Nebulizer System is a portable medical device for multiple patient use that is intended to aerosolize physician-prescribed solution and suspensions for inhalation to patients on and off ventilation or other positive pressure breathing assistance.

The following specification are according to Aerogen, the manufacturer of the Aerogen Pro and Aerogen Solo nebulizers.

Note The manufacturer does not recommend a minimum fill volume, but specifications which are tested with a minimum volume, use a volume of 2 ml.

Aerogen Pro	
Maximum capacity	10 ml of liquid
Noise level	Less than 35 dB at 1 m distance
Temperature increase above ambient during normal use	Not more than 10° C (18° F)
Flow rate	Greater than 0.2 ml/min (average: 0.4 ml/min)
Mass Median Aerodynamic Diameter (MMAD)	• Average tested with the Anderson Cascade Impactor (spec range 1-5 µm) : 3.1 µm • Average tested with the Marple 298 Cascade Impactor (spec range 1.5-6.2 µm) : 3.9 µm
Aerosol output rate (starting dose of 2 ml)	0.24 ml/min
Aerosol output (starting dose of 2 ml)	1.08 ml
Residual volume (3 ml dose)	Less than 0.1 ml
Particle distribution (representative for Albuterol)	• 20% greater than 5 µm • 35% 2 to 5 µm • 45% less than 2 µm
Respirable Fraction Performance (% < 5 µm)	80%
Life of Product	The life of the Aerogen Pro nebulizer and components have been validated for use by the manufacturer Aerogen for 730 doses and 26 autoclave treatments based on a typical one year usage profile of four treatments per day and one sterilization per week, where the device is assumed to be in service for 50% of the time. Note that any use in excess of this may result in reduced life of the nebulizer.

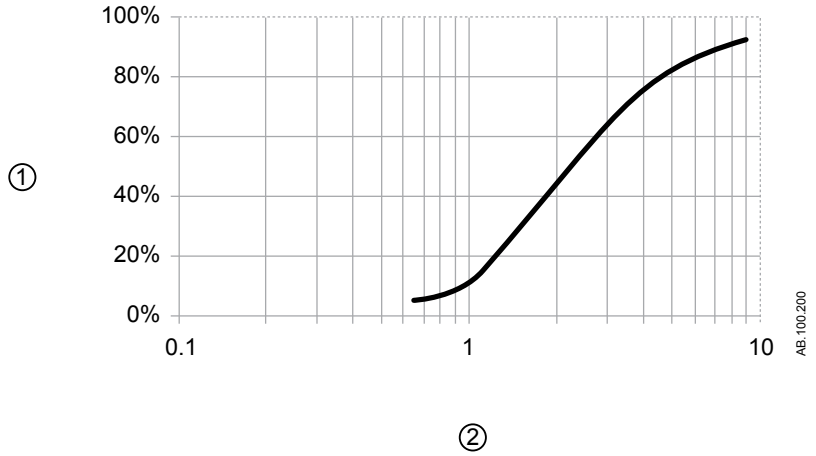


Figure 13-1 • Representative particle size distribution for Albuterol as per EN 13544-1 for use with the Aerogen Pro nebulizer

1. Cumulative undersize (%)
2. Particle size (microns)

Aerogen Solo	
Maximum capacity	6 ml of liquid
Noise level	Less than 35 dB at 1 m distance
Temperature increase above ambient during normal use	Not more than 10° C (18° F)
Flow rate	Greater than 0.2 ml/min (average: 0.38 ml/min)
Mass Median Aerodynamic Diameter (MMAD)	• Average tested with the Anderson Cascade Impactor (spec range 1-5 µm) : 3.1 µm • Average tested with the Marple 298 Cascade Impactor (spec range 1.5-6.2 µm) : 3.9 µm
Aerosol output rate (starting dose of 2 ml)	0.30 ml/min
Aerosol output (starting dose of 2 ml)	1.02 ml
Residual volume (3 ml dose)	Less than 0.1 ml
Particle distribution (representative for Albuterol)	• 35% greater than 5 µm • 30% 2 to 5 µm • 35% less than 2 µm
Respirable Fraction Performance (% < 5 µm)	65%

Aerogen Solo	
Life of Product	• The life of the Aerogen Solo nebulizer and components have been validated for use by the manufacturer Aerogen for intermittent use for a maximum of 28 days based upon a typical usage profile of 4 treatments per day • For continuous use the life of the Aerogen Solo nebulizer unit and the continuous nebulization tube set have been validated for use for a maximum of 7 days. The user should note that use in excess of these periods is not validated by Aerogen.

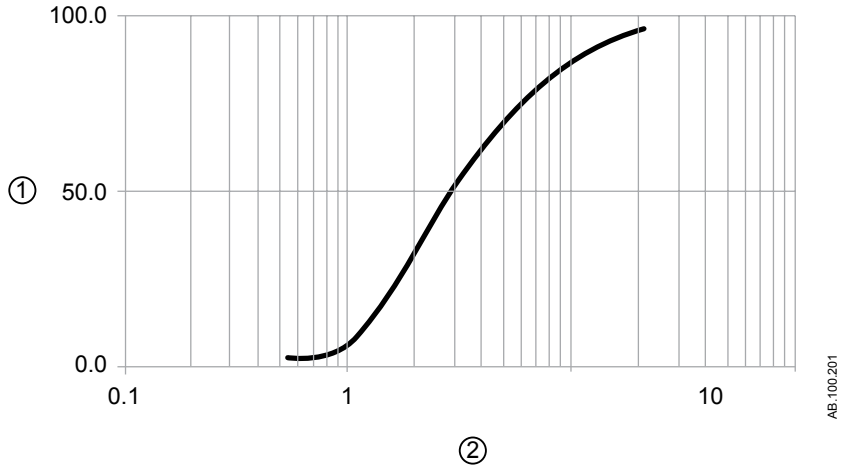


Figure 13-2 • Representative particle size distribution for Albuterol as per EN 13544-1 for use with the Aerogen Solo nebulizer

1. Cumulative mass (%)
2. Aerodynamic size (microns)

Ventilation delivery specifications

Ventilation delivery and monitoring accuracy is maintained under the following conditions:

- System Checks performed when the ventilator power is turned on are performed at ventilation conditions and after a 30 minute warm-up period.
- Completed and passed all System Check tests.
- Operating at steady state (for example, after stabilization following a patient or settings change).
- Operating at ISO 80601-2-12 patient conditions.

- Operating with a humidifier or HME according to the Circuit Setup menu selection.
    - Operating with a humidifier, a heated breathing circuit with a heated expiratory limb, and an exhalation valve heater when the Humidifier setting is selected (all patient types).
    - Operating with an HME, a non-heated breathing circuit, and without an exhalation valve heater when the HME setting is selected (adult and pediatric patient types only with a VT >200 ml).
- Operating with recommended circuit configurations and accessories.

Tidal volume delivery

Accuracy	± 10% of setting or ± 5 ml, whichever is greater
1σ repeatability	± 2% or ± 3 ml, whichever is greater
Change response time 90% full scale (FS)	less than 6 breaths

Inspired pressure control

The values shown only apply to invasive pressure control ventilation modes.

Accuracy	± 2 cmH2O
1σ repeatability	± 1 cmH2O

PEEP control

The values shown only apply to invasive pressure control ventilation modes.

Accuracy	± 2 cmH2O
1σ repeatability	± 1 cmH2O

Oxygen-air mixture accuracy

Mixture accuracy is measured at one meter from the inspiratory port.

Accuracy	± 2.95% volume/volume of setting
1σ repeatability	± 1% volume/volume of setting
Mixture deviation greater than 75 ms within inspiratory phase of breath	± 5% volume/volume at steady state level
21% to 90% FiO2 response time at tidal volumes of 500 ml, 150 ml, and 30 ml	< 6 breaths or 30 seconds, whichever is longer

Ventilator breathing system compliance and resistance

The values in this table represent the ventilator breathing system compliance and reistance ranges for recommended circuit configurations.

Ventilator Breathing System Compliance (ml/cmH2O)		
	Minimum	Maximum
Adult	1.977	2.411
Pediatric	0.835	2.089

***Ventilator Breathing System Configuration Limits**	
Value	Adult and Pediatric
Total Resistance*	48 cmH2O/l/s
Inspiratory Resistance*	38.4 cmH2O/l/s
Compliance	< 8 ml/cmH2O
*Inspiratory resistance must be limited to 80% of the total VBS resistance.	

***Ventilator Breathing System Resistance (cmH2O/l/s)**		
Adult (60 lpm)		
Inspiratory	3.00	5.93
Expiratory	3.04	6.54
Pediatric (30 lpm)		
Inspiratory	1.40	31.51
Expiratory	1.38	25.55
*Each patient type was tested at different flow rates.		

Filter specifications

Inspiratory Safety Guard Efficiency	
Efficiency	> 99.94% at a particle count at a size of 0.3 microns
Bacterial Efficiency	> 99.9999%
Viral Efficiency	> 99.9999%
Resistance to flow	< 1.5 cmH2O at 30.00+0.15 l /min< 3.6 cmH2O at 60.00+0.15 l/min
Filter weight	< 60 g
Internal dead space	< 85 ml

Expiratory Uni-Filter	
Bacterial Efficiency	> 99.98%
Viral Efficiency	> 99.9%
Resistance to flow	0.4 cmH2O at 30 l/min 0.8 cmH2O at 60 l/min
Filter weight	27 g
Internal dead space	60 ml

Ventilation monitoring specifications

The following specifications are monitoring measurements specific to the ventilator. Measurements with the same range, resolution, filtering technique, and accuracy are grouped together in the table.

Measurements	**Range**	**Resolution**	**Filtering Technique**	**Accuracy**
Ppeak Pmean Pplat PEEPe PEEPi PEEPe + i Paux Peak Paux Mean Paux Min	-20 to 120 cmH2O	1 cmH2O	Value from the last detected breath.	± 2 cmH2O ± (2 cmH2O + 4% of reading) with HME

Measurements	Range	Resolution	Filtering Technique	Accuracy
MVexp MVinsp MVexp spont MVexp mech	0 to 99.9 l/min	0 to 1.0 by 0.01 l/min 1.0 to 99.9 by 0.1 l/min	Running value for the last one minute + one breath.	• ± 10% or 10 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • ±15% or 15 ml with leak compensation on and steady/ stable leak below leak compensation limits • ±20% or 15 ml with pneumatic nebulizer flow compensation On and compensation level set to flow being introduced into the circuit

Measurements	Range	Resolution	Filtering Technique	Accuracy
VTinsp VTexp VTexp spont VTexp mech	5 to 2500 ml for adult and pediatric	5 to 50 by 0.1 ml 50 to 2500 by 1 ml	Value from last detected breath.	• ± 10% or 10 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • ±15% or 15 ml with leak compensation on and steady/ stable leak below leak compensation limits • ±20% or 15 ml with pneumatic nebulizer flow compensation On and compensation level set to flow being introduced into the circuit
RR RRspont RRmech	0 to 120 /min	1 /min	Running value for the last one minute + one breath.	±10% or 1 /min, whichever is greater
C	0.1 to 150 ml/cmH2O	0.1 to 10 by 0.1 ml/cmH2O 10 to 150 by 1 ml/cmH2O	Five breath median filter.	—
Raw	1 to 500 cmH2O/l/s	1 cmH2O/l/s	Five breath median filter.	—
FiO2	10 to 100%	1%	10 s moving average.	± 2.95% volume/ volume of setting, ±(2.5% volume/ volume + 2.5% of gas value) of delivered value, with less than 30 s, 10 to 95% FS response. Drift: less than 0.4% over 24 h.
RSBI	1 to 999 /min/l	1 /min/l	Running value for the last one minute + one breath.	—

Airway module

Gas specifications for E- series modules

E- series airway modules	
Airway humidity	0 to 100% condensing
Sampling delay	2.5 seconds typical with a 3 m sampling line
Sampling flow rate	200 ml/min ±20 ml/min
Total system response time	2.9 seconds typical with a 3 m sampling line, including sampling delay and rise time
Warm-up time	2 minutes for operating with CO2 and O2 30 minutes for full specifications
Respiration rate	4 to 60 breaths /min
Airway pressure	-20 cmH2O to 100 cmH2O

E- series airway modules: Accuracy under different conditions		
Ambient temperature: 10 to 40° C		
Ambient pressure: 500 to 800 mmHg, ±50 mmHg of calibration		
Ambient humidity: 10 to 98% RH, ±20% RH of calibration		
Automatic compensation for ambient pressure		
Full module accuracy for respiration rate of 4 to 35 breaths/min		
	During warm-up 10 to 30 minutes, under normal conditions	During warm-up 2 to 10 minutes, under normal conditions
CO2	± (0.3 vol% + 4% of reading)	± (0.4 vol% + 7% of reading)
O2	± (2 vol% + 2% of reading)	± (3 vol% + 3% of reading)

E- series airway modules: Gas exchange specifications	
Applicable when a 2 meter gas sampling line is used, and a wye-piece with a physical dead space less than 8 ml.	
Applicable if the FiO2 level delivered to the patient is varying by less than 0.2% at the measurement point during the inspiratory cycle.	
VO2 and VCO2	• Measurement range: 20 to 1000 ml/min • Accuracy: (valid for respiration rates of 4 to 35/min) • FiO2 less than 65 ± 10% or 10 ml • FiO2 greater than or equal to 65%, and less than 85% ± 15% or 15 ml

Gas specifications for CARESCAPE modules

CARESCAPE airway modules	
Airway humidity	0 to 100% condensing
Sampling delay	3.0 seconds typical with a 3 m sampling line
Sampling flow rate	120 ml/min ± 20 ml/min
Total system response time	Less than 3.8 seconds with a 3 m sampling line
Warm-up time	1 minute for operating with CO2 and O2
Respiration rate	4 to 100 breaths /min
Airway pressure	-20 cmH2O to 100 cmH2O

CARESCAPE airway modules: Accuracy under different conditions			
Ambient temperature: 10 to 40° C			
Ambient pressure: 495 to 795 mmHg			
Ambient humidity: 10 to 98% RH, non-condensing			
Automatic compensation for ambient pressure			
Full module accuracy for respiration rate of 4 to 70 breaths/min			
	During stable condition	During warm-up 10 to 20 minutes, under normal conditions	During warm-up 1 to 10 minutes, under normal conditions
CO2	± (0.2 vol% + 2% of reading)	± (0.3 vol% + 4% of reading)	± (0.4 vol% + 7% of reading)
O2	± (1 vol% + 2% of reading)	± (2 vol% + 2% of reading)	± (3 vol% + 3% of reading)

CARESCAPE airway modules: Gas exchange specifications	
Applicable when a 2 meter gas sampling line is used. Excessive dead space and unstable FiO2 may affect the accuracy of the gas exchange measurement.	
VO2 and VCO2	• Measurement range: 20 to 1000 ml/min • Accuracy: valid for respiration rates of 4 to 35/min for D-lite(+) and 8 to 35/min for Pedi-lite(+) • FiO2 less than 65 ± 10% or 10 ml • FiO2 greater than or equal to 65%, and less than 85% ± 15% or 15 ml

E-series typical performance

CO2	• Measurement range: 0 to 15 vol% (0 to 15 kPa, 0 to 113 mmHg) • Measurement rise time: 10% to 90% less than 400 ms typical • Resolution: 0.1% • Accuracy: ± (0.2 vol% + 2% of reading) • Gas cross effects less than 0.2 vol% (O2) • Drift per 6 h operation: < 0.1 vol% • EtCO2 values are updated breath-by-breath
O2	• Measurement range: 0 to 100 vol% • Measurement rise time: 10% to 90% less than 400 ms typical • Resolution: 1% • Accuracy: ± (1 vol% + 2% of reading) • Gas cross effects less than 2 vol% (N2O) • Drift per 6 h operation: < 0.2 vol% • EtO2 and FiO2 values are updated breath-by-breath
VCO2 and VO2	• Measurement range: 20 to 1000 ml/min • Accuracy: (valid for respiration rates of 4 to 35/min) • FiO2 less than 65 ± 10% or 10 ml • FiO2 greater than or equal to 65%, and less than 85% ± 15% or 15 ml • Displayed values are in STPD (OC, 0% RH). Stated specifications also apply to BTPS conditions.
FRC	• Accuracy: ± 20% or 180 ml • Repeatability: ± 10% when conducted under the same settings and conditions
Airway Pressure	• Measurement range: -20 cmH2O +100 cmH2O • Resolution: 1 cmH2O • Accuracy: ± 1 cmH2O • Values calculated from the measured airway pressure data
Respiration Rate	• Breath detection 1 vol% change in CO2 level • Measurement range: 4 to 60 breaths/min • RR value is updated breath-by-breath

Tidal Volume	• The module calculates the volume by integrating the measured gas flow over time. Tidal volumes (VTinsp and VTexp) are obtained as the change of volume during inspiration and expiration. • Measurement range: D-lite(+): 200 to 2000 ml Pedi-lite(+): 15 to 200 ml • Resolution: 5 to 50 by 0.1 ml 50 to 2500 by 1 ml • Accuracy: D-lite(+): ±6% or 30 ml (whichever is greater) Pedi-lite(+): ± (4 ml + 15%)
RQ	0.6 to 1.3, resolution 0.1
Raw	0 to 40 cmH2O/l/s, resolution 1 cmH2O/l/s
Compl	4 to 100 ml/cmH2O (D-lite), 1 to 100 ml/cmH2O (Pedi-lite) Resolution: 1 ml/cmH2O (D-lite), 0.1 ml/cmH2O (Pedi-lite)

CARESCAPE module typical performance

CO2	• Measurement range: 0 to 15 vol% (0 to 15 kPa, 0 to 113 mmHg) • Measurement rise time: less than 260 ms typical • Resolution: 0.1% • Accuracy: ± (0.2 vol% + 2% of reading) • Gas cross effects less than 0.2 vol% (O2) • Drift per 6 h operation: < 0.1 vol% • EtCO2 values are updated breath-by-breath
O2	• Measurement range: 0 to 100 vol% • Measurement rise time: less than 260 ms typical • Resolution: 1% • Accuracy: ± (1 vol% + 2% of reading) • Gas cross effects less than 2 vol% (N2O) • Drift per 6 h operation: < 0.3 vol% • EtO2 and FiO2 values are updated breath-by-breath
Airway Pressure	• Measurement range: -20 cmH2O +100 cmH2O • Resolution: 1 cmH2O • Accuracy: ± 1 cmH2O • Values calculated from the measured airway pressure data

VCO2 and VO2	• Measurement range: 20 to 1000 ml/min • Accuracy: valid for respiration rates of 4 to 35/min for D-lite(+) and 8 to 35/min for Pedi-lite(+) • FiO2 less than 65 ± 10% or 10 ml • FiO2 greater than or equal to 65%, and less than 85% ± 15% or 15 ml • Displayed values are in STPD (OC, 0% RH). Stated specifications also apply to BTPS conditions.
FRC	• Accuracy: ± 20% or 180 ml • Repeatability: ± 10% when conducted under the same settings and conditions
Respiration Rate	• Breath detection 1 vol% change in CO2 level • Measurement range: 4 to 100 breaths/min • RR value is updated breath-by-breath • Accuracy at 4 to 20 breaths/min: ±1 breath/min at 20 to 100 breaths/min: ±5%
RQ	• 0.6 to 1.3, resolution 0.1
Tidal Volume	• The module calculates the volume by integrating the measured gas flow over time. Tidal volumes (VTinsp and VTexp) are obtained as the change of volume during inspiration and expiration. • Measurement range: D-lite(+): 200 to 2000 ml Pedi-lite(+): 15 to 200 ml • Resolution: 5 to 50 by 0.1 ml 50 to 2500 by 1 ml • Accuracy: D-lite(+): ±6% or 30 ml (whichever is greater) Pedi-lite(+): ±(4 ml + 15%)
Raw	0 to 200 cmH2O/l/s, resolution 1 cmH2O/l/s
Compl	4 to 100 ml/cmH2O (D-lite), 1 to 100 ml/cmH2O (Pedi-lite) Resolution: 0.1 ml/cmH2O (D-lite), 0.1 ml/cmH2O (Pedi-lite)

Airway module measurement limitations

- The gas exchange measurement does not function with a leaking endotracheal tube.
- The gas exchange measurement does not function when the ventilator bias flow is greater than 10 l/min.

- For continuous monitoring, use the HME(F) for humidification or use the D-lite+. Condensed water inside the D-lite may distort the volume readings.
- When FiO2 measures greater than 85%, gas exchange values become invalid.
- When respiratory rate measures greater than 35 breaths per minute for D-lite(+) and 50 breaths per minute for Pedi-lite(+), spirometry values become invalid.
- When respiratory rate measures less than 4 or greater than 35 breaths per minute, gas exchange values become invalid.
- For the best measurement results, it is recommended to use a two-meter gas sampling line, a bacterial filter at the expiratory port, and a straight patient wye.
- Airway modules readings should not be relied upon as the primary measurement value during patient transport.
- For best results, a 5 ml (minimum) spacer should be used between the circuit wye and the D-lite(+) or Pedi-lite(+) sensor.
- An elbow should be used between the D-lite(+) or Pedi-lite(+) sensor and the patient.
- Gas leaks may dilute the gas sample from the patient circuit and result in erroneous gas readings.
- Accuracy of the airway module gas readings are dependent upon the conditions under which it is used.

Important The ventilator is not intended for use with anesthetic agents.

Electromagnetic compatibility (EMC)

WARNING Changes or modifications to the ventilator or accessories not expressly approved by the manufacturer could cause the ventilator or other equipment to malfunction due to EMC issues. Contact the manufacturer for assistance. The ventilator is designed and tested to comply with applicable regulations regarding EMC as follows:

- The ventilator should not be used or stored in the presence of strong magnetic fields, such as within an MRI environment.
- Use of portable phones or other radio frequency (RF) emitting equipment, which exceed electromagnetic interference levels specified in "*Guidance and manufacturer's declaration - electromagnetic immunity*", near the ventilator may cause unexpected or adverse operation. Monitor the function of the ventilator when RF emitters are in the vicinity, including RFID readers and interrogators.
- Use of other electrical equipment adjacent to or stacked with the ventilator may cause interference. If adjacent or stacked use is necessary, the ventilator should be observed to verify normal operation in the configuration in which it will be used.

Essential performance

Essential performance may also be found in the CARESCAPE R860 Technical Reference Manual.

The essential performance of the system consists of:

- Delivery of ventilation at the patient-connection port within the alarm limits set by the operator or the generation of an alarm.

The ventilator provides alarms relating to the following areas:

- Oxygen level
- Airway pressure
- Expired volume
- AC Mains failure
- Battery nears depletion
- Gas supply failure
- Gas failure cross flow

Cables and accessories

The CARESCAPE R860 ventilator complies with the Emissions and Immunity sections (6.1 and 6.2) of IEC 60601-1-2:2007 when equipped with the following:

- Main Power cord
- Cart with AC outlet panel assembly
- Power cord jumper from chassis to AC outlet
- EVair Compressor with main power cord
- Display unit with cable
- Module Bay assembly with shielded cable
- Neonatal flow sensor with shielded cable on chassis port 1
- Nebulizer assembly with shielded cable
- Exhalation valve heater assembly with shielded cable on chassis port 3
- Fisher & Paykel MR850 humidifier with heater wire and temperature probe
- Nurse call Isolation cable and shielded db-15 serial cable (maximum length of 2.5 m) on chassis port 4
- Ohmeda Com Isolation cable and shielded db-9 serial cable (maximum length of 1.8 m) on DU ports 5 or 6
- EGAS/CARESCAPE monitoring Modules

WARNING Use of cables, accessories, or transducers other than those specified by GE Healthcare could cause the ventilator to malfunction due to increased emissions or decreased immunity.

Guidance and manufacturer's declaration - electromagnetic emissions

The ventilator is suitable for use in the specified electromagnetic environment. The customer and/or user of the ventilator should make sure that it is used in an electromagnetic environment as described below.

Emissions test	Compliance	Electromagnetic environment guidance
RF emissions CISPR 11	Group 1	The system 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.

Emissions test	Compliance	Electromagnetic environment guidance
RF emissions CISPR 11	Class A	The system is suitable for use in all establishments other than domestic 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	Not applicable	The system is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Voltage fluctuations/flicker emissions IEC 61000-3-3	Not applicable	The system is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.

Guidance and manufacturer's declaration - electromagnetic immunity

The ventilator is intended for use in the electromagnetic environment as specified in the power and radiated tables below. The customer and/or user of the ventilator should make sure that it is used in such an electromagnetic 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 and/or hospital environment.
Surge IEC 61000-4-5	± 1 kV line(s) to line(s) ± 2 kV line(s) to earth	± 1 kV differential mode ± 2 kV common mode	Mains power quality should be that of a typical commercial and/or hospital environment.
Voltage dips, short interruptions, and voltage variations on power supply input lines IEC 61000-4-11	<5% UT (>95% dip in UT) for 0.5 cycles 40% UT (60% dip in UT) for 5 cycles 70% UT (30% dip in UT) for 25 cycles <5% UT (>95% dip in UT) for 5 s	<5% UT (>95% dip in UT) for 0.5 cycles 40% UT (60% dip in UT) for 5 cycles 70% UT (30% dip in UT) for 25 cycles <5% UT (>95% dip in UT) for 5 s	Mains power quality should be that of a typical commercial and/or hospital environment. If the user of the system requires continued operation during power mains interruptions, it is recommended that the system be powered from an uninterruptible power supply or battery.

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment guidance
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 typical commercial or hospital environment.
Note: UT is the main power voltage prior to application of the test level.			

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment guidance
			Portable and mobile RF communications equipment should be used no closer to any part of the ventilator, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. The recommended separation distance is
Conducted RF IEC 61000-4-6	3 Vrms 150 kHz to 80 MHz outside ISM bands (1)	10 Vrms (V1)	$D = 0.35\sqrt{P}$
	10 Vrms 150 kHz to 80 MHz in ISM bands	10 Vrms (V2)	$D = 1.2\sqrt{P}$
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.5 GHz	10 V/m (E1)	$D = 1.2\sqrt{P}$ 80 MHz to 800 MHz $D = 2.3\sqrt{P}$ 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). (2) Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, (3) should be less than the compliance level in each frequency range. (4) 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.			

Immunity test	IEC 60601 test level	Compliance level	Electromagnetic environment guidance
(1) 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. (2) 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 a mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas. For this reason, an additional factor of 10/3 has been incorporated into calculating the recommended separation distance for transmitters in these frequency ranges. (3) 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 re-orienting or relocating the ventilator. (4) Over the frequency range of 150 kHz to 80 MHz, field strengths should be less than 10 V/m.			

Recommended separation distances

The ventilator is intended for use in the electromagnetic environment in which radiated RF disturbances are controlled. The customer and/or user of the ventilator can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the ventilator as recommended below, according to the maximum power of the communications equipment.

Separation distance in meters (m) according to frequency of the transmitter				
Rated maximum output power of transmitter watts (W)	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
	$D=0.35\sqrt{P}$	$D=1.2\sqrt{P}$	$D=1.2\sqrt{P}$	$D=2.3\sqrt{P}$
0.01	0.035	0.12	0.12	0.23
0.1	0.11	0.38	0.38	0.73
1	0.35	1.2	1.2	2.3
10	1.1	3.8	3.8	7.3
100	3.5	12	12	23
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.				

Separation distance in meters (m) according to frequency of the transmitter
Note 1: At 80 MHz to 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 of 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.

Electrical safety

WARNING Do not touch non-medical electrical equipment and the patient at the same time. This may cause an unsafe electrical shock to the patient.

- Do not connect electrical equipment other than approved accessories to the AC outlets. Connecting electrical equipment to the accessory AC outlets effectively creates a medical electrical system as defined by IEC 60601-1 and the result can be a reduced level of safety.
- The ventilator must be connected to a reliable power source that is appropriate for use with a life support device.
- Additional multiple socket-outlets or extension cords not provided with the ventilator must not be connected to the ventilator. Those provided with the ventilator must only be used for supplying power to equipment that is intended to form part of the ventilator system.

  Only connect items that are intended to be part of the ventilator.

  The ventilator provides connections hospital information networks (only connect items that are intended to be part of the ventilator). When these items (non-medical equipment) are combined with the ventilator, these precautions must be followed.

  - Do not place items not approved to IEC 60601-1 closer than 1.5 m to the patient.
  - All items (medical electrical equipment or non-medical electrical equipment) connected to the ventilator by a signal input/signal output cable must be supplied from the main power source which uses a separating transformer (in accordance with IEC 60989) or be provided with an additional protective earth conductor (ground).
  - If a portable multiple socket outlet assembly is used as the main power source, it must comply with IEC 60601-1. The assembly must not be placed on the floor. Using more than one portable multiple socket outlet assembly is not recommended. Using an extension cord is not recommended.

  After connecting anything to these outlets, conduct a complete ventilator leakage current test (according to IEC 60601-1).

Classification

The classification of the ventilator and approved accessories are in accordance to IEC 60601-1 as follows:

- Class 1 equipment
- IP21 Ingress protection

  The Ingress Protection classification of IP21 is for solid particle protection greater than 12.5 mm in diameter (e.g. Fingers or similar objects), and liquid ingress protection against vertically dripping water.
- Type B equipment (breathing circuit)
- Type BF equipment (respiratory gas monitor)
- Not for use with flammable anesthetics
- Continuous operation

14 Clinical theory

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

Functional residual capacity

Functional Residual Capacity (FRC) is the volume of air in the lungs after the current breath has been exhaled, but before the next breath has been taken. Having adequate volume in the lung during this period of time and ensuring the lung is open (able) to receive the next breath, will increase ventilation opportunities throughout the lung. A patient's FRC can be projected from their estimated total lung capacity. A patient's projected FRC can be compared to the results of a ventilator-measured FRC to evaluate the effect of the current ventilator PEEP settings. If the FRC measurement is lower than expected, a clinician may consider an increase to the PEEP setting. Increasing the PEEP setting will cause more pressure to be held in the lungs during the expiratory phase. A change in PEEP may also directly affect the amount of volume held in the lung, based on the compliance of the lung, or its ability to displace volume. The additional volume in the lung may increase ventilation opportunities for the displacement of the next delivered breath.
By identifying a better FRC and setting the appropriate PEEP level, areas of the lung that were unavailable for ventilation may become available.

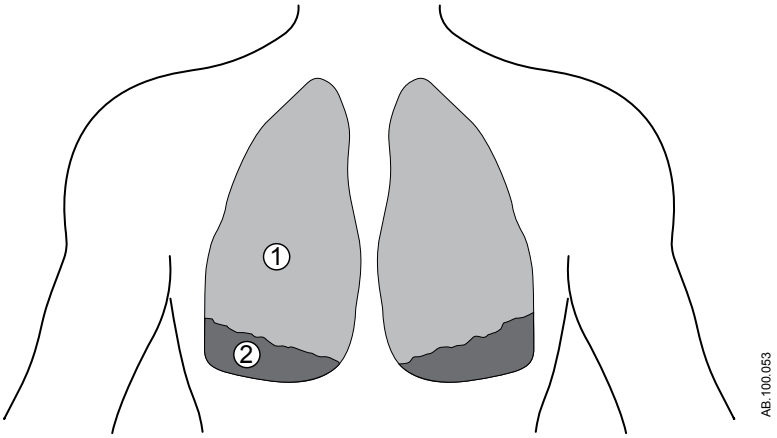


Figure 14-1 • Lungs before FRC recruitment without adequate PEEP

1. Functioning lung tissue (able to hold volume during the expiratory phase)
2. Poorly functioning lung tissue (unable to hold volume during the expiratory phase)

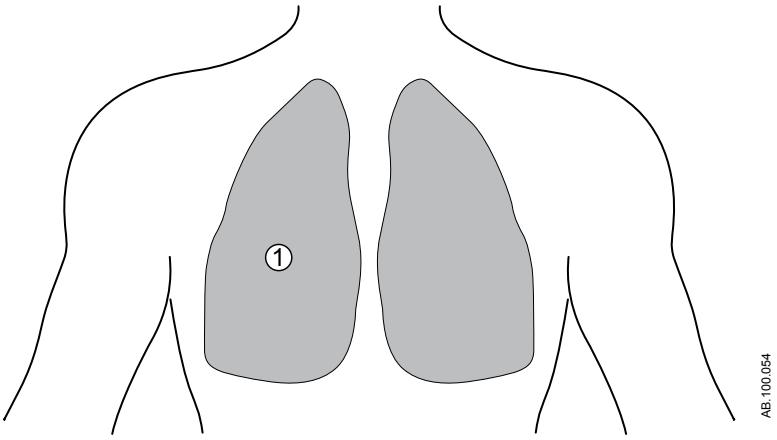


Figure 14-2 • Lungs after FRC recruitment with adequate PEEP

1. Functioning lung tissue (able to hold volume during the expiratory phase)

Nitrogen washout

The FRC procedure measures the patient's FRC using a nitrogen washout process. The nitrogen washout uses a change in the oxygen concentration (FiO2) delivered to the patient to measure FRC. The following occurs during an FRC procedure:

- Baseline nitrogen is measured.
- FiO2 changes to the FRC O2 setting.
- Over the course of approximately 20 breaths, the patient exhales the nitrogen contained in the lungs. The cumulative volume of nitrogen over the series of breaths represents the patient's FRC.
- The FRC curve and FRC measurement displays as data is available.
- FRC O2 changes to the initial FiO2 setting.
- Over the course of approximately 20 breaths, the nitrogen volume is measured. The change in the volume of cumulative nitrogen represents the patient's FRC.
- FRC curve is completed and the final FRC value is shown.
- The FRC curves and values are averaged if the measurements are within 25%.

Metabolics

The ventilator provides analysis for Indirect Calorimetry (Metabolics), a technique used to measure the caloric needs of the patient and evaluate metabolic status and energy expenditure. Indirect Calorimetry calculates the total Energy Expenditure (EE) and Respiratory Quotient (RQ) by measuring respiratory gas exchange, the consumption of oxygen and the production of carbon dioxide, which is the result of converting food and nutrients to energy.

Use the Metabolics view to determine if the patient's caloric intake is appropriate. The patient must be ventilated in a steady state to produce accurate data. See "*Metabolics view*" in the "*Clinical decision support*" section for more information.

Leak compensation calculation

The ventilator calculates the instantaneous leak compensation rate using the leak volume over the previous 30 seconds and the instantaneous and mean airway pressures.

- V_{leak} = leak volume from previous 30 seconds x 2
- Leak rate = V_{leak} x (instantaneous Paw/mean Paw from the previous 30 seconds)
- Leak compensated patient flow rate = measured flow - leak rate

Airway module

Gas exchange

The clinical applications of gas exchange measurements range from the calculation of energy requirements and response to nutrition to comprehensive analysis of ventilation and oxygen transport.

The airway modules with the gas exchange capability can monitor airway gases and calculate metabolic indicators such as:

- Spirometry
- O2 consumption (VO2)
- CO2 production (VCO2)
- Respiratory quotient (RQ)
- Energy expenditure (EE)

Gas exchange measurements are used to calculate the difference between oxygen delivery and oxygen consumption, which may show the effort of breathing. Measurements can also be used to monitor changes to the metabolic condition of a patient and help find their nutritional needs to avoid over- or under-nutrition. The data can be used as guidance for adjusting the ventilator settings to better meet the needs of patients and help in the success of weaning patients from the ventilator.

The airway module measures the quantity of O2 that is inhaled and subtracts the exhaled quantity from it to calculate the O2 consumption (VO2) of a patient. CO2 production (VCO2) is measured by subtracting the quantity of inhaled CO2 from the quantity of exhaled VO2. These quantities can be calculated by multiplying each measured volume sample by the corresponding gas concentration.

The height and weight of a patient must be entered to calculate their body surface area (BSA). The BSA is then used to calculate the O2 consumption and CO2 production.

Gas exchange measurements

The E-COVX, E-CAiOVX, E-sCOVX, and E-sCAiOVX airway modules with gas exchange option enable monitoring of O2 consumption (VO2), CO2 production (VCO2), energy expenditure (EE) and respiratory quotient (RQ).

To provide an accurate breath-to-breath measurement of respiratory gas exchange, the modules algorithmically integrate sidestream gas concentrations (CO2 and O2) as well as flows and volumes generated by each breath. This is done with the D-lite(+)/Pedi-lite(+) flow sensor in conjunction with the fast paramagnetic oxygen sensor

and the infrared gas bench for CO2 measurement. Due to the sidestream measurement principle, there is a delay of approximately 2.5 seconds in the measurement, caused by the traveling time of the sample through the sampling line to the module. The module algorithmically synchronizes these concentrations and flows.

To obtain the oxygen consumption of a patient, the gas exchange module measures the amount of oxygen that is inhaled and subtracts the exhaled amount from it. Carbon dioxide production is measured by subtracting the amount of inhaled carbon dioxide from the amount of exhaled. These amounts can be obtained by multiplying each measured volume sample by the corresponding gas concentration.

To ensure volume measurement accuracy the Haldane transformation is applied. The Haldane transformation is based on the assumption that nitrogen is an inert gas, and an individual will neither consume nor produce it, except in the case of air emboli. Therefore, the amount of nitrogen inhaled is equal to the amount exhaled.

Static measurements

The airway module measures the following values:

- Static plateau pressure (Static Pplat)
- Static extrinsic and intrinsic end expiratory pressures (Static PEEPe+i)
- Static compliance (Cstat)

A pause is defined as a period during which the flow remains less than 2 l/min and the airway pressure changes are less than 1 cmH2O. An end inspiratory or expiratory pause is used for static measurement when the following occur:

- The end inspiratory or expiratory pause lasts at least 1 second longer than the end inspiratory/expiratory pause in spontaneous breaths. The previous three spontaneous breaths are used for this comparison.
- The end inspiratory or expiratory pause is at least 1.5 seconds.
- During the previous minute there were not more than three spontaneous breaths.

Static compliance is calculated based on the measured Static Pplat and end expiratory pressure values if:

- The end inspiratory and end expiratory pauses are detected within 2 minutes of each other.
- Ventilator settings have not changed between pauses.
- Dynamic PEEP is less than 2 cmH2O.
- Dynamic VT is less than 15%.
- The difference between static Pplat and PEEPe+i is less than 3 cmH2O.

Evaluate airway module data

Though the measurements can be made easily, accuracy and reproducibility of results requires understanding of the basic principles of the measurement and related physiology. Gas exchange and metabolics (indirect calorimetry) are sensitive to measurement errors; the need for routine procedures of quality control is emphasized. Despite accurate measurement, several clinical and physiological factors influence the results of gas exchange measurements and should be considered in interpretation. In this respect, the relationship between ventilation and gas exchange is of crucial importance. Any acute change in alveolar ventilation will be immediately reflected in CO2 production, which will not measure the metabolic production of CO2, until a new steady state has been achieved. Similar, but shorter, transient will also be seen in O2 consumption. Analogously, acute changes in tissue perfusion may influence both tissue oxygen uptake and removal of CO2 from the tissues.

Pulmonary gas exchange measurement means monitoring of oxygen consumption (VO2) and carbon dioxide production (VCO2). Based on these measurements, it is possible to calculate the respiratory quotient (RQ), which is the ratio between CO2 production and O2 consumption, as well as the energy expenditure (EE), which indicates the number of calories of energy the patient is using. The measurement of pulmonary gas exchange corresponds to the release of energy from the body in a steady state. A steady state condition can be defined as a period of time after the patient has stabilized from any changes and will not incur further changes in treatment that may affect their gas exchange or increase metabolism. Whenever the homeostasis of a patient is changed, the steady state condition is disrupted, and a certain period of time has to pass before a new steady state is re-established. This should be noted in short-time measurement. In continuous measurement, obtaining average results over longer periods helps eliminating the effects of varying steady state.

Oxygen consumption (VO2)

Indirect calorimetry measures oxygen consumption as the uptake of oxygen from the respiratory gases. Acute changes in ventilation, hemodynamics, and physical activity may induce wide variations in the VO2 measured by any method. Since VO2 can be measured continuously, the transient changes in the measured VO2 can be readily observed in prolonged measurements.

Under aerobic conditions, VO2 depends on the metabolic activity of the tissues. At a given metabolic rate, the substrates of energy metabolism also have an impact on the VO2 since the amount of oxygen required to produce the same amount of energy from different substrates varies. The amount of oxygen needed to produce

1 kcal of energy from carbohydrate is 207 ml, from fat 213 ml, and from protein 223 ml.

If the amount of oxygen delivered to the tissues is inadequate for metabolic needs, tissue oxygen consumption becomes dependent on oxygen delivery and anaerobic metabolism with lactic acid production will ensue. During anaerobic metabolism, the VO2 measured from the respiratory gases does not reflect the tissue oxygen needs, since an oxygen debt develops in the tissues. When aerobic conditions are restored, the oxygen debt will be reflected as increased oxygen consumption.

Carbon dioxide production (VCO2)

Measurement of carbon dioxide production (VCO2) by indirect calorimetry is susceptible to major errors unless the close relationship between VCO2, alveolar ventilation (VA), and arterial CO2 (PaCO2) is taken into account. According to the classical Bohr's equation, VCO2 = VA x PaCO2/k, where k is a constant that depends on the units and the conditions (pressure, temperature, humidity) of the measurement. The constant is equal to 0.1150 when:

- VCO2 is given in ml/min, standard temperature (0°C) and dry gas (STPD),
- VA is given in l/min, 37 °C, and fully saturated with water vapor (BTPS),
- and PaCO2 is given in kPa.

The Bohr's equation demonstrates that the measurement of VCO2 is sensitive to changes in ventilation: any change in alveolar ventilation will be directly reflected in VCO2 until a new steady state of PaCO2 has been achieved.

In steady state, VCO2 depends on the metabolic activity of the tissues and, similarly to VO2, on the substrates of the energy metabolism. Production of one kcal of energy from carbohydrate produces 207 ml of CO2, from fat it produces 151 ml, and from protein it produces 181 ml. If any of the variables in the Bohr's equation changes, the body CO2 pool will change. Under these circumstances, enough time should be allowed for the body CO2 pool to stabilize if the measured VCO2 should reflect the metabolic production of CO2. Continuous measurement of gas exchange facilitates the verification of a steady state.

Respiratory quotient (RQ)

The ratio between VCO2 and VO2 is called the respiratory quotient when measured in steady state conditions. In steady state conditions, the RQ reflects the mixture of substrates used by the energy metabolism. The RQ is 1.0 for carbohydrate, 0.7 for fat, and

approximately 0.81 for protein. Detailed analysis of substrate oxidation requires measurement of urinary urea excretion for the assessment of protein oxidation and calculation of the non-protein RQ.

For clinical purposes, major shifts in substrate oxidation are reflected in the total RQ, as measured directly from the respiratory gases. Increased glucose oxidation may be observed as an RQ approaching 1.0, whereas increased fat oxidation may result in an RQ approaching 0.7.

A steady state RQ above 1.0 may indicate fat synthesis and is a clinical rarity associated with excessive carbohydrate feeding. Even in these conditions, the RQ rarely exceeds 1.3. A steady state RQ below 0.7 is also a rarity but may occur during ketosis if the ketone bodies are incompletely oxidized and excreted into the urine. RQ values exceeding 1.0 or below 0.7 should be carefully examined for measurement errors and the lack of steady state. Typically the most common causes for unphysiological or erroneous RQ values are changes in ventilation: hyperventilation increases RQ, hypoventilation decreases it until a new steady state of body CO2 pool has been achieved. Analogously, the development of an oxygen debt will increase the RQ, whereas replenishment of an oxygen debt will reduce the RQ.

Energy expenditure (EE)

Energy expenditure cannot be measured by indirect calorimetry; it is calculated from the measured gas exchange variables.

Resting normal values for VO2 and VCO2 vary according to the body size, age, and sex of the patient. Rough estimates of normal values can be obtained, for example, by using the Harris-Benedict formula.

An increase in energy expenditure will be reflected as a proportional increase in both VO2 and VCO2. Temporary increase of up to 200% can occur due to shivering and convulsions, for instance. Clinical conditions associated with hypermetabolism, like injury or sepsis, may increase energy expenditure by up to 50% and in extreme cases, even up to 100%.

Patients with severe pulmonary pathology and impairment of respiratory mechanics may have markedly increased work of breathing: the oxygen cost of breathing can be up to 20% of the whole body VO2, whereas it normally represents less than 5% of the total VO2.

Hemodynamic catastrophes, like circulatory collapse, may acutely reduce both VO2 and VCO2, and a compensatory increase can be observed once adequate tissue perfusion has been restored.

The following table shows examples of different factors that can contribute to increased energy expenditure.

Condition	Percent above expected EE
Injury, infection	50%
Anxiety	30%
Fever	25%
Work of breathing	20%
Thermogenic effect	15%

Airway module test method

This test method is used to determine the rated respiration rate range and the corresponding effects of end-tidal gas reading accuracy as a function of respiratory rate.
The gas respiration rate (RR) measured by the airway module is tested at nominal conditions within the range of 4 to 100 breaths/min (bpm) with accuracy of ±1 bpm in the range 4 to 20 bpm and ±5% in the range 20 to 100 bpm. Breath time, inspiration time, and gas concentration were recorded for a sample flow of 120 ±3 ml/min and I:E ~1:1. The test gas is fed via a T-connector or equivalent, a signal generator driven valve and a 3 m/10 ft PE/PVC sampling line to the airway module. The airway module measurement result for the used gas was checked to be within 0.5 vol% of the gas.

VT setting calculation

Changing the value of Patient Weight on the New Patient menu will change the VT setting to a value that is a suggested starting point for the weight entered.

Suggested VT is 6 ml per kg for adult (IBW) and pediatric (set weight). Suggested VT is 5 ml per kg for neonatal (set weight).

Body Surface Area (BSA) calculation

BSA is estimated for adult and pediatric patients:

{(Height ^0.725) * (Weight ^0.425) * 0.007184}

- BSA in units of m^2
- Height in units of cm
- Weight in units of kg

Ideal Body Weight (IBW) calculation

IBW is estimated for adult patients with heights 55 inches (140 cm) and greater, as outlined in Egan's Fundamentals of Respiratory Care, Eighth Edition, 2003:Male: 106 + [6*(height - 60)], where weight is in lb and height is in inches. Female: 100 + [5*(height - 60)], where weight is in lb and height is in inches. IBW is the set patient weight for pediatric and neonatal patients.

15 System theory of operation

In this section

Note Shared information section for adult, pediatric, and neonatal patient types.

System operation

The system is a software-controlled, microprocessor-based product that receives clinical control inputs and then shows the information through a graphical user interface display unit. The display unit microprocessor communicates in real-time with two other system microprocessors that control ventilation delivery and safety related monitoring. The display unit is able to communicate with monitoring modules in order to acquire and show additional monitoring information such as CO2 and O2.

The system delivers controlled volume or pressure breath profiles in response to (clinical) inputs. The system is time cycled for controlled breaths and flow cycled with a time cycle override for spontaneous breaths. The system triggers on both pressure and flow, and responds to positive inspiratory trigger conditions. The system uses proportional flow control valves and an active exhalation valve in order to provide ventilation delivery.

A controllable bias flow is maintained during ventilation delivery to detect and respond to spontaneous breath activity of the patient. The system includes airway pressure, FiO2, and exhaled volume monitoring which are independent of the ventilation delivery. The system also has an integrated nebulizer system that employs electronic micropump technology for delivery of inhaled drugs.

Electrical operation

The system contains the following four major processor control boards:

- Display Unit (DU) Carrier Board, item 10
- Ventilator Control Board (VCB), item 20
- Power Management Board (PMB) item 34
- Ventilation Monitoring Board (VMB) item 38

Two other analog boards, the Module Interface Board (MIB, item 12) and the Motherboard (item 13), complete the electronic architecture.

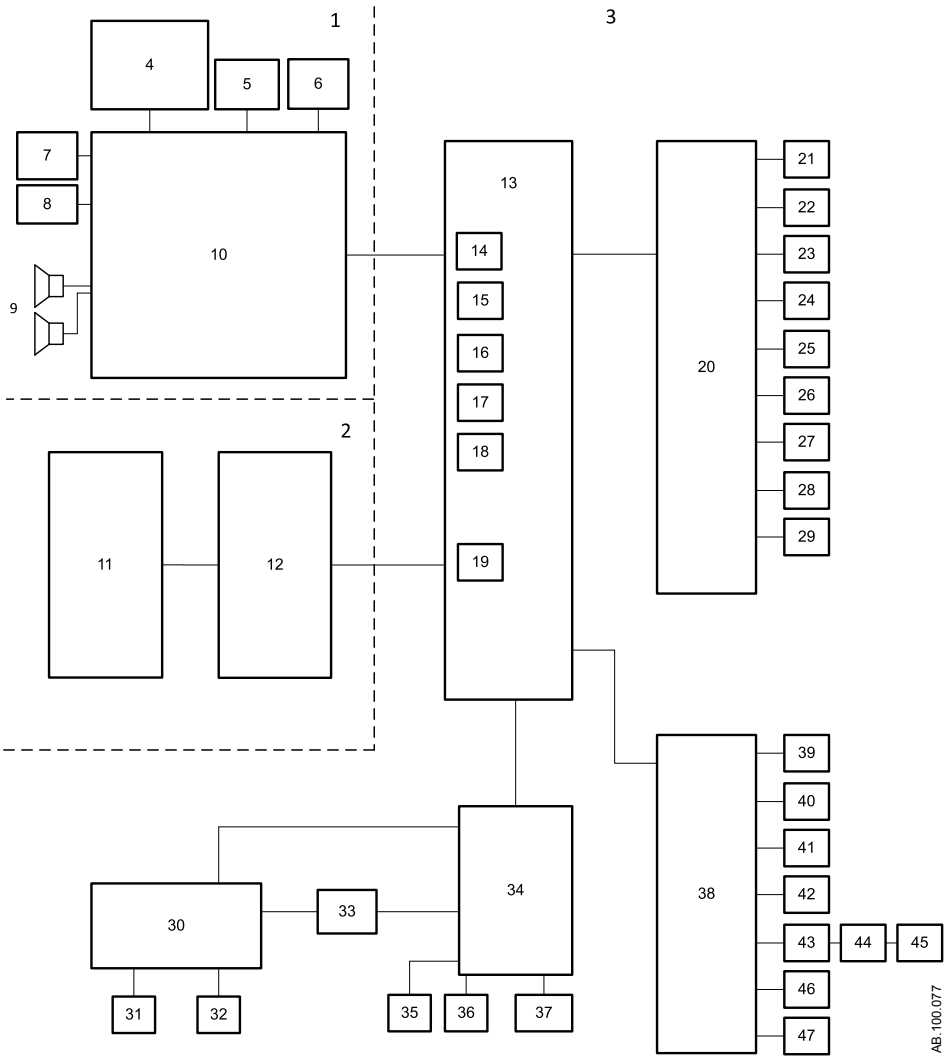


Figure 15-1 • Electrical architecture

1. Display unit compartment
2. Monitoring module compartment
3. Ventilator chassis
4. COM express module
5. LCD display
6. Trim Knob
7. Touchscreen
8. Alarm light
9. Speakers
10. Display unit carrier board
11. Module bays
12. Module interface board (MIB)
13. Motherboard
14. Display unit port
15. External serial input/output port
16. RS-422 port
17. RS-422 port
18. Patient-side monitor port
19. Module bus port
20. Ventilator control board (VCB)
21. Electronic micropump nebulizer board
22. Air flow valve
23. O2 flow valve
24. Exhalation valve
25. Air flow and temperature sensor
26. O2 flow and temperature sensor
27. Total flow and temperature sensor
28. Inspiratory pressure sensor and valve
29. Auxiliary pressure sensor and valve
30. Power panel connectors
31. System switch
32. AC Power cord
33. Main power supply
34. Power management board (PMB)
35. Ventilator engine fan
36. Power module fan
37. Internal batteries
38. Ventilation monitoring board (VMB)
39. Inspiratory effort valve
40. Relief valve
41. High air pressure sensor
42. High O2 pressure sensor
43. Expiratory flow sensor board
44. Expiratory flow interface board
45. Expiratory flow sensor
46. O2 concentration sensor
47. Expiratory pressure sensor and valve

Display Unit

The Display Unit (DU) has four circuit boards: COM Express Module, carrier board, touchscreen controller, and alarm light.

- COM Express Module contains the CPU and RAM.
- Carrier board is the main circuit board and provides connections between all subsystems within the DU.
- Touchscreen controller manages the touchscreen and communicates to the system with a serial connection.
- Alarm light provides a redundant visual alarm indicator.

The DU communicates with the rest of the system through five digital channels on the motherboard. Settings and alarm annunciation data are sent directly to the VMB and VCB from the DU. The display screen is a 38 cm active matrix LCD with 8 bits per color and a LED backlight.

If a DU communication error occurs, such as the screen goes blank, the ventilator will continue ventilating at the current settings.

Ventilator Control Board

The Ventilator Control Board (VCB) collects information from all of the system sensors and controls all the actuators necessary to execute ventilation delivery. The VCB subsequently computes and supplies all ventilation sensor monitoring data shown on the display unit. If there are alarms to be generated based on this monitoring data, the VCB informs the display unit to post the appropriate alarm message and audio sequence. The VCB then monitors the display unit's response to ensure that the alarm was correctly presented.

The VCB receives expiratory flow, expiratory pressure, and O2 sensor data from the VMB. The VCB contains actuator drive circuits for the air and oxygen inspiratory valves and the expiratory valve. The VCB also contains digital control signals for activating the inspiratory effort and relief valves.

Ventilation Monitoring Board

The Ventilation Monitoring Board (VMB) performs as an independent monitoring system that provides computational and oversight redundancy to the display unit and VCB. The VMB acquires sensor data relating to the expiratory airway pressure, delivered O2 percentage, and exhaled minute and tidal volumes. The VMB communicates directly with the display unit and transmits sensor data over a separate link to the VCB.

The VMB monitors the air and oxygen supply pressures and also controls the relief valve actuator, which allows it to unilaterally release pressure in the breathing circuit.

Power Management Board

The Power Management Board (PMB) determines the source of power and controls the charging operation of the internal battery. The PMB communicates directly with the display unit about the charge status of the internal battery, as well as the unit shutdown sequence.

Motherboard

The Motherboard provides connectivity for the VCB, VMB, and PMB assemblies. Analog circuits on the board limit the current for external peripheral connections to ensure that the primary ventilation and monitoring functions are not compromised by excessive power draw.

Monitoring Interface Board

External monitoring module bays support the use of E-s or E-series airway modules. The Monitoring Interface Board (MIB) is located within the housing of the module bay and regulates power to the levels required for use by the airway modules.

Pneumatic operation

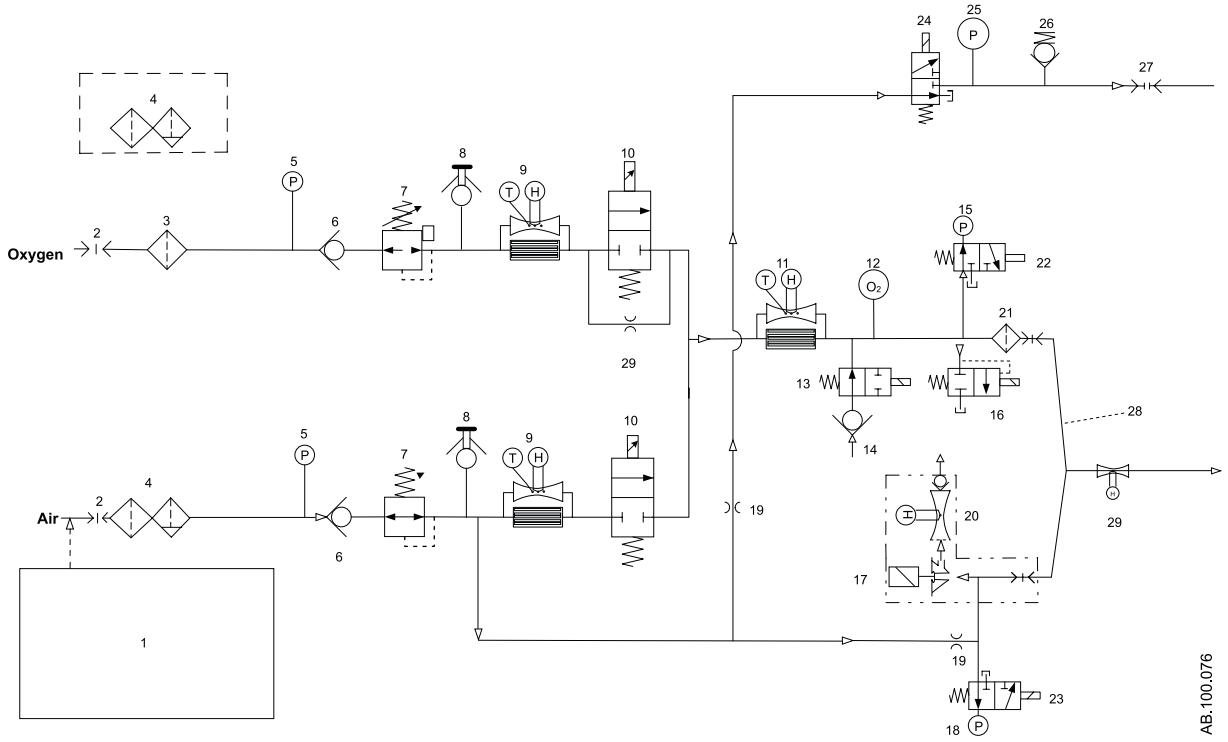


Figure 15-2 • Pneumatic architecture

1. Compressor
2. Pipeline source (Primary inlet)
3. Standard inlet filter
4. Optional particle and coalescing filter (factory-installed for Air, optional for O2)
5. Supply pressure transducer
6. Check valve
7. Pressure regulator
8. Test port with plug
9. Inspiratory flow sensor
10. Inspiratory flow valve
11. Total flow sensor
12. Oxygen sensor
13. Inspiratory maneuver valve
14. Free breathing check valve
15. Inspiratory pressure transducer
16. Relief valve
17. Exhalation valve
18. Expiratory pressure transducer
19. Pneumatic resistor
20. Exhalation flow sensor
21. Inspiratory safety guard
22. Inspiratory zero valve
23. Expiratory zero valve
24. Auxiliary pressure purge valve
25. Auxiliary pressure transducer
26. Auxiliary pressure relief valve
27. Auxiliary pressure connection
28. Piezoelectric aerosol nebulizer
29. Neonatal flow sensor (optional - neonatal only)

The supply of ventilator pneumatic power is drawn from compressed oxygen and air sources. Two separate inspiratory channels (air and O2) are incorporated in the system in order to provide dynamic mixture control of the O2 percentage. The air supply side may

include an optional air compressor unit for applications where compressed air is not available or as a backup source when compressed gases have been lost.

Inspiratory

Compressed gas enters the ventilator through a coupling that is specific to the air or O2 gas localization requirements. The gas is filtered as it enters the pneumatic engine manifold of the ventilator. A supply pressure transducer is used to monitor the adequacy of the supply pressure. Supply gas, coupling hoses, or occluded filter failures may be identified using the supply pressure transducer.

Check valves prevent any backflow from the system that would possibly contaminate the supply gas lines. The pressure regulators ensure a constant pressure supply to the inspiratory flow valves. The inspiratory flow sensors are used during operation of the system to measure the volume of gas dispensed from the air and O2 channels during inspiration. Adjustment as to the relative proportion of volume to dispense from each channel are made using data in order to precisely control the percentage of O2 being delivered to the patient.

Each inspiratory flow valve is capable of metering flows from approximately 0.05 l/min to 160 l/min. The valve is a proportional solenoid, normally closed type, that is powered by a current feedback loop.

The total flow sensor is used to measure the combined inspiratory flow being dispensed in the system. Using the known mixture composition, mass flow data from the sensor is converted to delivered volumetric flow towards the patient.

During normal operation, the inspiratory effort maneuver valve is open, allowing the free breathing check valve to admit flow if the patient draws a significant amount of inspiratory pressure. The free breathing valve allows the patient to spontaneously breathe in the event of a ventilation delivery failure. During an inspiratory effort procedure, the inspiratory effort maneuver valve closes, locking out the free breathing valve from the patient circuit.

The O2 sensor operates using the paramagnetic principle of oxygen. The sensor is used to monitor the O2 mixture being produced by the air and O2 inspiratory channels. The displayed FiO2 value is adjusted by the ratio of the barometric pressure and a 1.3 second moving average of the cyclic pressures obtained by the inspiratory pressure transducer. The sensor uses non-depleting technology.

The relief valve is capable of venting the inspiratory delivery side of the system at full flow rate. The valve is normally closed and would be powered open by either of the two control processors in the event that an overpressure condition is detected. The relief valve will also open mechanically at 110 cmH2O. The inspiratory airway pressure transducer serves as one of the two airway pressure devices. All pressure transducers use silicone piezoresistive technology.

Expiratory

A solenoid powered exhalation valve controls exhaust from the breathing circuit. The solenoid is proportional in nature, allowing the valve to be used to actively adjust and control the exhalation sealing pressure.

The expiratory pressure transducer is continuously purged with clean, dry air in order to ensure that water plugs will not occlude the tap. This continuous flow of air is established off of the regulated air supply using a fixed purge flow pneumatic resistor. The expiratory pressure transducer uses silicon piezoresistive technology and operates between -20 and 120 cmH2O.

The expiratory flow transducer operates using hot wire anemometry principles whereby a wire having a large temperature to electrical resistance relationship is placed in the stream of the flow. At the output of the flow sensor is a flapper type check valve that prevents gas from being drawn in through the expiratory valve and minimizes patient rebreathing in the event of a ventilator failure.

The inspiratory flow sensors, total flow sensor, and expiratory flow sensors use heat transfer technology and operate between 0 and 160 l/minute.

Hazard protection

Potential software hazards are detected and prevented through the identification of unsafe patient conditions relative to O2 concentration, airway pressure, apnea, and low minute volume.

Checks and alarms are in place for inspired O2, airway pressure, apnea, and low minute volume. Inspired O2 is sensed by the air and oxygen flow sensors and verified by the paramagnetic O2 sensor. The paramagnetic O2 sensor data sample rate is 5 Hz. Airway pressure is sensed and verified by the inspiratory and expiratory pressure sensors. Apnea and low minute volume are sensed by the expiratory flow sensor or neonatal flow sensor (optional) and verified by the air and oxygen flow sensors.

16 Parts and accessories

In this section

Note Shared section for adult, pediatric, and neonatal patient types.

Replacement parts and accessories

This section shows replacement parts and accessories that are validated for use with the CARESCAPE R860.

WARNING GE Healthcare CARESCAPE R860 ventilator specified cables, accessories, or transducers are not recommended for use with other ventilators or equipment, as it may result in increased emissions or decreased immunity of that equipment.

- Incorrect installation of components could result in barotrauma, hypoventilation, hyperventilation, incorrect FiO2, contaminated breathing gases, or fire hazards. Please follow the instructions contained in the Technical Reference Manual when servicing the ventilator.
- Only connect items to the ventilator that have been specified as part of the ventilator system or that have been specified as being compatible with the ventilator system. Incompatible parts can result in degraded performance.

Note Refer to the Technical Reference Manual for instructions on the correct replacement of interchangeable or detachable parts.

Note All parts of the ventilator are suitable for use within the patient environment.

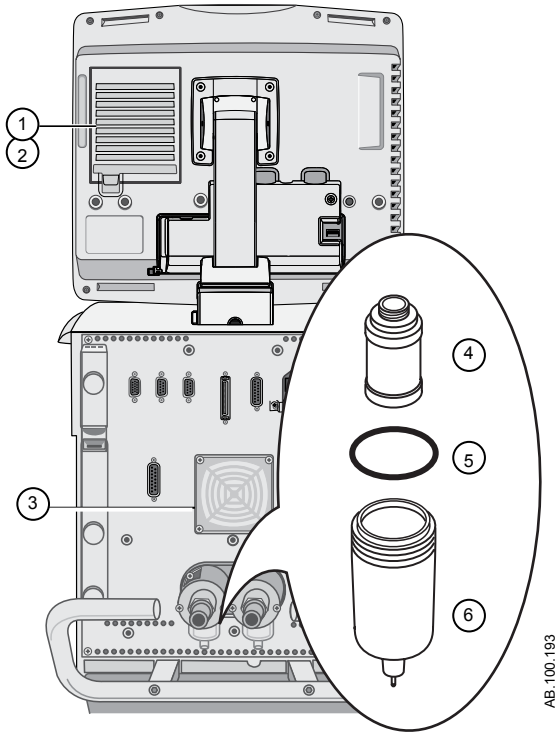
System accessories

Description	Part Number
Breathing circuit arm	1505-3801-000
Breathing circuit kit, Adult, Disposable, 1.5 m/60 in, (20)	8570106
Breathing circuit kit, Pediatric, Disposable, 1.5 m/60 in, (20)	M1012152
Breathing circuit, Infant, Fisher & Paykel RT265 (F>4LPM) EVAQUA	RT265
Breathing circuit, Infant, Fisher & Paykel RT266 (F<4LPM) EVAQUA	RT266
Breathing circuit, Adult, Fisher & Paykel RT200, Non-US	RT200
Breathing circuit, Adult, Fisher & Paykel RT210, US only	RT210
Aerogen nebulizer kit, includes Adult and Pediatric tee	1505-3846-000
Aerogen Solo Nebulizer silicone plug (for use with tee) (10)	AG-AS3450
Aerogen Solo Nebulizer (5)	AG-AS3100-S
Aerogen Solo Nebulizer (10)	AG-AS3200-S
Aerogen Nebulizer tee, Adult (10)	AG-AS3010
Aerogen Nebulizer tee, Pediatric (10)	AG-AS3020
Aerogen Nebulizer tee, Neonatal, 12 mm M/12 mm F, (10)	AG-AS3035
Nebulizer cable	1505-5602-000
Aerogen Nebulizer filler cap (5)	AG-AP1030
Aerogen Nebulizer head with filler cap	AG-AP1000
Aerogen Nebulizer tee-adapter with silicone plug, adult (5)	AG-AP1010
Aerogen Nebulizer replacement kit, adult (includes two nebulizer heads with filler caps and two adult tees)	AG-AP1100
Aerogen Nebulizer tee-adapter with silicone plug, pediatric (5)	AG-AP1020
Aerogen Nebulizer replacement kit, (includes two nebulizer heads with filler caps and two pediatric tees)	AG-AP1200
Aerogen Nebulizer T-adapter with silicone plug, neonatal, 12mm/12mm (5)	AG-AP1035
Aerogen Nebulizer silicone plug (for use with tee) (5)	AG-AP1005
Expiratory filter - Uni filter	557021200
Expiratory water trap hose, Adult, 0.35 m/14 in	M1010719
Expiratory water trap kit	M1003463
Gas cylinder holder	WM-0009-80
Inspiratory safety guard - disposable (1)	2066713-001
Inspiratory safety guard - disposable (10)	2083208-001
Intratracheal pressure catheter (10)	M1045564
Fisher & Paykel humidifier, with heater wire (900MR805) and temperature probe (900MR869)	MR850
HMEF 500, (75/pkg)	557070500
HMEF 1000/S with sample port, (50/pkg)	557070100

Description	Part Number
Module Bay	1505-3849-000
Module Bay assembly kit	1505-3849-000
Support tube – 250 mm for patient hose support arm	1505-3800-000
IV Pole	0217-5378-800
Mounting Bracket adapter (dovetail to channel)	1001-3626-000
Utility basket (6 inches deep)	WM-0001-02
Adjustable mounting rail	M1165123
Aerogen Connection Luer	AG-AS3400
Adjustable Mounting Rail adapter	M1165134
Fisher and Paykel autofill humidification chamber	MR290
Hans Rudolph, Inc 6500 Series V2 Mask, Large	114501
Hans Rudolph, Inc 6500 Series V2 Mask, Medium	114502
Hans Rudolph, Inc 6500 Series V2 Mask, Small	114503
Hans Rudolph, Inc 6500 Series V2 Mask, Extra Small	114504
Hans Rudolph, Inc 6500 Series V2 Mask, Petite	114505
Monitoring adapter, 22mm OD/15mm ID x 15mm OD	1669
Exhalation valve kit with flow sensor	1505-3848-000
Exhalation valve kit without flow sensor	1505-8568-000
Patient Spirometry Accessory Kit for ICU, 2 m sampling line and spirometry tube	894255
Patient Spirometry kit for humid conditions, 2 m sampling line and spirometry tube	8004381
Pediatric Spirometry kit, 2 m sampling line and spirometry tube	8002718
Spirometry kit, disposable, D-lite with preconnected 3 m spirometry tube	889560
Shelf mount kit	M1081203

Note Some countries may use a specific country code part, please confirm wth your customer service representative. Accessories may not be available in all markets.

System parts



	Description	Part Number
1	Display filter	M1220155
2	Display filter holder	M1220155
3	Fan filter, ventilator engine	1505-3029-000
4	Filter element	1505-3060-000
5	O-ring, filter bowl	1503-3034-000
6	Filter bowl with o-ring	1505-3062-000

Power cords

Power cords should only be replaced by authorized service personnel. Refer to the CARESCAPE R860 Technical Reference Manual for ordering information.

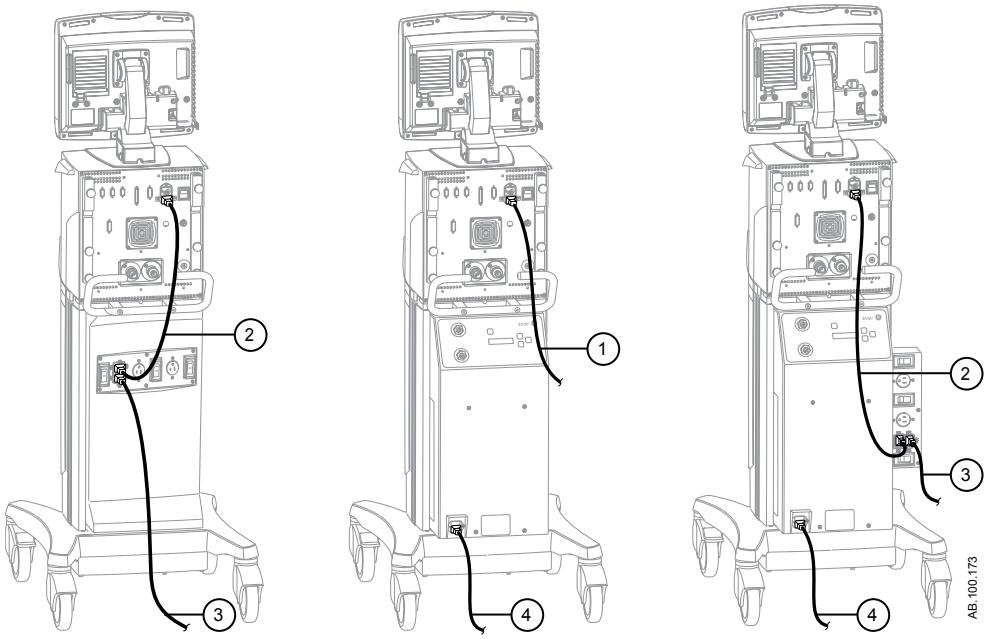


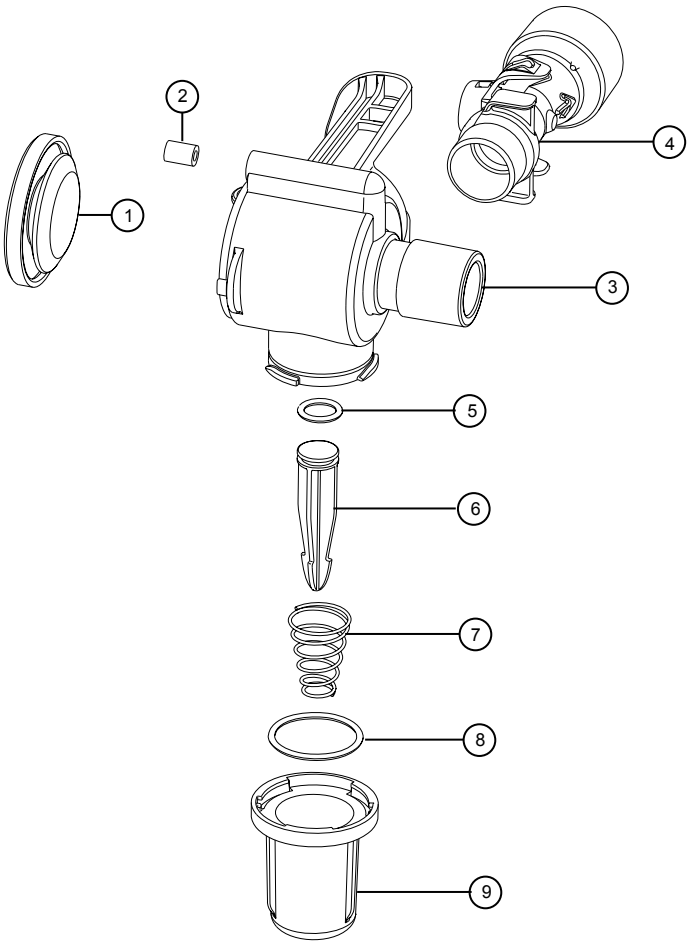
Figure 16-1 • Power cord configurations

1. Ventilator to main power supply
2. Ventilator to accessory outlet
3. Ventilator accessory outlet to main power supply
4. Compressor to main power supply

Airway module

Description	Part Number
D-fend+ water trap, single use (10)	881319-HEL
D-fend Pro+ water trap, single use	M1200227
D-fend water trap, Mini	8002174
Disposable D-lite(+) sensor, Adult, for humid conditions (50)	896952
Disposable Pedi-lite(+) sensor, Pediatric, for humid conditions (50)	8001948
Reusable D-lite sensor, Adult (1/pk)	733910-HEL
Reusable Pedi-lite sensor, Pediatric (1/pk)	73393
Spirometry tube, disposable, yellow 2 m/7 ft(5)	890031
CO2 sampling line, 2 m/7 ft	73318
Blank airway module	M1024982
E-CO	
E-COV	
E-COVX	
E-miniC	
E-sCO	
E-sCOV	
E-sCOVX	
E-CAiO	
E-CAiOV	
E-CAiOVX	
E-sCAiO	
E-sCAiOV	
E-sCAiOVX	

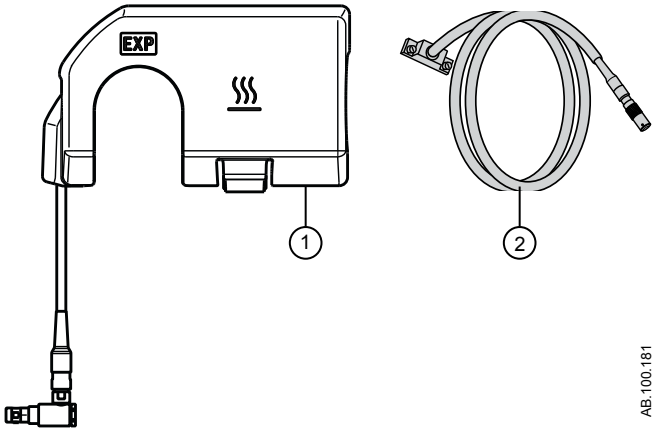
Exhalation valve assembly



	Description	Part Number
—	Exhalation valve assembly (without flow transducer)	1505-8568-000
1	Diaphragm	1505-3224-000
2	Seal	1505-3223-000
3	Housing	1505-3222-000
4	Flow transducer (includes check valve and screen)	1505-3231-000
5	O-ring	1503-3056-000
6	Plunger	1505-3245-000
7	Spring	1505-3013-000
8	O-ring	1505-3009-000
9	Water trap	1505-3244-000

Note The expiratory flow sensor has a 90-day warranty.

Exhalation valve heater



	Description	Part Number
1	Exhalation valve heater	M1200693
2	Cable (order separately)	M1188723

17 Neonatal Introduction

In this section

Overview of neonatal ventilation

The neonatal option on the CARESCAPE R860 provides ventilation for neonatal patients weighing down to 0.25 kg. Using an optional neonatal flow sensor at the patient wye, which connects to the ventilator with a cable, allows for more accurate flow and volume monitoring in the neonatal patient type.

WARNING While ventilating in the neonatal patient type, additional patient monitoring methods, such as SpO2, ECG, and CO2 are recommended.

Several features are available with the neonatal option:

- The calculated tidal volume per unit of weight is displayed while adjusting the tidal volume setting.
- The volume delivered per unit of weight can be displayed during ventilation for continuous monitoring.
- Safety-related limits have been imposed on ventilation settings and alarm limits for the intended patient population.

Information presented in other sections of this manual applies to all patient types, including neonatal. Exceptions are detailed in this section.

Neonatal manual

The neonatal manual is located within this manual and begins at Section 17 - Neonatal Introduction. The neonatal portion of this manual has been tailored to facilities whose main patient type is neonates. See Table of Contents for exact location information. Shared sections of this manual for adult, pediatric, and neonatal patient types:

- "*Introduction*"
- "*Symbols and abbreviations*"
- "*Navigation*"
- "*Setup and connections*"
- "*System configuration and service*"
- "*Cleaning and maintenance*"
- "*Clinical theory*"
- "*System theory of operation*"
- "*Parts and accessories*"

18 Neonatal setup and connections

In this section

Note See "*Setup and connections*" (shared information section for adult, pediatric, and neonatal patient types) for additional information.

General use and safety precautions

The following section describes the setup of the ventilator. Follow all safety precautions and warnings.

WARNING Make sure system batteries are fully charged before use.

It is recommended that the ventilator maintain connection to the main power supply at all times to prevent battery discharge and degradation. A green LED indicator located on the front lower left of the display unit indicates (when illuminated) that the ventilator is connected to a main power source.

- Access to an appropriate means of ventilation at all times is required to prevent patient injury or death in the event of ventilator failure.
- Do not modify the ventilator equipment without authorization of the manufacturer.
- Adding attachments or other components to the breathing system may change the pressure gradient. Ensure the inspiratory and expiratory resistance do not exceed 6 cmH2O for the following flows:
  - 2.5 l/min for neonatal use: VT <= 50 ml
- Do not attach a gas scavenging system or other accessories to the gas exhaust port. Occluding the gas exhaust port will prevent proper ventilation for the patient.
- If sampled gas is returned to the breathing system, there is a risk of patient cross-infection.
- Use of other electrical equipment adjacent to or stacked with the ventilator may cause interference. If adjacent or stacked use is necessary, the ventilator should be observed to verify normal operation in the configuration in which it will be used.
- Use of portable phones or other radio frequency (RF) emitting equipment, which exceed electromagnetic interference levels specified in "*Guidance and manufacturer's declaration - electromagnetic immunity*", near the ventilator may cause unexpected or adverse operation. Monitor the function of the ventilator when RF emitters are in the vicinity, including RFID readers and interrogators.
- The ventilator must not be used in a hyperbaric chamber.
- The ventilator must not be used with helium or mixtures with helium.

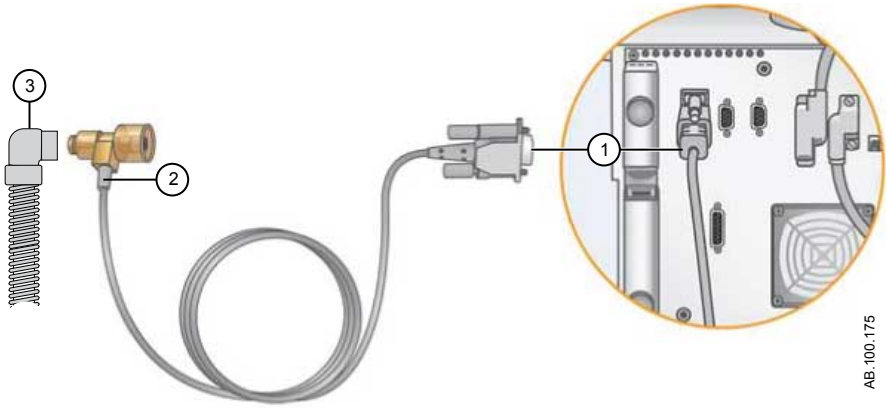
- A movable part or removable component may present a pinch or crush hazard. Use care when moving or replacing system parts and components.
- Do not cover fans and exhaust ports or position the ventilator in such a way that the operation or performance is adversely affected. Do not place near a radiator or heating unit.
- A compressor should be used if a reliable air pipeline source is not available.

CAUTION It is strongly recommended that at least two gas sources be used during clinical use.

Connecting the Neonatal Flow Sensor (NFS)

WARNING Calibrate the Neonatal Flow Sensor after every day of continuous use and after replacement.

CAUTION Port 1 must only be used to connect the neonatal flow sensor.



1. Connect the neonatal flow sensor cable connector to to port 1 on the back of the ventilator.
2. Connect the neonatal flow sensor to the cable.
3. Connect the neonatal flow sensor to the patient breathing circuit.
4. Connect the neonatal flow sensor to the patient airway connection.

Note To disconnect, follow the steps in reverse order.

19 Neonatal ventilation modes

In this section

Ventilation mode basics

Invasive and non-invasive ventilation

The ventilator provides several standard modes for invasive ventilation and non-invasive modes (nCPAP for neonates).

- Invasive ventilation modes provide a range of patient support, from fully controlled mechanical breaths to pressure supported breaths for spontaneously breathing patients.
- Non-invasive modes are intended to be used for spontaneously breathing patients only.

Note See ventilation mode descriptions for details about the settings and features each mode provides.

The primary difference between setting up a patient for invasive and non-invasive ventilation is the accessories used.

- Invasive ventilation is delivered through an artificial airway (e.g., endotracheal tube), which is inserted into the patient's trachea.
- Non-invasive ventilation is delivered using positive-pressure ventilation through an accessory such as a nasal mask or mouthpiece. These accessories are often attached to the patient’s head to increase the quality of the airway seal to minimize airway leaks.

  Non-invasive ventilation masks should be non-vented and must not include an entrainment (inspiratory) valve. Patient circuits for use with non-invasive ventilation must be dual-limb with connections for both the inspiratory and expiratory ports of the ventilator.

Mechanical and spontaneous breaths

The ventilator offers multiple ventilation modes, which support mechanical and spontaneous breaths.

Mechanical breaths are controlled by the ventilator. The ventilator uses the selected mode settings to determine the characteristics of the breath such as timing, volume, and pressure. Depending on which mode is set, mechanical breaths are initiated by the ventilator or the patient.

- Ventilator-initiated: the ventilator uses the set respiratory rate to initiate a breath.
- Patient-initiated: the patient activates the set inspiratory trigger (flow or pressure) to initiate a breath.

Spontaneous breaths are initiated and controlled by the patient.

Note In ventilation modes with a PS setting, spontaneous breaths are pressure-supported at the PS level.

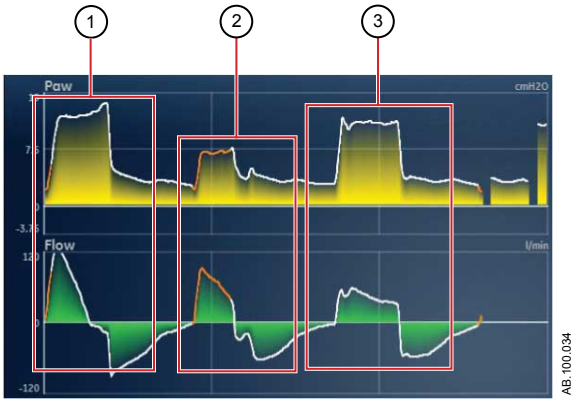


Figure 19-1 • Breath Types

1. Patient-initiated, mechanical breath
2. Spontaneous pressure supported breath
3. Ventilator-initiated, mechanical breath

Note The segment colored orange in the waveform represents the breath trigger.

Ventilation mode settings

Ventilation mode settings are separated into four categories:

- Main Parameters
- Breath Timing
- Patient Synchrony
- Safety

Each ventilation mode has a unique set of settings. See each ventilation mode description for a list of applicable settings.

Quick Keys on the lower portion of the display provide access to ventilation mode settings that are likely to be adjusted frequently. The remaining settings can be adjusted in the ***Current Mode*** > ***Mode Settings*** menu.

Note When changing ventilation modes, some settings may change if the two modes do not share the same limits or increments.

- When the setting is greater than the maximum value allowed in the new mode, the maximum value is set.

- When the setting is less than the minimum value of the new numeric range, the minimum value is set.
- When the setting is between increments, the value is rounded to the increment above or below it.

Main Parameter	**Definition**	
FiO2	Fraction of inspired oxygen	The percentage of oxygen that the ventilator delivers to the patient.
PEEP	Positive End Expiratory Pressure	The pressure that the ventilator holds in the patient's lungs during the expiratory phase.
VT	Tidal Volume	The volume of gas that the ventilator delivers with each volume-regulated or controlled breath.
Pinsp	Inspiratory Pressure	The pressure above PEEP that is maintained during the inspiratory phase of a pressure-regulated breath. In BiLevel mode, Pinsp is the pressure above PEEP at which the patient can spontaneously breathe.
PS	Pressure Support	The pressure above PEEP that is maintained during a pressure-supported breath.
Plow	Low Pressure	The low pressure level at which the patient can spontaneously breathe in APRV mode. This setting is equivalent to PEEP in other modes.
Phigh	High Pressure	The high pressure level at which the patient can spontaneously breathe in APRV mode.

Breath Timing	**Definition**	
Rate	Respiratory rate	The number of breaths delivered to the patient in one minute.
Flow	Inspiratory flow	The rate at which the gas is delivered to the patient during the inspiratory phase of a volume-controlled breath.
I:E	Inspiratory time:Expiratory time	The ratio of inspiratory time to expiratory time.
Tinsp	Inspiratory Time	The time in seconds that the ventilator uses to deliver the inspiratory phase of the breath cycle.
Insp Pause	Inspiratory Pause	The percentage of the inspiratory phase during which the breath is held and no additional flow is delivered by the ventilator during volume controlled breaths.
Tpause	Pause Time	The period in seconds at the end of the inspiratory phase during which the breath is held and no additional flow is delivered by the ventilator during volume controlled breaths.
Thigh	High Time	The time in seconds that the ventilator holds the high pressure level in APRV mode.

Breath Timing	Definition	
Tlow	Low Time	The time in seconds that the ventilator holds the low pressure level in APRV mode.

Patient Synchrony	Definition	
Insp Trigger	Inspiratory Trigger	The patient effort required to initiate the inspiratory phase of a breath. The trigger can be set as either a positive flow value (Flow Trigger) or a negative pressure deflection below PEEP (Pressure Trigger).
Exp Trigger	Expiratory Trigger	The percentage of peak flow at which the pressure supported breath inspiratory phase ends and the expiratory phase begins.
Rise Time	Rise Time	The time in milliseconds for pressure to reach 90% of the set inspiratory pressure.
PS Rise Time	Pressure Support Rise Time	The time in milliseconds for pressure to reach 90% of the set pressure support level.
Bias Flow	Bias Flow	The continuous flow that is circulated through the patient circuit during the expiratory phase of the breath cycle. The bias flow may be increased above this setting by the ventilator for some FiO2 settings.
Tsupp	Pressure Support Time	The maximum inspiratory time for a pressure-supported breath.

Safety	Definition	
Pmax	Maximum Pressure	The maximum pressure allowed in the patient breathing circuit. Once reached, the inspiratory phase ends, and the ventilator immediately begins the expiratory phase.
Plimit	Pressure Limit	The pressure at which the breath is limited and held for the remaining inspiratory time in a volume-controlled breath.
Pmin	Minimum Pressure	The minimum target pressure offset from PEEP allowed in PRVC, VS, SIMV PRVC, and BiLevel VG modes.
Minimum Rate	Minimum respiratory rate	The minimum number of breaths per minute a patient must draw before the ventilator delivers a backup breath.
Backup Pinsp	Backup Inspiratory Pressure	The pressure above PEEP that the ventilator maintains as it delivers a mechanical breath in CPAP/PS and NIV modes.
Backup Tinsp	Backup Inspiratory Time	The time in seconds that the ventilator uses to deliver the inspiratory phase for a mechanical breath in VS, CPAP/PS and NIV modes.

Positive end expiratory pressure (PEEP)

PEEP is the low pressure maintained in the patient's airway during the expiratory phase. PEEP prevents the patient's lungs from collapsing at the end of expiration. Maintaining a PEEP level improves the possibility of increasing oxygenation. PEEP (or the equivalent setting of Plow) is available in all ventilation modes.

Pressure support

Pressure support provides additional pressure during the inspiratory phase of spontaneous breaths in spontaneous breathing modes. The PS setting is available in the following ventilation modes:

- CPAP/PS
- SIMV VC
- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG
- NIV
- SBT

The maximum duration of the inspiratory phase for pressure-supported breaths is Tsupp or 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates. The inspiratory phase of pressure-supported breaths ends when one of the following occurs:

- Set Exp Trigger is detected.
- Set VT is delivered (VS mode only).
- Pressure exceeds PEEP + PS + 2.5 cmH2O.
- Set Tsupp is reached.

Flow and pressure triggering

The ventilator detects a patient's spontaneous breathing effort based on changes in flow or pressure.

- Flow trigger: A breath is delivered when the patient's inspiratory effort reaches the Insp Trigger setting.
- Pressure trigger: A breath is delivered when the patient's negative airway pressure (below PEEP) reaches the Insp Trigger setting.

To set a flow or pressure trigger, adjust the Insp Trigger setting.

- To set a flow trigger, select Current Mode, select the trigger setting, set a positive value using the Trim Knob and confirm.
- To set a pressure trigger, select Current Mode, select the trigger setting, set a negative value using the Trim Knob and confirm.

The ventilator synchronizes mechanical breaths with patient triggers when in the following modes:

- SIMV VC
- SIMV PC
- SIMV PRVC

- BiLevel
- BiLevel VG

And when assist control is active in the following modes:

- A/C VC
- A/C PC
- A/C PRVC

Breath timing preferences

The parameters used to represent the timing of a delivered breath or inspiratory phase of a delivered breath may be selected by the facility.

Note Timing and Flow default settings may be changed by a Super User. See the "*Configuration menu (Super User)*" section for more information.

The following table shows which settings are available based on the ventilation mode and Timing and Flow selections.

Timing	**I:E**	**I:E**	**Tinsp**	**Tinsp**	**Tpause**
Flow	**On**	**Off**	**On**	**Off**	**On**
A/C VC	I:E Flow	I:E Insp Pause	Tinsp Flow	Tinsp Insp Pause	Tpause Flow
A/C PC	I:E	I:E	Tinsp	Tinsp	Tinsp
A/C PRVC	I:E	I:E	Tinsp	Tinsp	Tinsp
SIMV VC	Tinsp Flow	Tinsp Insp Pause	Tinsp Flow	Tinsp Insp Pause	Tpause Flow
SIMV PC	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
SIMV PRVC	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
BiLevel	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
BiLevel VG	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp
APRV	Thigh Tlow	Thigh Tlow	Thigh Tlow	Thigh Tlow	Thigh Tlow
CPAP/PS	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
VS	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
NIV	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp	Backup Tinsp
nCPAP	Tinsp	Tinsp	Tinsp	Tinsp	Tinsp

Note Selecting a breath timing for the modes listed in the table will not affect other ventilation modes.

Ventilation mode features

Assist control

Assist control allows the ventilator to synchronize mechanical breaths to the patient's spontaneous efforts and the patient to trigger additional mechanical breaths to the set respiratory rate in the following ventilation modes:

- A/C VC
- A/C PC
- A/C PRVC

When the patient initiates a breath with assist control enabled, the ventilator delivers a breath based on the mode settings. After a patient-initiated mechanical breath, the ventilator may delay the delivery of the next mechanical breath to prevent two mechanical breaths from being delivered consecutively (breath stacking).

Note Under certain conditions, such as high spontaneous breathing rates or high leakage, the rate of mechanical breaths may not meet the set respiratory rate.

A general message shows when assist control is off. When assist control is off, the patient is able to draw spontaneous breaths at the set PEEP level between mechanical breaths.

To set Assist Control, select ***Current Mode*** > ***Mode Settings*** and select ***Assist Control*** (On or Off).

Leak compensation

WARNING The exhaled volume of the patient can differ from the measured exhaled volume due to leaks.

When the ventilator detects breathing circuit leaks, leak compensation does two or three functions depending on the selected ventilation mode. In all modes:

- Flow and volume waveforms and measured volume data are adjusted to account for leaks.

In the following volume-controlled modes, the ventilator adjusts the tidal volume delivered to compensate for leaks:

- A/C VC
- A/C PRVC
- SIMV VC
- SIMV PRVC
- BiLevel VG

- VS

The maximum tidal volume adjustment is limited to 100% of the set tidal volume for the neonatal patient type.

- Neonatal - 100% of the set tidal volume

To set leak compensation, select ***Current Mode*** > ***Mode Settings*** and select ***Leak Comp***. A general message shows when leak compensation is on.

Trigger compensation

Leaks can cause the ventilator to initiate breaths automatically (auto-triggering). Trigger compensation adjusts the flow trigger to compensate for leaks, reducing the need to manually adjust the Insp Trigger setting to prevent auto-triggering.

Trigger compensation is available in all ventilation modes. To set trigger compensation, select ***Current Mode*** > ***Mode Settings***, and select ***Trigger Comp***.

Backup mode

Backup mode is available if the ventilator detects insufficient ventilation in modes that allow spontaneous breaths. When enabled, the ventilator automatically enters the set Backup mode if either of the following occur:

- The Apnea alarm is activated.
- The patient's expired minute volume (MVexp) is below 50% of the set low MVexp alarm.

The set Backup mode is shown under the Backup mode check box in ***Current Mode*** > ***Mode Settings*** . To enable Backup mode, select the check box.

Backup settings are a subset of available settings in each ventilation mode. Adjust Backup settings in ***Current Mode*** > ***Mode Settings*** > ***Backup Settings***.

Note Settings that are not designated as Backup settings remain at the current value when the ventilator transitions to the set Backup mode.

WARNING Ensure that all users at the facility have been trained and notified of the facility default Backup mode settings. Before deactivating backup ventilation for a specific mode, ensure that all users at the facility have been trained and notified of these settings.

Backup mode is available in the following ventilation modes:

- SIMV VC

- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG
- CPAP/PS
- VS
- APRV

The following ventilation modes may be set as the Backup mode:

- A/C VC
- A/C PC
- A/C PRVC
- SIMV VC
- SIMV PC
- SIMV PRVC
- BiLevel
- BiLevel VG

Nasal continuous positive airway pressure (nCPAP)

The nCPAP mode is a purchasable option. The nCPAP mode is intended for non-invasive ventilation of neonatal patients only.

WARNING Before using nCPAP mode, the patient should demonstrate all of the following characteristics:

- Is responsive
- Breathes spontaneously
- Has a controlled airway
- Requires pressure support ventilation
- Patient needs oxygen therapy

- While in nCPAP ventilation, the ventilator is to be provided with CO2 monitoring equipment that complies with ISO 80601-2-55 or ISO 21647.
- If the Apnea Time, Leak Limit, or MVexp low alarms are disabled, additional monitoring, such as SpO2, ECG, and CO2, is recommended to prevent the patient from hypoventilating while ventilating in the neonatal patient type without the neonatal flow sensor.
- The Patient Disconnected alarm is not enabled during nCPAP mode. The Apnea, Circuit Leak, MVexp low, and PEEPe low alarms are the primary disconnection notifications. To make sure that the ventilator detects a patient disconnect, set the PEEPe Low limit correctly for the patient's condition.

Note The neonatal flow sensor is not used during nCPAP.

The nCPAP mode allows a clinician to set a FiO2 and Bias Flow rate for gas through the patient circuit. The clinician can also set a level of PEEP to be maintained in the patient circuit and a respiratory rate for mechanical breaths. The mechanical breaths delivered are time cycled, but are synchronised with a patient trigger where necessary. The clinician will set the inspiratory pressure inspiratory time for the time cycled breaths.

The Bias Flow rate, set by the clinician will be used to maintain PEEP and for the inspiratory phase of the time cycled mechanical breaths. Insufficient setting of the Bias Flow rate may cause an inability to reach or maintain the set PEEP and or inspiratory pressure during the mechanical breaths.

During nCPAP, the patient draws spontaneous breaths through a nasal interface as the ventilator maintains the set inspiratory pressure.

If large patient circuit leaks are present, the user may disable the MVexp low, Apnea Time, and Leak Limit alarms.

Important Backup ventilation is not available while using nCPAP mode.

The following settings are available in nCPAP mode:

Category	Setting
Main Parameters	FiO2
	PEEP
	Pinsp
Breath Timing	Rate
	Tinsp
Patient Synchrony	Bias Flow
	Insp Trigger
Safety	Pmax

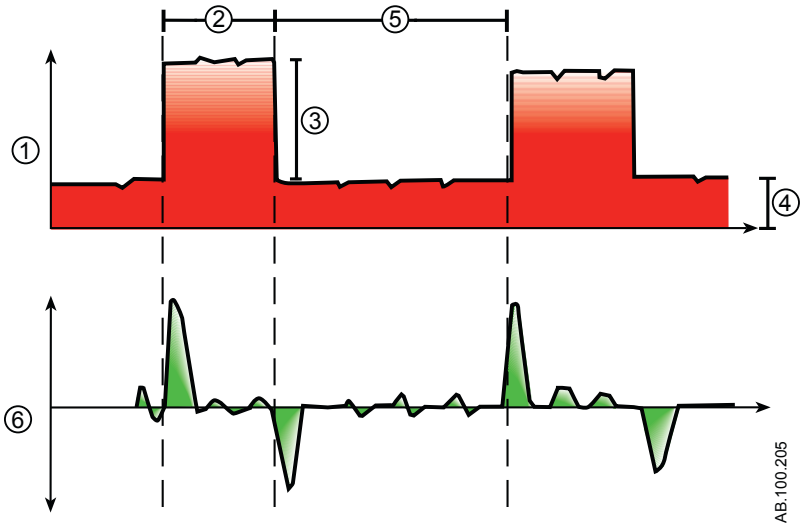


Figure 19-2 • nCPAP waveform

1. Airway pressure (Paw) waveform
2. Tinsp
3. Pinsp
4. PEEP
5. Expiratory time
6. Flow waveform

Invasive neonatal ventilation modes

The following invasive ventilation modes are availble for neonatal patients. See "*Ventilation modes*" for detailed information.

- A/C VC
- A/C PC
- A/C PRVC
- SIMV VC
- SIMV PC
- CPAP/PS
- BiLevel
- SIMV PRVC
- BiLevel VG
- APRV
- VS
- SBT

Note BiLevel, SIMV PRVC, BiLevel VG, APRV, and VS are purchasable options.

20 Neonatal Operation

In this section

Power

Turning on power to the ventilator

1. Plug the power cord into an electrical outlet.
   - The LED indicator illuminates (green) to indicate the main power is connected.
2. Press the power switch on the back of the ventilator to the On position.
   - The start-up screen appears while the system runs a series of automated self tests.
   - When the self tests pass, the system goes into Standby and the display shows the Standby menu.
   - If the self tests fail, the display shows an alarm. See "*List of alarms*" and "*Troubleshooting*" in the "*Alarms and troubleshooting*" section or "*List of alarms – Neonatal*" in the "*Neonatal alarms and troubleshooting*".
3. Listen for two distinctly different audio tones to sound to make sure the primary speaker and backup buzzer are working properly.
4. Watch and verify the alarm light on the top of the display unit cycles through the following colors: blue, red, and yellow.

WARNING If both the primary and backup audio tones do not sound or the alarm lights do not function correctly when the ventilator is powered on, take the ventilator out of service. Contact an authorized service representative to repair the system.

Turning off power to the ventilator

The ventilator may only be turned off when in Standby, Configuration (Super User), or Service. If the ventilator is turned off during ventilation, an alarm sounds and ventilation and monitoring continue. This ensures the ventilator cannot be accidentally shut off during ventilation.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventilation to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.

3. Select ***Pause Ventilation***.

   - Monitoring and ventilation will stop.

4. Press the power switch on the back of the ventilator to the Off position.

Patient Setup

New Patient

Use these instructions for preparing the ventilator for a New Patient in neonatal. After powering on the ventilator, the Standby menu displays.

WARNING To protect patient privacy, do not use the patient's name when entering the patient ID (identification). Consider the facility's privacy policies when entering the patient ID.

1. Select ***NEW PATIENT***.

   The New Patient menu shows with the Neonatal patient type.

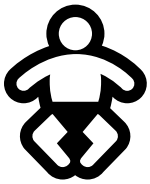


Figure 20-1 • Neonatal patient type symbol

2. Select ***Neonatal***.

Note The neonatal patient type views are displayed with a purple background.

3. Select ***Patient ID*** (identification).

   - Enter up to 10 characters and then select ***Confirm***. (Only English alpha-numeric characters may be entered).

4. Select ***Gender*** (male or female).
5. Select ***Height***.
6. Select ***Weight***.

   - When patient height and weight are entered, the system automatically calculates and displays the patient weight in kilograms, BSA (Body Surface Area), and a suggested VT (Tidal Volume).

7. Verify and confirm settings.

Previous Patient

The Previous Patient button shows upon power up of the ventilator when previous patient data exists. Previous Patient allows the clinician to use the patient settings and alarm limits that were

previously used and view trends and historical data. For example, if a patient is extubated, but fails to progress and needs to be re-intubated, the clinician may use the previous patient settings.

From the Standby menu, select ***PREVIOUS PATIENT***.

Important Previous Patient data is only saved when a normal shutdown sequence is performed. Abrupt or unexpected power loss will prevent this data from being saved.

Current Patient

The Current Patient menu shows the current patient type, patient ID, height, weight, IBW, and BSA of the patient. Use this screen to update settings or change patient type from Neonatal to Pediatric or Pediatric to Neonatal.

1. Select ***Standby***.
2. Select ***Current Patient***.

   The Current Patient menu shows.
3. Select the desired patient type and adjust settings.

System Check

System Check overview - neonatal

The ventilator should be fully cleaned and prepared for a patient before performing the System Check.

When started, the System Check runs automatically. Selecting the information icon will show the active progress in the System Check Details menu. The steps will show a green check mark (pass) or a red X (fail). When each check is completed, the next check begins.

A General Warning icon in the System Check indicates that a check has not been performed or completed for the current patient. Both the yellow warning icon and the yellow Start Ventilation button serves as a visual warning that a System Check needs to be performed.

WARNING To help ensure the proper function of the system, it is highly recommended to complete the System Check between patients.

- The patient must not be connected to the ventilator while completing the System Check.
- Changing the patient circuit after completion of System Check will affect volume delivery and exhaled volume measurements. If any change is made to the patient circuit, repeat the System Check.
- Complete the System Check with the breathing circuit and accessories that will be used during ventilation.
- If a System Check is not completed for the current patient, the system uses the compliance and resistance data from the last completed system check for the set patient type for all internal compensations. If the current breathing circuit differs significantly from the previous circuit, differences in ventilation parameters due to changes in the compensation process are possible.
- Failure to complete a System Check may result in inaccurate delivery and monitoring. This may result in risk to the patient.

Additional System Check information

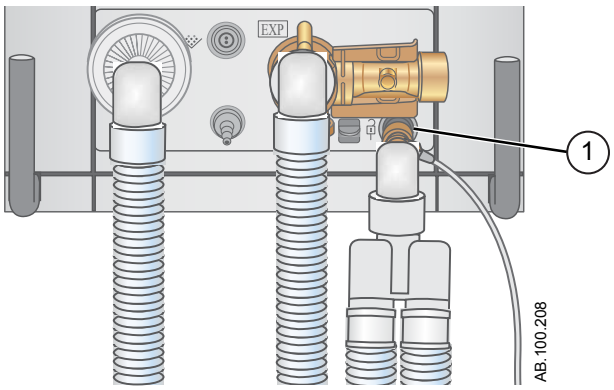
- The circuit leak is measured at 25 cmH2O. The resistance is the measured resistance of the inspiratory limb of the patient circuit. If the circuit leak is greater than 0.5 l/min or resistance or compliance measurements cannot be calculated, the Circuit Check will fail.

- If the circuit leak is greater than 0.5 l/min or if the exhalation flow sensor is changed after the System Check, the expiratory tidal volume may have decreased accuracy.
- If the relief valve failure alarm activates after the System Check then the ventilator will not allow ventilation until the relief valve portion of the System Check has passed.

Running a neonatal system check

1. From Standby, select ***SYSTEM CHECK***.

   The Run System Check menu shows.
2. Attach the neonatal flow sensor to the breathing circuit and all accessories that will be used to ventilate the patient.
3. Occlude the patient wye using the occlusion port.



1. Occlusion port

4. Select Start.

   The System Check starts and shows the results of each check.

   The system runs the following checks:

   - Paw transducer check
   - Barometric pressure check
   - Relief valve check
   - Exhalation valve check
   - Expiratory flow sensor check
   - Air flow sensor check
   - Oxygen sensor check
   - O2 flow sensor check
   - Neonatal flow sensor check
   - Resistance check

- Circuit measurements check (circuit leak, compliance, and resistance)

Important When performing the Neonatal Flow Sensor Check, remove the occlusion from the neonatal flow sensor, keeping the flow sensor attached to the patient circuit.

5. Select the information icon to see the System Check Details menu.

   The System Check starts and shows the results of each check.

Note Follow all on-screen system check instructions.

As the System Check runs, the results of each check are displayed as a green check mark (pass) or red X (fail). If a check fails, a Help icon displays next to the failed check (red X). Select the Help icon to view possible causes and help for troubleshooting a failure.

When the System Check is complete, the Final Result line will display the patient type icon, a green check mark (pass) or red X (fail), and the date and time of the System Check.

Patient ventilation

Setting the ventilator data source

The data source is used to obtain patient monitoring parameters from either the ventilator or the Neonatal Flow Sensor (NFS). See "*Neonatal patient monitoring*" for detailed information.

WARNING Calibrate the Neonatal Flow Sensor after every day of continuous use.

- While ventilating in the neonatal patient type without the neonatal flow sensor, additional patient monitoring such as SpO2, ECG, and CO2 are recommended.
- Flow and volume accuracy are decreased when not using the neonatal flow sensor for the neonatal patient type.

1. Select ***Menu*** >***System***.
   The System menu shows.
2. Select ***Ventilator*** or ***NFS*** and confirm settings.
   If the ventilator is selected as the data source the Ventilator Data icon displays, the internal flow sensors of the ventilator will be used for flow and volume monitoring.

   If the NFS is selected as the data source the Patient Data icon displays, the neonatal flow sensor will be used for flow and volume monitoring.

Ventilator Data Source Icons	
	
Ventilator Data	NFS (Patient) Data

System menu (neonatal)

The System menu contains settings for data source selection, NFS calibration options, display brightness and system information.

WARNING Calibrate the Neonatal Flow Sensor after every day of continuous use.

1. Select ***Menu*** > ***System***.
2. Select Data Source (***Ventilator*** or ***NFS***).

3. Select Calibrations (***NFS***, ***Paux Zero***, or ***Purge Flow***) .

   - Select NFS to calibrate the Neonatal Flow Sensor. A green check mark indicates the NFS calibration was successful.
   - Select Paux Zero. A green check mark indicates Paux Zeroing calibration was successful.
   - Select Purge Flow. The Purge Flow check box may be checked or unchecked when performing a Paux Zero. Continuous purge flow will come from the Paux outlet when the Purge Flow check box is selected. A white check mark indicates Purge Flow is active.

Note See "*Purging the auxiliary pressure tubing*" and "*Zeroing auxiliary pressure*" in the "*Setup and connections*" section.

4. Select ***Display Brightness*** to adjust the brightness level of the user interface.

   Select brightness level of 1 (low) to 5 (high).

5. View system information: Software version, Service Pack version, Running hours, Altitude, O2 pressure, Air pressure, and Battery status.

Setting a ventilation and backup mode

Ventilation modes are selected through the Current Mode button. The selected ventilation mode shows with the corresponding mode settings.

Ventilation modes may be changed in Standby or during ventilation.

Ventilation mode settings should be set prior to connecting a patient to the ventilator.

See "*Backup mode*" in the "*Ventilation modes*" section for additional information.

1. Select ***Current Mode***.
2. Select the desired ventilation mode.

   The title of the vent mode shows in the Mode Settings menu along with the parameters for that mode. See "*Ventilation modes*" section for detailed information on types of modes and settings.

   Depending upon the facility default setup for ventilation modes, the Mode Settings menu may contain two icons. The partial list icon represents the facility's set ventilation modes and the full list icon represents the full set of ventilation modes available.

   Select the appropriate icon to see available ventilation modes.

	
Partial list of ventilator modes	Full list of ventilator modes

3. Select ***Assist Control***, ***Leak Comp***, or ***Trigger Comp*** if desired.

   - Assist Control is only available in the following ventilation modes: A/C VC, A/C PC, and A/C PRVC.
   - See "*Assist control*", "*Leak compensation*", or "*Trigger compensation*" in the "*Ventilation modes*" section for detailed information.

4. Set the desired settings for the ventilation mode and confirm.

   When ventilator settings are confirmed, the Mode Settings menu closes and the selected ventilation mode shows in Current Mode.

5. To set a Backup Mode, select ***Current Mode***.
6. Select ***Backup Settings***.

   - Set the desired settings for the backup mode and confirm.

7. Confirm all ventilation mode settings.

Setting limit indicators

When adjusting ventilation mode settings, yellow and red visual indicators show when parameters are approaching their setting limits. Green visual indicators show the parameters are appropriate for the setting limits.

Starting patient ventilation

WARNING Ventilation will not start until 'Start Ventilation' is selected.

- Ensure that the ventilator battery is fully charged before starting patient ventilation. See "*Battery status*" for additional information.

1. From Standby, select ***START VENTILATION***.

   If the Start Ventilation button is green, a System Check has been completed for the current patient and when selected, will start ventilation.
   If the Start Ventilation button is yellow, the Complete System Check warning alert will display the following:

   Select Continue to bypass System Checkout and start ventilation. Select Cancel to remain in Standby.

Note It is recommended that System Check is completed prior to starting ventilation.

2. After ventilation has started, connect the breathing circuit to the patient.

Standby

Pausing ventilation

WARNING The patient will not be ventilated when in Standby.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventilation to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.
3. Select ***Pause Ventilation***.

   • Monitoring and ventilation will stop.

Park Circuit

Park Circuit allows the patient circuit to be occluded without the ventilator alarming while in Standby. When the patient circuit is positioned on the occlusion port the display activates the PARK CIRCUIT selection.

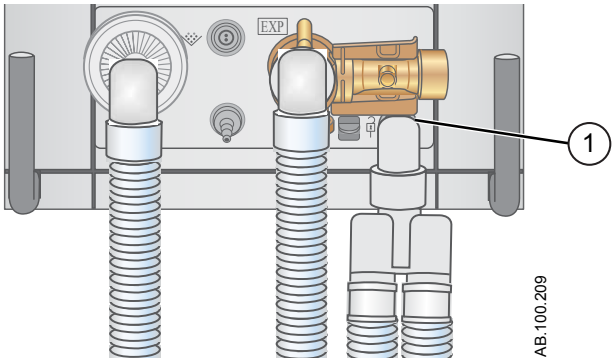
WARNING The patient will not be ventilated while the circuit is parked and in Standby.

1. Disconnect the patient from the breathing circuit.
2. Select ***Standby***.

   Select Pause Ventialtion to go to Standby. No ventilation will be delivered. Select Cancel to continue ventilation if a warning message is displayed.
3. Select ***Pause Ventilation***.

   • Monitoring and ventilation will stop.

4. Occlude the patient circuit using the occlusion port.



1. Occlusion port

5. Select ***PARK CIRCUIT***.

   - The display will show: Patient circuit is occluded and the ventilator is in Standby.

Ventilation adjustments

Ventilaltion modes and setting adjustments may be changed while in Standby or while ventilating.

Changing ventilation modes

1. Select the ***Current Mode***.

   The Mode Settings menu shows.
2. Select the desired mode from the list.

   - Use the scroll bar to view additional modes.

3. Confirm setting.

Setting Favorites

Up to four Favorite procedures may be selected to show on the upper-right corner of the user interface.

1. Select ***Menu***.
2. Select ***Procedures***, ***Lung Mechanics***, or ***Suction*** menus.
3. Select ***Assign Favorites***.

   The Assign Favorites menu shows with a list of the following procedures: Increase O2, Suction, Auto PEEP, Inspiratory Hold Expiratory Hold, P 0.1, NIF, Vital Capacity, and Manual Breath.

4. Select up to four Favorites.

   Favorites show in the upper right corner of the display.

Note The following Favorite procedures begin automatically after they are selected: Manual Breath, Suction, and Increase O2.

21 Neonatal procedures

In this section

Note See "*Procedures*" (shared information section for adult, pediatric, and neonatal patient types) for additional information.

Suction

Closed Suction: Any ventilation modes and settings may be used with a closed suction catheter. Patient Disconnected, RR low, MVexp low, VTexp low, Apnea, and other alarms may occur during use of a closed suction catheter.

Open Suction: To perform suctioning without nuisance alarms, an open suction procedure is provided by the ventilator.

The Open Suction procedure has three phases:

Suction oxygenation - Phase 1: The ventilator delivers increased oxygen at the current Increase O2 setting (factory default value is +25% for neonatal or 100% for pediatric and adult) for two minutes or until the patient is disconnected.

Suction Standby - Phase 2: The ventilator enters Suction Standby for two minutes or until the patient is reconnected.

Oxygenation - Phase 3: The ventilator resumes ventilating at the current Increase O2 setting delivering the increased oxygen value for two minutes.

CAUTION If the current set value is 1 cmH2O or less, PEEP or Plow will be increased to a minimum value of 1.5 cmH2O to better detect a patient disconnect condition during the Suction procedure.

1. Select as a Favorite - see "*Setting Favorites*" in the Operation section or select ***Menu*** >***Suction***.
2. Select Start.

   The Suction oxygenation, Suction, and Oxygenation general messages show as each phase occurs.
3. Wait for the pre-oxygenation phase and then disconnect the patient at the wye.

   An audible tone sounds to indicate the patient is disconnected and ventilation is paused.
4. Suction the patient.
5. Reconnect the patient to resume ventilation.

   The Suction procedure will end after the oxygenation phase completes, if Stop is selected, or if the Suction Favorite is selected.

Nebulizer treatment

The Aerogen Professional Nebulizer System is a portable medical device for multiple patient use that is intended to aerosolize physician-prescribed solutions and suspensions for inhalation to patients on and off ventilation or other positive pressure breathing assistance.

The ventilator supports the Aerogen Pro and Aerogen Solo (disposable) in-line nebulizers by Aerogen.

The nebulizer time can be set for specific duration delivery times or for the volume of medication that will be delivered to the patient. A general message shows the nebulizer treatment time remaining.

CAUTION Only the Aerogen Solo (disposable) may be used for continuous delivery of nebulized medication.

- Using a solution, suspension or emulsion in the nebulizer different from that recommended by the manufacturer, in particular for a suspension and/or high-viscosity solution, may alter the particle size distribution curve, the mass median aerodynamic diameter, aerosol output and/or aerosol output rate, which may be different from those disclosed by the manufacturer.
- If the patient type is neonatal and a neonatal flow sensor is in use, remove it from the patient circuit during the delivery of nebulized medication and change the data source to ventilator to prevent damage to the neonatal flow sensor.

1. Select ***Menu*** > ***Nebulizer*** > ***Aerogen*** .
2. Select ***Time*** or ***Continuous***.

   Selecting Continuous will deliver nebulized medication until medication delivery is stopped or runs out.

   The time and approximate volume of nebulized medication are shown in the table.

   The time and approximate volume of nebulized medication are shown in the table. This calculated volume is based on an average nebulization rate of 0.38 ml/min, but the actual nebulization rate of each individual nebulizer cannot be guaranteed and may vary significantly.

Time (min)	7	8	11	16	21	26	32
Volume (ml)	2.5	3.0	4.0	6.0	8.0	10.0	12.0

3. Select Start.

Note To end a nebulizer treatment before the set time, select Stop.

Pneumatic nebulizer

The ventilator can compensate for additional flow introduced by a pneumatic nebulizer into the patient circuit. The displayed FiO2 measurement does not reflect the additional gas introduced to the patient through the nebulizer.

WARNING Use of an external pneumatic nebulizer may significantly modify the mixture of gas that is delivered to the patient.

- Use of external pneumatic nebulization may significantly impact volume delivery and monitoring, decrease trigger sensitivity, and cause alarms if external flow is introduced and Pneumatic Nebulizer Flow Compensation is not used.
- When the Pneumatic Nebulizer Flow Compensation is On, flow and volume accuracy may be decreased.
- Leaks and flow sensor alarms may not be identified by the ventilator when Pneumatic Nebulizer Flow Compensation is On.

1. Select ***Menu*** > ***Nebulizer*** > ***Pneumatic***.
2. Select the ***Flow*** value.
   - Set the flow value to match the amount of flow that will be introduced into the circuit. Flow setting is patient type dependent: 1.0 to 4.0 l/min for neonatal; 1.0 -12.0 l/min for adult and pediatric.
3. Select Start.

   A general message shows when nebulizer flow compensation is on.
4. Introduce the pneumatic nebulizer into the patient circuit.
   - For best results, introduce the pneumatic nebulizer into the patient circuit within approximately 15 seconds after selecting Start.

Note To end a nebulizer treatment, turn the pneumatic nebulizer flow source off, then select Stop.

Performing an Increase O2 procedure

Increase O2 is used to increase the amount of oxygen delivered to the patient to prevent low oxygen saturation levels.

1. Select as a Favorite (the procedure will start immediately - see "*Setting Favorites*" in the Operation section), or select ***Menu*** > ***Procedures*** > ***Increase O2***, or press the Increase O2 hard key.
2. Use the facility set increase O2% (factory default value is +25% for neonatal or 100% for pediatric and adult) or adjust the O2% to the desired concentration and confirm the setting.
3. Select Start.
    - The oxygenation general message shows along with the progress bar and a 2 minute countdown timer. The progress bar fills in proportion to the amount of time the Increase O2 procedure has completed.
    - The procedure will end when the time has elapsed or when Stop is selected, or when the Increase O2 Favorite is selected, or when the Increase O2 hard key is pressed.

22 Neonatal alarms and troubleshooting

In this section

Alarms

WARNING If an alarm occurs, attend to the patient before troubleshooting or doing any repair procedures.

- A hazard can exist if different alarm settings are used for the same parameter for similar equipment in any single area, such as an intensive care unit.
- The ventilator must not be enclosed in a room where the auditory alarm signals cannot be heard by the clinician.

CAUTION Repairs should only be performed by an authorized service representative. See "*Repair policy*" in the "*Cleaning and maintenance*" section for more information.

Important The alarm light can be seen from all sides of the ventilator, but messages can only be viewed from the front of the ventilator using the display.

During ventilation, there are two types of alarms that can occur, parameter and technical. Parameter alarms occur when the measured patient data is not in the range of the set limits. Technical alarms occur when an error condition is detected within the ventilator. A technical alarm may also occur when data cannot be interpreted or data is not available.

When an alarm occurs during ventilation, the ventilator emits an audible tone, flashes a light on the top of the display unit, and shows the alarm message on the screen.

Note The facility must determine the maximum remote alarm signal generation delay for its distributed alarm system.

Note Current alarm settings will be maintained upon main power interruption, when the system operates using the internal battery. The alarm settings will be lost when both main power and battery are lost, and will change to default settings upon restart of the system.

Alarm management

During ventilation, alarms are managed from the alarm bar, which gives a visual indication of the priority and type of alarm. Use the alarm bar to acknowledge alarms and access alarm settings. When a parameter alarm occurs, the measured data can be selected to quickly access the setting that is out of range.

CAUTION Do not set alarm limits to extreme values that can render the alarm system useless.

Alarm bar

The alarm bar gives a visual indication of parameter and technical alarms. The alarm bar includes audio pause, alarm status, and alarm setup.

- If there are no current active alarms or previous alarms requiring user acknowledgement, the alarm status shows No Alarms and the alarm bar is green. The alarm list is not available.
- If there are active alarms, the alarm status shows the alarm message for the most recent alarm with the highest priority. The alarm bar color shows the priority of the alarm.The alarm list contains a list of all active alarms, as well as previous alarms requiring user acknowledgement.
- If the alarm bar is grey, there are no active alarms but a previous alarm requires user acknowledgement.

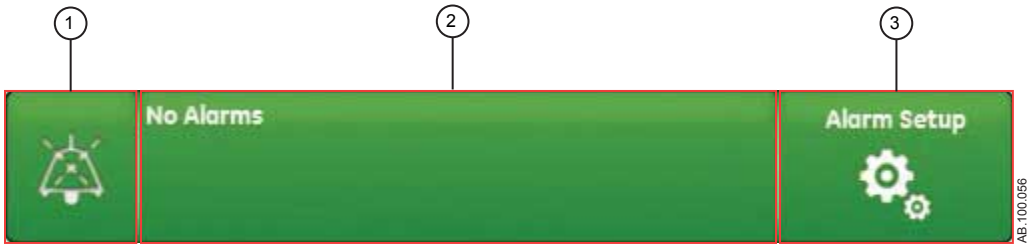


Figure 22-1 • Alarm bar with no active alarms

1. Audio pause
2. Alarm status
3. Alarm setup

Figure 22-2 • Alarm count

1. Audio pause timer
2. Active alarm count

Adjacent to Alarms is a number that shows how many alarms are in the list. Select the alarm status to show the list of alarm messages. The alarm messages are in the order of when the alarm occurred, with the most recent alarm shown at the top of the list. In addition, each alarm in the list has a timestamp to show when it occurred.

When the alarm list is expanded, select the question mark next to an alarm to show details about the alarm. The detailed information gives a description of the cause and what action is necessary to correct the alarm condition. See "*List of alarms*" for more information.

Alarm messages that are grey will show in the list after the condition is corrected and stay until they are viewed in the alarm list. When the list is closed, these messages are removed from the list and are available in the Trend log.

Alarm setup

Alarm limits and other alarm settings can be adjusted in the Alarm Setup menu. Select to show the following alarm limits:

- Ppeak - Low and High
- MVexp - Low and High
- VTexp - Low and High
- RR - Low and High
- FiO2 - Low and High
- Paux High
- PEEPe - Low and High
- Leak Limit High
- Apnea Time

Figure 22-3 • Alarm setup menu

Note Alarm limits for EtCO2, EtO2, and PEEPi are only available when an airway module with these measurement capabilities is installed. If the patient type is Neonatal, these alarm limits are not shown.

Select either the low or high alarm limit on the screen, and then use the Trim Knob to adjust the setting.

- Alarm setting changes that are not confirmed prior to the end of a timeout period are cancelled.

A Super User can set alarm limit defaults. See "*System configuration (Super User) and service*".

1.	Apnea Time	Set Apnea time up to 60 seconds. Apnea time can be turned off in NIV and nCPAP ventilation modes.
2.	Alarm Light Brightness	Set the brightness of the alarm light. The range is 1 (low) to 5 (high).
3.	Alarm Volume	Set the volume of the alarm tone. The range is 1 (low) to 5 (high).
4.	High Alert Audio	Set the delay time in which a high priority alarm must be resolved or acknowledged before the audio tone pitch and volume increase to the maximum level. The range is 0 to 30 seconds or Off. A general message shows when High Alert Audio is set to off.
5.	Alarm Limits	Select the check box to show alarm limits adjacent to the measured data in Basic, Basic Waveforms, Advanced Waveforms, and Splitscreen views. The alarm limit always shows when an alarm occurs for the measured data, even if it is set to Off.

6. Auto Limits — Select to set auto alarm limits based on the current measured data.

Auto limits - Neonatal

Select to change the alarm limits for the following measured data values.

- MVexp – Low and High
- VTexp – Low and High
- Rate – Low and High
- PEEPe – Low and High

The alarm setting change is dependent on the current measured data. An alarm limit set to Off will not change when Auto Limits is selected. The table shows how the alarm limits are calculated from the current measured data to the adjusted setting.

Alarm Setting	Low Limit	High Limit
MVexp	current value x 0.5	current value x 2.5
VTexp	current value x 0.5	current value x 2.5
Rate	current value - 2	current value + 30
PEEPe (cmH2O or mbar)	current value - 5	current value + 5
PEEPe (kPa)	current value - 0.5	current value + 0.5

Alarm priority

Audible and visual indicators tell the priority of the alarm.

Priority	Color	Light	Tone
High	Red	Flashes red	Series of five tones, twice
Medium	Yellow	Flashes yellow	Series of three tones
Low	Blue	Solid blue	Single tone

Note For medium and high priority alarms, the alarm tone is repeated until audio pause is selected or the alarm condition is resolved. When high priority alarms are not resolved within the set high alert audio time limit, the pitch and volume of the tone increases to the maximum audio level. See "*Alarm setup*" for information on how to set High Alert Audio.

When more than one alarm occurs at the same time, the alarm bar, alarm light, and audible alarm tone indicates the highest priority alarm.

The color on the right side of the alarm light shows the priority of the alarm. The left side of the alarm light is blue when audio pause is active.

Some medium priority and high priority alarms are de-escalated and change to low priority alarm when audio pause is selected. To see which alarms can be de-escalated, see "*List of alarms - adult and pediatric*" or "*List of alarms – Neonatal*". Until the de-escalated alarm condition is resolved, the low priority alarm stays active.

Audio pause

Audio pause temporarily mutes the audible tone of an alarm for two minutes.

To pause audio, select the audio pause icon on the alarm bar or press the audio pause hard key on the front of the display. When audio pause is selected, a timer above audio pause in the alarm bar starts to count down from two minutes. If the alarm is still active or a new alarm occurs after the timer expires, the alarm tone becomes audible for the highest priority alarm.

Select audio pause while the timer is counting down to cancel audio pause; the alarm tone then becomes audible.

Important The nurse call alert is off while audio pause is active.

The following alarms are always audible, even if they become active during audio pause:

- Battery error
- Battery in use
- Patient circuit occluded
- Patient disconnected
- Sustained airway pressure
- System shutdown in less than 20 (10, 5, and 1) minutes
- Power supply error

Audio pause will not mute the alarm tone for the folowing alarms:

- Patient detected
- Turn off ventilator?

Secondary audio alarm

If the primary audio alarm fails, the ventilator has a secondary audio alarm as a backup. When the ventilator is initially turned on, the primary and secondary audio each emit an audible tone.

Measured data alarms

When an alarm occurs for measured data, the number and alarm limits are shown with a border around them. The color of the border and the alarm limit (when in the Alarm Setup menu) shows the priority of the alarm. Select within the border of the active alarm to open the Alarm Setup menu. If necessary, use the Trim Knob to adjust the setting for the alarm limit.

Figure 22-4 • Select inside of the border to open the Alarm Setup menu.

List of alarms

Note See Alarms and Troubleshooting and Alarm Tests for additional information about alarms and to see a list of general messages.

These notes apply to the alarm messages in the table below:

- A [1] by the priority indicates an alarm that is enabled when an inspiratory hold is not in progress.
- A [2] by the priority indicates an alarm that is enabled when an expiratory hold is not in progress.
- A [3] by the priority indicates an alarm that is enabled when P 0.1 or NIF procedures are not in progress.
- A [4] by the priority indicates an alarm that is de-escalatable.
- * The removal criteria for an alarm is the removal or reversal of the listed condition.

Alarm	Priority	Condition*	Cause	Action
Air and O2 supply pressure low	High	O2 supply pressure and air supply pressure is less than 24.3 psig for more than 0.5 seconds.	Air supply pressure is low and O2 supply pressure is low.	• Check the Air and O2 connections. • Check the air source. • Check the O2 source. • Prepare to disconnect the patient from the ventilator and manually ventilate.
Air supply pressure high	Low	Air supply pressure is greater than 95 psig for more than 0.5 seconds.	Air supply pressure is high.	• Check the air source. • Set FiO2 to 100%.
Air supply pressure low	Medium[4]	Air supply pressure is less than 24.3 psig for more than 0.5 seconds.	Air supply pressure is low. The ventilator is delivering O2 only. O2 may be leaking into the air supply system.	• Check the Air connection. • Check the air source.
Air supply pressure sensor error	Low	Air supply pressure sensor data is invalid during a non-ventilation state.	The ventilator is not able to measure air supply pressure.	• Perform System Check. • Contact an authorized service representative.
Air temperature high	High	Total flow sensor temperature is above 51° C.	Air supply temperature is high.	• Check the air source. • Clean the compressor filter.
Airway module error	Low	Airway module installed with a neonatal patient type.	Airway modules use is not allowed when patient type is neonatal.	• Remove the airway module.

Alarm	Priority	Condition*	Cause	Action
Airway pressure sensor error	High	The difference between expiratory pressure and inspiratory pressure is greater than 10 cmH2O for more than 350 ms.	Expiratory pressure is greater than inspiratory pressure.	• Check for an occlusion in the expiratory pressure port. • Perform System Check.
		Expiratory pressure sensor data is invalid.	The ventilator is not able to measure expiratory pressure.	• Perform System Check.
		Inspiratory pressure sensor data is invalid.	The ventilator is not able to measure inspiratory pressure.	• Perform System Check.
	Low	Zeroing of expiratory pressure sensor data was out of range for 3 consecutive zeroing attempts.	The ventilator is not able to measure expiratory pressure.	• Perform System Check.
		Zeroing of inspiratory pressure sensor data was out of range for 3 consecutive zeroing attempts.	The ventilator is not able to measure inspiratory pressure.	• Perform System Check.
Alarm light error	Medium[4]	An error was detected with the alarm light.	The alarm light is not working.	• Cycle power. • Contact an authorized service representative.
Apnea	High[1, 2]	No valid breaths were detected for the set Apnea Time.	Expired tidal volume not detected within the set Apnea Time.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the Apnea Time setting in Alarm Setup.
Apnea alarm off	Medium[4]	Apnea Time selection is Off.	Apnea Time is set to Off.	• Review the Apnea Time setting in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
Backup ventilation on	Medium	Apnea has been detected.	Apnea detected. Backup ventilation is being delivered.	• Check the status of the patient. • Review the ventilator settings. • Confirm the current mode in Mode Settings to continue using backup ventilation settings. • Select Previous Mode in Mode Settings to end backup ventilation and return to the settings used prior to entering backup ventilation. • Confirm a different mode in Mode Settings to end backup ventilation.
	Medium[1, 2]	Measured expired minute volume is less than 50% of the MVexp low alarm limit.	Low expired minute volume detected. Backup ventilation is being delivered.	• Check the status of the patient. • Review the ventilator settings. • Confirm the current mode in Mode Settings to continue using backup ventilation settings. • Select Previous Mode in Mode Settings to end backup ventilation and return to the settings used prior to entering backup ventilation. • Confirm a different mode in Mode Settings to end backup ventilation.
Barometric pressure sensor error	Low	Barometric pressure data is invalid.	The ventilator is not able to measure barometric pressure.	• Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
Battery error	Medium[4]	Battery power is not available due to one of the following issues: • Battery charge failed • Battery failed • Battery missing • Battery not connected • Battery connection is reversed • Power system self-test failed • Battery is degraded • Battery current was too high while the power switch was off	Battery power is not available. Ventilation will stop if main power supply is lost.	• Contact an authorized service representative.
		No battery power is detected due to one of the following issues: • Power system communication error. • The battery is not charging properly.	No battery power detected. Ventilation may stop if main power supply is lost.	• Contact an authorized service representative.
Battery in use	Medium[4]	The system has been powered by internal battery for more than 3 seconds.	Main power supply is not available. The ventilator is powered by the battery.	• Prepare to disconnect the patient from the ventilator and manually ventilate. • Connect to main power supply. • Contact an authorized service representative.
		Mains power is unavailable and the remaining internal battery time is less than 30 minutes.	Main power supply is not available. The ventilator is powered by the battery.	• Connect to main power supply.
		Batteries are discharging while the ventilator is plugged in.	Main power supply is not available. The ventilator is powered by the battery.	• Check main power supply connections.
Circuit leak	High	Measured leak is greater than the set Leak limit while the patient is connected.	Leak % is greater than the set Leak Limit.	• Check for leaks in the patient circuit or airway. • Review the Leak Limit setting in Alarm Setup. • Clean or replace the expiratory flow sensor.

Alarm	Priority	Condition*	Cause	Action
Circuit leak alarm off	Medium[4]	Leak Limit is set to Off.	Leak Limit is set to Off.	• Review the Leak Limit setting in Alarm Setup.
Cooling fan error	High	A power system component has overheated.	Ventilator is overheating. Ventilation may stop.	• Clean the ventilator unit fan filter. • Contact an authorized service representative.
	Medium[4]	There is a problem with the display cooling fan due to one of the following issues: • An internal display board has overheated • Display fan speed is too low	The system detected a display cooling fan error.	• Contact an authorized service representative.
		Power system cooling fan failed.	The system detected a display cooling fan error. The system may overheat and stop ventilation.	• Contact an authorized service representative.
Expiratory flow sensor error	High	Expiratory flow sensor communications failed.	The ventilator is not receiving data from the expiratory flow sensor. Flow and volume measurements may not be available.	• Replace the expiratory flow sensor. • Contact an authorized service representative.
		The Expiratory flow sensor is not connected.	The expiratory flow sensor is not detected.	• Install the expiratory flow sensor. • Check the expiratory flow sensor connection. • Replace the expiratory flow sensor.
	Medium[4]	• For a Neonatal patient, measured expired tidal volume is greater than the measured inspired tidal volume by 20% or 18 ml, whichever is greater for 6 consecutive breaths	Expiratory flow sensor measurement is high.	• Check for additional flow into the patient circuit. • Clean or replace the expiratory flow sensor.

Alarm	Priority	Condition*	Cause	Action
FiO2 high	High	Measured FiO2% is higher than the FiO2 high alarm limit.	Inspired O2 is greater than the high alarm limit.	• Check for additional O2 flow into the patient circuit. • Review the FiO2 high alarm limit in Alarm Setup. • Perform System Check. • Perform airway module calibration.
FiO2 low	High	Measured FiO2% is lower than the FiO2 low alarm limit.	Inspired O2 is less than the low alarm limit.	• Check the O2 connection. • Check the O2 source. • Review the FiO2 low alarm limit in Alarm Setup. • Perform System Check. • Perform airway module calibration.
FiO2 sensor error	Medium[4]	FiO2 cannot be measured due to one of the following issues: • O2 sensor data is invalid. • There is a communication error with the O2 sensor.	The ventilator is not able to measure FiO2.	• Perform System Check.
Flow control valve error	High[4]	Insufficient inspiratory flow is being measured by the total flow sensor for 65 seconds.	The ventilator is not delivering flow.	• Prepare to disconnect the patient from the ventilator and manually ventilate. • Check the Air and O2 connections. • Check the air source. • Check the O2 source. • Contact an authorized service representative.
Hard keys or trim knob error	High	Key pad failed to communicate for greater than 10 seconds.	The system detected a hard key or Trim Knob error.	• Cycle power. • Contact an authorized service representative.
Inspiratory flow sensor error	High[4]	Total flow sensor communications failed.	The ventilator is not receiving data from the total flow sensor. Flow and volume measurements may not be available.	• Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
	Medium[4]	Air Flow sensor communications failed.	The ventilator is not receiving data from the Air flow sensor. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
		O2 Flow sensor communications failed.	The ventilator is not receiving data from the O2 flow sensor. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
Inspiratory temperature sensor error	Low	Air temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure air flow temperature. The delivered FiO2 may not match the set FiO2.	• Set FiO2 to 100%.
		O2 temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure O2 flow temperature. The delivered FiO2 may not match the set FiO2.	• Contact an authorized service representative.
		Total flow temperature sensor failed during a non-ventilation state.	The ventilator is not able to measure total flow temperature.	• Contact an authorized service representative.
MVexp high	High	Measured expired minute volume is greater than the MVexp high alarm limit.	Expired minute volume is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the MVexp high alarm limit in Alarm Setup.
MVexp low	High[1, 2]	Measured expired minute volume is less than the MVexp low alarm limit while the patient is connected.	Expired minute volume is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the MVexp low alarm limit in Alarm Setup.
MVexp low alarm off	Medium[4]	MVexp low alarm selection is Off.	MVexp low alarm limit is set to Off.	• Review the MVexp low alarm limit in Alarm Setup.
Nebulizer not connected	Low	The Aerogen Nebulizer procedure is active but the nebulizer is not connected.	The nebulizer cable is not detected.	• Connect the nebulizer and cable.

Alarm	Priority	Condition*	Cause	Action
Negative airway pressure	High[3]	Inspiratory pressure is below -10 cmH2O for more than 50 continuous ms.	The ventilator detected negative airway pressure from the patient.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Review the Insp Trigger setting in Mode Settings.
Neonatal flow sensor error	High	Neonatal flow sensor error can be caused by one of the following issues: • The expired tidal volume measured by the expiratory flow sensor is 20% or 5 ml (whichever is greater) more than the expired tidal volume measured by the neonatal flow sensor, for 6 breaths. • The inspired tidal volume measured by the neonatal flow sensor is 30% or 30 ml (whichever is greater) more than the inspired tidal volume measured by the ventilator inspiratory flow sensor, for 6 breaths. • The expired tidal volume measured by the neonatal flow sensor is 30% or 5 ml (whichever is greater) more than the inspired tidal volume measured by the neonatal flow sensor, for 6 breaths.	Neonatal flow sensor measurement is not correct.	• Check for additional flow into the patient circuit. • Clean or replace the neonatal flow sensor.
		Neonatal flow sensor is not measuring flow as expected.	The ventilator is not able to measure flow from the neonatal flow sensor. Flow and volume measurements are not available.	• Replace the neonatal flow sensor. • Remove the neonatal flow sensor and set the Data Source to Ventilator.

Alarm	Priority	Condition*	Cause	Action
		Inspiratory tidal volume measured by the neonatal flow sensor is below -3 ml for 6 consecutive mechanical breaths or 16 seconds, whichever is longer.	Neonatal flow sensor is not installed correctly.	• Reverse the direction of the neonatal flow sensor. • Clean or replace the neonatal flow sensor.
		Neonatal flow sensor is not detected.	Data Source is Neonatal Flow Sensor, but a neonatal flow sensor is not detected. Flow and volume measurements are not available.	• Check the neonatal flow sensor connection. • Calibrate the neonatal flow sensor. • Replace the neonatal flow sensor. • Remove the neonatal flow sensor and set the Data Source to Ventilator.
	Medium	Neonatal flow data from the neonatal flow sensor is invalid.	There is debris in the neonatal flow sensor. Flow and volume measurements are not available.	• Clean or replace the neonatal flow sensor. • Remove the neonatal flow sensor and set Data Source to Ventilator.
	Low	Neonatal flow sensor is not detected, and ventilator is Standby.	Data Source is Neonatal Flow Sensor, but a neonatal flow sensor is not detected. Flow and volume measurements are not available.	• Check the neonatal flow sensor connection. • Calibrate the neonatal flow sensor. • Remove the neonatal flow sensor and set the data source to ventilaotr. • Replace the neonatal flow sensor
Neonatal flow sensor not in use	Medium[4]	Data source is set to Ventilator while the patient type is Neonatal and the ventilation mode is invasive.	Patient type is Neonatal, but Data Source is not set to Neonatal Flow Sensor. Low flow and volume measurements are less accurate from the ventilator sensor.	• Set Data Source to NFS.
O2 supply pressure high	Low	O2 supply pressure is greater than 95 psig for more than 0.5 seconds.	O2 supply pressure is high.	• Check the O2 source. • Set FiO2 to 21%.
O2 supply pressure low	Medium[4]	O2 supply pressure is less than 24.3 psig for more than 0.5 seconds.	O2 supply pressure is low. The ventilator is delivering Air only. Air may be leaking into the O2 supply system.	• Check the O2 connection. • Check the O2 source.

Alarm	Priority	Condition*	Cause	Action
O2 supply pressure sensor error	Low	O2 supply pressure sensor data is invalid while not in therapy.	The ventilator is not able to measure O2 supply pressure.	• Perform System Check. • Contact an authorized service representative.
Patient circuit occluded	High	An occlusion in the patient circuit was detected.	Inspiratory pressure is greater than expiratory pressure.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Replace the inspiratory safety guard.
Patient connection leak	High	Leak measured by the neonatal flow sensor is greater than the set leak limit.	Leak % is greater than the set Leak Limit.	• Check for leaks in the patient airway. • Review the Leak Limit setting in Alarm Setup. • Clean or replace the neonatal flow sensor.
Patient detected	High	A patient connection is detected while in Standby with the circuit not parked.	A patient connection is detected.	• Start ventilation if a patient is connected. • Select Park Circuit if a patient is not connected.
Patient disconnected	High	Patient is disconnected.	Low expiratory pressure or flow detected.	• Check the status of the patient. • Check for leaks in the patient circuit. • Review the Tdisconnect setting in Alarm Setup.
Paux high	Medium	Auxiliary pressure is greater than the Paux high alarm limit.	Paux is greater than the high alarm limit	• Review the Paux high alarm limit in Alarm Setup.
Paux sensor error	Low[3]	Auxiliary pressure sensor data is invalid.	The ventilator is not able to measure auxiliary pressure.	• Remove the auxiliary pressure line from the patient circuit. • Zero the auxiliary pressure sensor.
	Low	Auxiliary pressure sensor zero procedure failed.	The ventilator is not able to measure auxiliary pressure.	• Remove the auxiliary pressure line from the patient circuit. • Zero the auxiliary pressure sensor.

Alarm	Priority	Condition*	Cause	Action
PEEPe high	Medium	Measured PEEPe is greater than the PEEPe high alarm limit.	PEEPe is greater than the high alarm limit.	• Review the ventilator settings. • Review the PEEPe high alarm limit in Alarm Setup.
PEEPe low	High	Measured expiratory pressure is less than the PEEPe low alarm limit for 2 seconds while in nCPAP mode	Airway pressure is less than the PEEPe low alarm limit.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the PEEPe low alarm limit in Alarm Setup.
	Medium[2]	Measured PEEPe is less than the PEEPe low alarm limit.	Airway pressure is less than the PEEPe low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit. • Review the ventilator settings. • Review the PEEPe low alarm limit in Alarm Setup.
Plimit reached	Medium[4]	Peak airway pressure has reached the set Plimit.	Peak airway pressure reached Plimit.	• Review the ventilator settings. • Review the pneumatic nebulizer Flow setting. • Review the Plimit setting in Mode Settings.
Power supply error	High	Power supply is failing.	Main power supply is not available. The ventilator is powered by the battery.	• Prepare to disconnect the patient from the ventilator and manually ventilate. • Check main power supply connections. • Contact an authorized service representative.
Ppeak high	High	Measured airway pressure is greater than Pmax.	Airway pressure is greater than Pmax.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Review the ventilator settings. • Review Pmax or the Ppeak high alarm limit in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
Ppeak low	High[2]	Measured peak airway pressure is less than the Ppeak low alarm limit.	Peak airway pressure is less than the low alarm limit.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the Ppeak low alarm limit in Alarm Setup.
Primary audio error	High[4]	An error was detected with the speaker.	The primary audio speaker is not working. (The backup buzzer sounds during this alarm.)	• Contact an authorized service representative.
Relief valve opened	High	Valid pressure data reached an extreme level in the patient circuit.	High airway pressure detected. Ventilator opened relief valve to relieve pressure.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Review the ventilator settings. • Review Pmax or the Ppeak high alarm limit in Alarm Setup. • Replace the inspiratory safety guard.
RR high	Medium	Measured respiratory rate is greater than the RR high alarm limit.	Respiratory rate is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the RR high alarm limit in Alarm Setup.
RR low	High[1, 2]	Measured respiratory rate from the ventilator is less than the RR low alarm limit.	Respiratory rate is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the RR low alarm limit in Alarm Setup.

Alarm	Priority	Condition*	Cause	Action
SBT completed successfully	Low	The SBT time remaining expired.	Spontaneous Breathing Trial has completed successfully. The ventilator has returned to the settings used prior to entering SBT.	• None.
SBT ended	Medium	Apnea was detected during an SBT.	Apnea detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		High expired minute volume was detected during an SBT.	High expired minute volume detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		Low expired minute volume was detected during an SBT.	Low expired minute volume detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		High respiratory rate was detected during an SBT.	High respiratory rate detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
		Low respiratory rate was detected during an SBT.	Low respiratory rate detected.	• Check the status of the patient. • Select Resume SBT in Mode Settings to continue the SBT. • Select confirm in Mode Settings to end the SBT.
Secondary audio error	Medium[4]	The backup buzzer did not sound during power-up.	The secondary audio speaker is not working.	• Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
Sustained airway pressure	High[1]	Measured airway pressure is greater than PEEP + 10 cmH2O or Plow + 10 cmH2O for greater than 15 seconds.	High airway pressure detected for greater than 15 seconds.	• Check for an occlusion in the patient circuit. • Check for an occlusion in the patient circuit filters. • Check for an occlusion in the expiratory flow sensor. • Replace the inspiratory guard filter.
System shutdown in less than 1 minute	High	Mains power is unavailable and the remaining internal battery time is less than 1 minute.	Battery time is less than 1 minute.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 5 minutes	High	Mains power is unavailable and the remaining internal battery time is less than 5 minutes.	Battery time is less than 5 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 10 minutes	High	Mains power is unavailable and the remaining internal battery time is less than 10 minutes.	Battery time is less than 10 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
System shutdown in less than 20 minutes	Medium[4]	Mains power is unavailable and the remaining internal battery time is less than 20 minutes.	Battery time is less than 20 minutes.	• Connect to main power supply. • Prepare to disconnect the patient from the ventilator and manually ventilate.
Tidal volume not delivered	Medium[4]	Ventilator has delivered 20% more tidal volume than the set tidal volume for 6 breaths.	Delivered tidal volume is less than the set tidal volume for six consecutive breaths.	• Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the pneumatic nebulizer Flow setting.
Turn off ventilator?	High	Power switch is switched Off while ventilation is being delivered.	Power switch is switched Off while ventilation is being delivered.	• Turn ventilator system switch On. • Contact an authorized service representative.

Alarm	Priority	Condition*	Cause	Action
Ventilation not available	High	During the most recent system check, the safety value could not sufficiently relieve pressure.	Relief valve failed to relieve patient circuit pressure during System Check.	• Perform System Check. • Contact an authorized service representative.
VTexp high	Medium	Measured expired tidal volume is greater than the VTexp high alarm limit.	Expired tidal volume is greater than the high alarm limit.	• Check the status of the patient. • Review the ventilator settings. • Review the VTexp high alarm limit in Alarm Setup.
VTexp low	Medium	Measured expired tidal volume was less than the VTexp low alarm limit for 3 breaths.	Expired tidal volume is less than the low alarm limit.	• Check the status of the patient. • Check for leaks in the patient circuit or airway. • Review the ventilator settings. • Review the VTexp low alarm limit in Alarm Setup.

Alarm filters

When an alarm is active and another similar alarm becomes active, the original alarm may be filtered or (removed) from the alarm list.

Alarm Filters	
Active Alarm	**Filtered (removed) Alarms**
Expiratory flow sensor error	VTexp low
	VTexp high
	MVexp high
	MVexp low
System shutdown in less than 1 minute	System shutdown in less than 5 minutes
	System shutdown in less than 10 minutes
	System shutdown in less than 20 minutes
	Battery in use
System shutdown in less than 5 minutes	System shutdown in less than 10 minutes
	System shutdown in less than 20 minutes
	Battery in use

Alarm Filters	
Active Alarm	**Filtered (removed) Alarms**
System shutdown in less than 10 minutes	System shutdown in less than 20 minutes
	Battery in use
System shutdown in less than 20 minutes	Battery in use
Neonatal flow sensor error	VTexp low
	VTexp high
	MVexp low
	MVexp high
	Patient connection leak
Air and O2 supply pressure low	Air supply pressure low
	O2 supply pressure low
	Inspiratory flow sensor error
	Flow control valve error
Apnea	VTexp low
	VTexp high
	MVexp low
	MVexp high
	RR low
Patient Connection Leak	Circuit leak
Ppeak low	Neonatal flow sensor error
Patient Disconnected	No patient effort
	Apnea
	Ppeak low
	VTexp low
	MVexp low
	RR low
	Circuit Leak
	Patient Connection Leak
	FiO2 low
Ppeak high	Ppeak low
Relief valve opened	Ppeak low

Alarm delays

Delay	Alarm
10 seconds since the last “Backup ventilation on” alarm was active	Backup ventilation on (due to Apnea or MVexp)
10 seconds since the last ventilation mode change	Backup ventilation on (due to Apnea)

Delay	Alarm
10 seconds upon transition to therapy	Patient disconnect
	PEEPe low (nCPAP)
60 seconds after an inspiratory or expiratory hold procedure	Backup ventilation on (due to MVexp)
	MVexp low
	RR low
	FiO2 high
	FiO2 low
60 seconds since last FiO2 setting change	FiO2 high
	FiO2 low
60 seconds since the last vent mode change	Backup ventilation (due to MVexp)
60 seconds since the start of the SBT	SBT ended (due to MVexp or RR)
60 seconds upon transition to therapy	Backup ventilation on (due to MVexp)
	FiO2 high
	FiO2 low
	MVexp high
	MVexp low
	PEEPe high
	PEEPe low
	RR low
	VTexp high
	VTexp low
60 seconds since the data source was changed to the Neonatal Flow Sensor	MVexp high
	MVexp low

Battery status

The following icons indicate what type of power the ventilator is operating on. These icons show in the bottom right-hand side of the display.

		
Main power	Battery power	No battery available or battery error

The battery icon shows when the ventilator is not connected to the main power. The color of the battery icon shows the approximate amount of time remaining on battery power.

Select the battery icon to see a status bar of the approximate battery charge. The color of the status bar shows the approximate amount of time remaining on battery power.

Use the following table to define the color of the battery icon and the status bar:

Color	**Time remaining on battery power**
Green	More than 20 minutes
Yellow	Between 10 and 20 minutes
Red	Less than 10 minutes

- The “No battery” icon shows when there is a battery error or battery power is not available.

  The Battery in use alarm becomes active when the ventilator changes from main power to battery power. If the ventilator continues to operate on battery power, it alarms to signal that approximately 20, 10, 5, and 1 minute of battery power is available. See "*List of alarms*" or "*List of alarms – Neonatal*" in the Alarms and Troubleshooting section for more information on battery alarms.

Internal errors

The ventilator is able to detect internal hardware or software errors.

If an internal error occurs while ventilating a patient, the ventilator will continue ventilating the patient with the current settings and show this message on the display:

- Ventilator failure. Prepare to disconnect the patient from the ventilator and manually ventilate. Contact an authorized service representative.

If an internal error is detected when the ventilator is initially turned on, one of the following messages is shown:

- No bootable device.
- Watchdog circuit failed.
- CPU data cache.
- RAM memory error.
- System Reset: ECxx xx xx.
- No bootable image available.
- Program load failed – CRC.
- Alarm speaker not detected.
- RTC date/time error.
- CPU Board Supply Voltage Out of Range.
- CMOS battery is weak.

If any of these internal error messages are shown, contact an authorized service representative and do not use the ventilator.

Troubleshooting

The table lists possible problems that could occur when using the ventilator. If a problem occurs that is not listed, see "*Repair policy*" in the "*Cleaning and maintenance*" section for more information.

Symptom	Problem	Solution
The main power indicator is not on.	The electrical power cord is not connected correctly.	• Connect the power cord. • Loosen the power cord retaining clamp and make sure plug is fully seated. Then tighten the retaining clamp.
	The inlet circuit breaker (switch) is off.	Turn the circuit breaker on.
	The power cord is damaged.	Replace the power cord.
	The electrical outlet that the power cord is connected to has no power.	Use a different electrical outlet.
	An internal fuse is open.	Contact an authorized service representative to repair the ventilator.
	The display unit cable is loose.	Turn the ventilator switch off, and then disconnect from the main power. Check and tighten the display unit connectors.
Ventilator cannot be turned off.	The ventilator is not in Standby.	Set the ventilator to Standby, and then turn the system off.
Backup audio alarm turns on.	A system failure has occurred.	Contact an authorized service representative to repair the ventilator.
	The display unit cable is loose.	Turn the ventilator switch off, and then disconnect from the main power. Check and tighten the display unit connectors.
An alarm shows although the data is within range.	The alarm is from the ventilator but the value shown is from the airway module. (Not applicable for neonatal.)	• Calibrate the airway module. • Go to Menu > System and change the selection for Data Source.
	The Ppeak high alarm conditions are checked before the display view is updated.	No action required. In some situations the ventilator will react to a transient high pressure before the data can be sampled and shown on the display.
Ventilator does not deliver set VT in A/C VC or SIMV VC modes.	The Plimit setting prevents the full VT from being delivered in the inspiratory period.	• Change the VT setting. • Change the Plimit setting.
Ventilator does not deliver set VT in A/C PRVC, SIMV PRVC, or BiLevel VG modes.	Pmax alarm limit is limiting delivered inspiratory pressure.	• Change the VT setting. • Change the Pmax setting.
	The ventilator is at minimum allowed delivery.	• Change the VT setting. • Change the Pmin setting.

Symptom	Problem	Solution
Ventilator transitions to Backup mode.	MVexp low, Apnea alarm, RR alarm, and insufficient patient ventilation.	Change ventilation settings.
Short delay in the breath cycle at the PEEP pressure level.	Automatic pressure transducer zeroing interference.	No action required. The situation will be corrected when zeroing is complete.
	Automatic flow sensor zeroing interference.	
Ventilator is automatically triggering a breath.	The breathing circuit leak rate is higher than the flow trigger level.	• Enable Trigger Compensation. • Check the breathing circuit for leaks. • Turn Leak Comp On. • Increase the Flow triggering level or change from Flow triggering to Pressure triggering. • Make sure the correct patient type is selected.
VT, compliance and resistance values are not accurate.	System Check was not done with the current patient circuit.	Complete System Check with the same breathing circuit that will be used on the patient.
	Flow sensors are dirty	• Clean expiratory flow sensor. • Clean neonatal flow sensor. • Replace D-lite flow sensor. • Replace D-lite spirometry sensing lines. • Calibrate gas module.
System Check fails.	Water trap on the exhalation valve is not on tightly.	Make sure the water trap is tightly secured.
	Patient circuit not connected to the ventilator.	Attach the patient circuit to the inspiratory and expiratory ports.
	Patient wye is not occluded correctly.	Make sure the patient wye is occluded completely with the leak test plug.
	Expiratory flow sensor has failed.	Clean or replace the flow sensor. Make sure flow sensor is connected correctly.
	Exhalation valve and seals are not seated correctly.	Remove and replace the exhalation valve.
	A connection port on the patient circuit is open.	Make sure all connection ports are occluded.
	Leak in patient circuit is very large.	Check the breathing circuit for leaks.
	System Check was stopped before it completed.	Do a System Check and let it complete.
Touchscreen does not respond.	The touchscreen is locked.	Press the Lock hard key at the bottom of the display unit.
	The touchscreen requires calibration or repair.	Contact an authorized service representative to repair the ventilator.

nCPAP Troubleshooting

Symptom	Problem	Solution
Auto-triggering.	Trigger setting is too sensitive.	• Increase the Insp Trigger setting. • Set a pressure Insp Trigger. • Enable trigger compensation. • Check the patient interface. • Check the expiratory flow sensor.
No triggering or missed triggers.	Trigger setting is not sensitive enough.	• Decrease the flow Insp Trigger setting. • Increase the pressure Insp Trigger setting.

General messages

General messages show notices, procedures status information, and system status information to the user. General messages show in the lower left corner of the display. The general messages are listed in order of priority from highest to lowest as shown in the following table.

A [1] indicates a countdown timer is shown with the general message.

General Message
Inspiratroy hold active
Expiratory hold active
Snapshot created
Snapshot deleted
Oxygenation[1]
Nebulizer[1]
Nebulizer flow compensation on
SBT[1]
Suction[1]
Suction oxygenation[1]
High Alert Audio off
Assist control off
Tube compensation on
Leak compensation on
Bench configuration. Not for patient use.
Calibration required.
NFS calibration required.

23 Neonatal patient monitoring

In this section

Note See the "*Patient monitoring*" section for additional information.

Patient data and waveforms

Neonatal measured data definitions

The ventilator and accessories are capable of measuring various neonatal patient data. This patient data is shown in patient monitoring views.

Note Some measured data can be viewed with different units. Set unit preferences in the ***Configuration*** > ***Units*** menu in the "*System configuration (Super User) and service*" section.

Gases Data	**Definition**	**Unit**
FiO2	The percentage of oxygen that the ventilator delivers to the patient.	%

Pulmonary Data	**Definition**	**Unit**
C	The compliance of the patient's respiratory system measured during the breath cycle.	ml/cmH2O, ml/kPa, or ml/mbar
Raw	The average inspiratory and expiratory airway resistance measured during the breath cycle.	cmH2O/l/s, kPa/l/s, or mbar/l/s
Time Constant	The time needed for the lungs to deflate by a certain amount or a percentage of volume. • One Time Constant allows 63% of volume to be exhaled. • Two Time Constants allows for 86% of volume to be exhaled. • Three Time Constants allows for 95% of volume to be exhaled. • Four Time Contants allows for 98% of volume to be exhaled.	ms

Mechanical/ Spontaneous Data	**Definition**	**Unit**
MVexp spont	The volume of gas the patient exhales per minute with spontaneous breaths.	l/min
RR spont	The number of spontaneous breath cycles the patient completes per minute.	/min
VTexp spont	The volume of gas the patient exhales with a spontaneous breath.	ml

Mechanical/ Spontaneous Data	Definition	Unit
MVexp mech	The volume of gas the patient exhales per minute with mechanical breaths.	l/min
RR mech	The number of mechanical breath cycles the patient completes per minute.	/min
VTexp mech	The volume of gas the patient exhales with a mechanical breath.	ml

Per Weight Data	Definition	Unit
Weight	The entered weight of the patient.	kg
MVexp/kg	The volume of gas the patient exhales per minute per patient weight.	l/min/kg
VTexp/kg	The volume of gas the patient exhales in a breath per patient weight.	ml/kg
MVexp spont/kg	The volume of gas the patient exhales per minute with spontaneous breaths per patient weight.	l/min/kg
VTexp spont/kg	The volume of gas the patient exhales in a spontaneous breath per patient weight.	ml/kg
C/kg	The dynamic compliance of the patient's lungs per patient weight.	ml/kPa/kg, ml/cmH_2O/kg, or ml/mbar/kg

Spirometry Data	Definition	Unit
Ppeak	The highest pressure level measured during the inspiratory phase.	cmH_2O, kPa, or mbar
Pplat	The pressure level measured after the inspiratory phase and before the expiratory phase (during an inspiratory pause).	cmH_2O, kPa, or mbar
Pmean	The average pressure level measured during the breath cycle.	cmH_2O, kPa, or mbar
PEEPe	The low pressure that the system maintains on the patient's airway at the end of the expiratory phase.	cmH_2O, kPa, or mbar
VTinsp	The volume of gas the patient inhales.	ml
MVinsp	The volume of gas the patient inhales per minute.	l/min
VTexp	The volume of gas the patient exhales.	ml
MVexp	The volume of gas the patient exhales per minute.	l/min
Leak	The percentage of volume leaked from the patient circuit.	%

Timing Data	Definition	Unit
I:E	The ratio of inspiratory time to expiratory time.	N/A
Tinsp	The duration of the inspiratory phase of the breath cycle.	s

Timing Data	Definition	Unit
Texp	The duration of the expiratory phase of the breath cycle.	s
RR	The number of breath cycles a patient completes per minute.	/min
Cycle Time	The sum of the duration of inspiratory and expiratory phases.	s

Waveform settings

Access waveform settings

All waveforms and spirometry loops are configured by selecting the Settings icon located in the right-hand corner of the waveform.

1. Select the waveform or spirometry loop.

   The settings menu displays with the Settings icon in the upper right-hand corner.
2. Select the Settings icon.
3. Configure or adjust the desired settings.

Waveform Settings	
Style	Solid or Outline
Speed	Fast or Slow
Color	White, Green, Red, Yellow, or Blue
Scaling	Auto or Manual

Spirometry Loop Settings	
Scaling	Auto or Manual

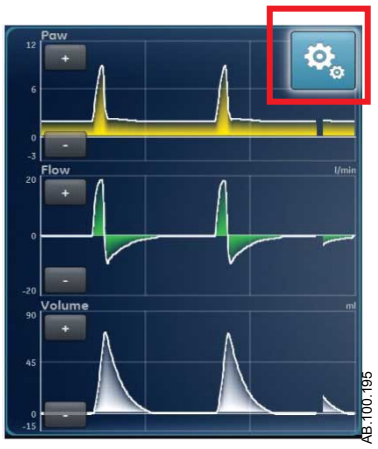


Figure 23-1 • Select the Settings icon to access waveform settings

Waveform field configuration

Use the Waveform Settings menu in the Basic Waveforms, Advanced Waveforms, and Splitscreen views to set up to four wave fields. The waveforms can be set to Off, Paw, Volume, Flow, and Paux.

Waveform style

On the Waveform Settings menu, waveforms can be set as one of the following styles:

- Solid: the waveform curve or loop is filled with the set color.
- Outline: the waveform curve or loop is shown as a line in the set color.

Waveform speed

On the Waveform Settings menu, waveform curves and loops can be set to Fast or Slow. The Fast setting travels at twice the speed of Slow.

Waveform color

On the Waveform Settings menu, measured data can be set to show as one of the following colors:

- White
- Green
- Red
- Yellow
- Blue

Waveform and spirometry loop scaling

The range of values shown for each waveform can be set automatically or manually.

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.

- Manual: Adjust the scaling controls to increase or decrease the scale of the waveform.

Manual adjustments to waveform scaling can be made when scaling is set to Auto. When a manual adjustment is made, the scaling setting changes to Manual.

Note Paw, Flow, and Volume scaling settings are available in both the Waveform Settings and Spirometry Settings menus. When set in either menu, they apply to both waveforms and spirometry loops.

Spirometry settings

Configure spirometry loops - Neonatal

On the Spirometry Settings menu, the Splitscreen view can be customized to display up to two spirometry loops or sets of measured data with data specified in the following table.

Wave Field	Options
Wave fields 1 and 2	P-V
	F-V
	P-F
	Spirometry
	Mech/Spont
	Per Weight
	Pulmonary
	Breath Timing

Waveform and spirometry loop scaling

The range of values shown for each waveform can be set automatically or manually.

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.
- Manual: Adjust the scaling controls to increase or decrease the scale of the waveform.

Manual adjustments to waveform scaling can be made when scaling is set to Auto. When a manual adjustment is made, the scaling setting changes to Manual.

Note Paw, Flow, and Volume scaling settings are available in both the Waveform Settings and Spirometry Settings menus. When set in either menu, they apply to both waveforms and spirometry loops.

Reading waveforms

Waveforms are dynamic illustrations of patient respiratory data received by the ventilator or neonatal flow sensor.Waveform curves show data collected during the breath cycle. As the ventilator or patient initiates a breath, a waveform curve appears on the graph. In the following figure, the periods between breaths show a lack of flow and volume as the system maintains the set PEEP level.

- The Y-axis represents the range of values for the data shown.
- The X-axis represents time.

Paw and Flow waveforms are colored orange when a patient makes a spontaneous breathing effort.

- When a patient draws a spontaneous, patient-controlled breath, Paw and Flow waveform curves are colored orange from the Insp trigger until the end of the inspiratory phase (Exp trigger).
- When a patient initiates a system-controlled breath, Paw and Flow waveform curves are colored orange for a short time following the inspiratory trigger.

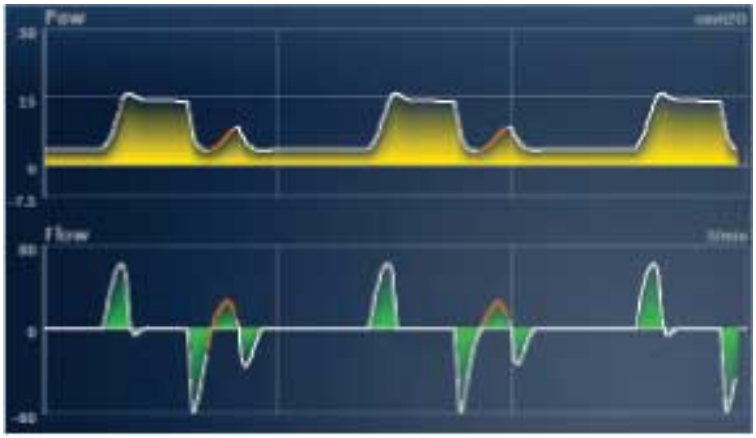


Figure 23-2 • Paw and Flow waveforms

Possible units used for the measured data are shown in the following table.

Data Type	**Unit**
Airway Pressure (Paw)	cmH2O
	mbar
	kPa
Volume	ml
Flow	l/min

Data Type	Unit
Auxiliary Pressure (Paux)	cmH2O
	mbar
	kPa

See "*Configuring units*" in the "*Configuration menu (Super User)*" section.

Reading spirometry loops

Spirometry curves are drawn on the graph as loops. A spirometry loop shows two types of measured data on the Y and X axes. The graph can show three different types of loops:

- Paw-Volume (P-V): Volume is shown on the Y axis and pressure on the X axis.
- Paw-Flow (P-F): Flow is shown on the Y axis and volume on the X axis.
- Pressure-Flow (Paw Flow): Flow is shown on the Y axis and pressure on the X axis.

Figure 23-3 • Splitscreen view

Neonatal Trends

Airway module trend data is unavailable for neonatal patients.

Note If the patient type was changed from pediatric to neonatal, airway module trend data is available during the period set to pediatric.

Trends workspace - Neonatal

Use the Trends workspace to view patient data trends.

The following trends views are available:

- Graphical trends
- Numerical trends
- Trend log
- Snapshot trends

Figure 23-4 • Graphical trends view

1.	Trends timeline	Shows the past 72 hours of data. See "*Trends timeline - Neonatal*" for more information.
2.	Guide setting	When set, shows MVexp, RR, or Ppeak data plotted on the timeline.
3.	Timeline cursor	Highlights the set period on the timeline. The timeline cursor range can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours.
4.	Trends list	Shows data based on the selected trends view. The trends list shows the period of trending data highlighted by the timeline cursor.
5.	Trends list cursor	Can be moved throughout the period shown to specific data points.

Review trends

1. Access one of the trends views.
   - Graphical trends
   - Numerical (Measured data) trends
   - Trends log

- Snapshot trends

2. Set a time period on the trends timeline cursor.
3. Position the timeline cursor to highlight the time period to show on the trends list.
4. Move the trends list cursor to review the data at specific points in time.

Trends timeline

In the Graphical, Numerical, and Trends log views, the trends timeline shows the past 72 hours of data. The Guide setting plots data points on the timeline for one of the following data types when selected:

- MVExp
- RR
- Ppeak

Figure 23-5 • Trends timeline with RR data plotted

The timeline cursor can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours. The period highlighted on the timeline is the period shown in the trends list.

When alarms have occurred during the period shown on the timeline, the alarm priority color is displayed for the duration of the alarm.

- Data curves are colored yellow for the duration of medium priority alarms.
- Data curves are colored red for the duration of active high priority alarms.
- If medium and high priority alarms overlap, the data curve is colored red for the duration of the overlap.

Graphical trends view

The Graphical trends view shows plotted data for the period selected on the timeline. A dashed line extends from the cursor and intersects the data plotted on the Graphical trends view. At the points of intersection, data values are shown. If an alarm is active at the point

of intersection, the data value is colored for the alarm priority. Move the trends list cursor to the desired time on the plotted data shown in the trends list. Scroll through the trends list to view the following data plotted in the Graphical trends view.

- MVexp
- RR
- Ppeak
- PEEPe
- FiO2
- Pplat
- C
- Raw
- Leak
- MVexp spont
- MVexp mech
- RR spont
- RR mech
- VTexp
- VTexp/kg
- VTinsp
- Pmean
- Paux Peak

Neonatal numerical trends view

The Measured data trends view has three tabs: the Measured tab, Mode tab, and Alarms tab.

- The Measured tab shows measured patient data measured by the ventilator or airway module.
- The Mode tab shows ventilation mode settings.
- The Alarms tab shows alarm settings.

Move the trends list cursor to view measured data or ventilation mode or alarm settings at the desired point in time. Use the Measured tab and Mode tab to compare the measured data to the ventilator settings.

Neonatal measured data trends

For neonatal patients, the Measured Values tab shows the following patient data.

Volumes	Pressures	Rate	Gases
VTexp	Ppeak	RR	FiO2

Volumes	Pressures	Rate	Gases
VTexp spont	Pplat	RR spont	
VTexp mech	Pmean	RR mech	
VTexp/kg	Paux Peak	I:E	
VTexp spont/kg	PEEPe	Tinsp	
VTinsp	C	Texp	
Leak	C/kg	Time Constant	
MVexp	Raw	Cycle Time	
MVexp spont			
MVexp mech			
MVexp/kg			
MVexp spont/kg			
MVinsp			

Neonatal vent mode and settings trends

Vent Mode	Main Parameters	Breath Timing	Safety	Patient Synchrony	Vent Preferences
A/C PC	FiO2	Rate	Pmax	Bias Flow	Backup mode
A/C PRVC	PEEP	Tinsp	Plimit	Rise Time	Assist Control
A/C VC	Pinsp	I:E	Pmin	Insp Trigger	Leak Comp
APRV	VT	Tpause	Minimum Rate	Exp Trigger	Trigger Comp
BiLevel	Flow	Insp Pause	Backup Tinsp	PS Rise Time	
BiLevel VG	PS	Thigh	Backup Pinsp	Tsupp	
CPAP/PS	Phigh	Tlow			
nCPAP	Plow				
SBT					
SIMV PC					
SIMV PRVC					
SIMV VC					
VS					

Neonatal alarm settings trends

The Alarms tab shows the alarm trends data for the following parameters:

- Apnea Time

Parameter	Low	High
Leak Limit		X
MVexp	X	X
Paux		X
PEEPe	X	X
Ppeak	X	X
RR	X	X
VTexp	X	X

Trends log view

The Trends log view shows a list of alarms and events that occurred during the period selected on the timeline. The log updates once a minute, therefore alarms may not appear immediately. Log entries are listed in the order they occurred with the most recent entry at the top. Each entry is labeled with the date and time of its occurrence.The Trends log view can be filtered to show or hide alarms, events, and setting changes.

- Alarms: Low, medium, and high priority alarms are shown as they occur.
- Events: Ventilation procedures and patient type changes are shown as they occur.
- Setting changes: Settings changes and mode changes are shown as they occur.

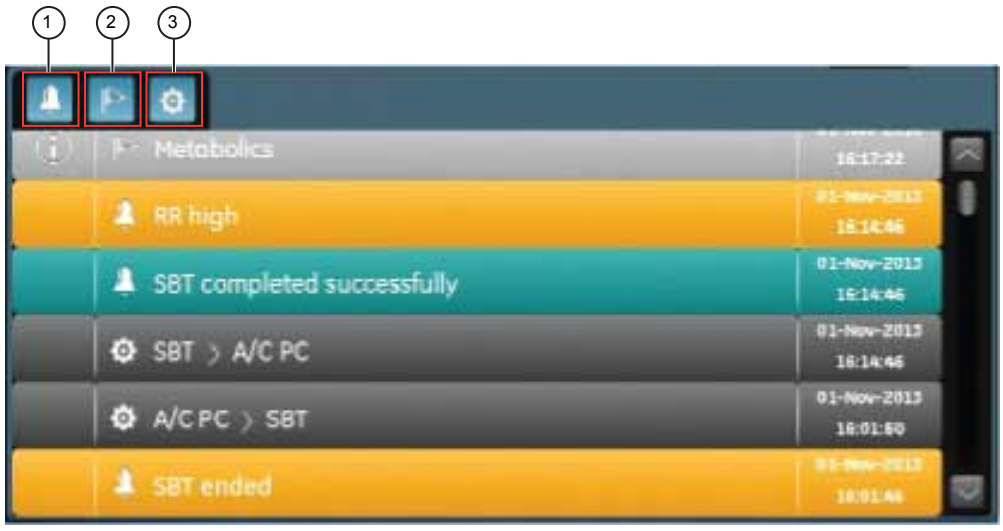


Figure 23-6 • Trends log with all filters selected

1. Alarms filter
2. Events filter
3. Settings filter

Figure 23-7 • Trends log with Settings filter selected

Snapshot trends view

The Snapshot trends view shows a collection of data saved at selected times within the past 72 hours. Up to ten snapshots can be saved. When more than ten snapshots are saved, the oldest snapshot is deleted. A general message shows when a snapshot is deleted.

Note To create a snapshot, press the Snapshot hard key on the Display Unit. The data is saved and can be reviewed on the Snapshot trends view.

A general message shows when a snapshot is created. Data is included in a snapshot and presented on the following tabs on the Snapshot trends view:

- Mode
- Measured
- Waveforms
- Alarms

On the Snapshot trends view, the trends timeline shows blue vertical lines to represent snapshots. Press the left or right arrow to navigate between snapshots.

Figure 23-8 • Snapshot trends view

Mode snapshots

The Mode tab shows the ventilation mode settings that were set when the snapshot was saved.

Vent Mode	Main Parameters	Breath Timing	Safety	Patient Synchrony	Vent Preferences
A/C PC	FiO2	Rate	Pmax	Bias Flow	Backup Mode
A/C PRVC	PEEP	Tinsp	Plimit	Rise Time	Assist Control
A/C VC	Pinsp	I:E	Pmin	Insp Trigger	Leak Comp
APRV	VT	Tpause	Minimum Rate	Exp Trigger	Trigger Comp
BiLevel	Flow	Insp Pause	Backup Tinsp	PS Rise Time	
BiLevel VG	PS	Thigh	Backup Pinsp	Tsupp	
CPAP/PS	Phigh	Tlow			
nCPAP	Plow				
SBT					
SIMV PC					
SIMV PRVC					
SIMV VC					
VS					

Measured patient data snapshots

The Measured tab shows measured patient data that was available when the snapshot was taken.

Volumes	Pressures	Rate	Gases
VTexp	Ppeak	RR	FiO2
VTexp spont	Pplat	RR spont	
VTexp mech	Pmean	RR mech	
VTexp/kg	Paux Peak	I:E	
VTexp spont/kg	PEEPe	Tinsp	
VTinsp	C	Texp	
Leak	C/kg	Time Constant	
MVexp	Raw	Cycle Time	
MVexp spont			
MVexp mech			
MVexp/kg			
MVexp spont/kg			
MVinsp			

Waveform snapshots

On the Waveforms tab, Paw, Flow, Volume, and Paux waveforms are shown if data was available when the snapshot was saved. Move the trends list cursor to show waveform data values.

When a snapshot is taken, the duration of the waveform is based on the set speed.

- If speed is set to Slow, 15 seconds of waveform data is shown.
- If speed is set to Fast, 30 seconds of waveform data is shown.

Waveforms are shown in the color and scale set in the Waveform Settings menu.

Alarms snapshots

The Alarms tab shows any low, medium, or high priority alarms that were active when the snapshot was saved.

Review snapshot trends

1. Access Trends > Snapshot Trends.
2. On the snapshot timeline, select the snapshot to show on the trends list.
3. Access the following tabs to review snapshot data:
   - Mode
   - Measured
   - Waveforms
   - Alarms

24 Neonatal clinical decision support

In this section

SBT view - Neonatal

During an SBT (Spontaneous Breathing Trial), a patient is spontaneously breathing with the assistance of Pressure Support (if desired). The patient is monitored with specific clinician selected alarm settings during the SBT. The ventilator will use these alarm settings as pass/fail criteria to decide if the mode of ventilation should be changed back to the previous mode. During a spontaneous breathing trial, the SBT view shows graphical and numerical data and trends related to the ongoing trial. This data may be used to see the progress of a patient during the SBT trial and evaluate SBT data. Data from a previous SBT may also be reviewed if it was performed in the past 12 hours.

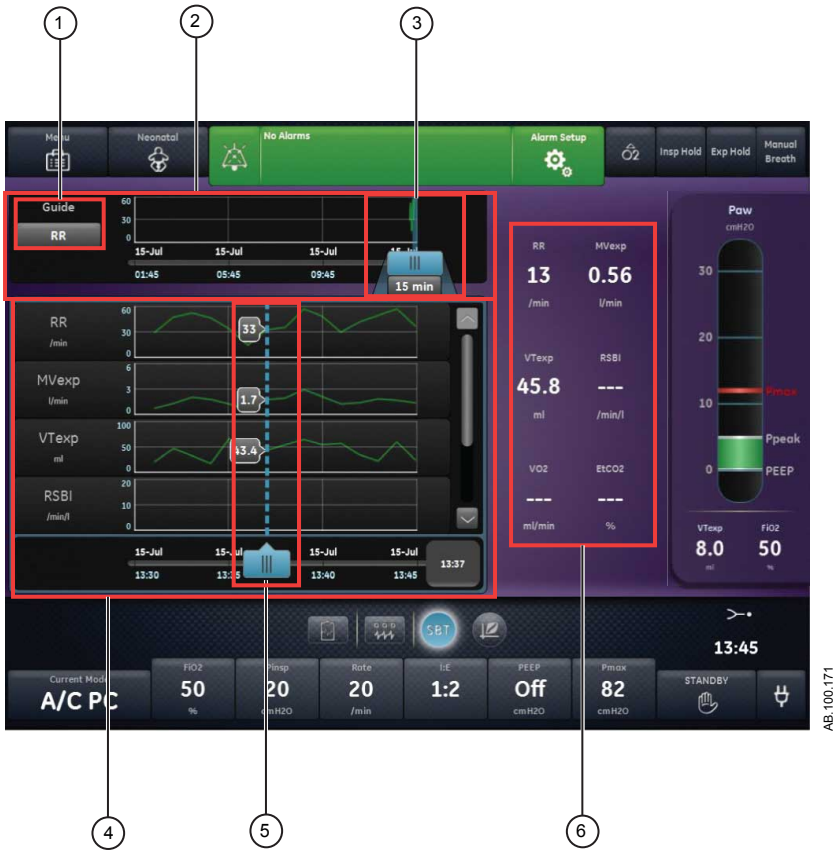


Figure 24-1 • SBT view

1.	Guide setting	When set, shows RR, MVexp, VTexp, or RSBI.
2.	SBT timeline	Shows the past 12 hours of data.
3.	SBT timeline cursor	Highlights the set period on the timeline. The timeline cursor range can be set to highlight 15 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 4 hours, 6 hours, or 8 hours.

4.	SBT trends list	Shows the period of SBT trending data highlighted by the SBT timeline cursor.
5.	SBT trends list cursor	Can be moved throughout the period shown to specific data points.
6.	Measured data	Shows numerical data for RR, MVexp, VTexp, and RSBI.

Perform a spontaneous breathing trial

While transitioning from a ventilation mode to an SBT, it may take a period of time for the patient to meet the criteria for the new set of alarms.

1. Select ***Current Mode***.
2. Select ***SBT***.
3. If desired, select the following features:
   - ***Tube Comp*** (Not applicable for neonatal.)
   - ***Leak Comp***
   - ***Trigger Comp***
4. Set the Stop Criteria limits:
   - ***RR low***, ***RR high***
   - ***MVexp low***, ***MVexp high***
   - ***Apnea Time***
5. Set the ventilation mode settings:
   - ***FiO2***
   - ***PEEP***
   - ***PS***
   - ***Bias Flow***
   - ***Exp Trigger***
   - ***Insp Trigger***
   - ***PS Rise Time***
   - ***Pmax***
6. Select ***Time*** and select a duration for the Spontaneous Breathing Trial.
7. Select ***Start SBT***.

   The SBT general message shows along with the procedure countdown timer and progress bar. The progress bar fills in proportion to the amount of time the SBT procedure has been running.

Note Access Clinical Decision Support > SBT to evaluate the data relevant to the Spontaneous Breathing Trial.

Note The Spontaneous Breathing Trial lasts for the set Time unless it is terminated by the Stop Criteria limits. After the Spontaneous Breathing Trial is complete, the ventilator resumes the previous ventilation mode. If needed, select Stop to return to the previous mode.

Note If any Stop Criteria limits are reached, an alarm occurs and the ventilator changes to the previous ventilation mode.

8. Select ***Current Mode*** and do one of the following:
   - Select ***Resume SBT*** to resume the Spontaneous Breathing Trial.
   - Select ***Confirm*** to end the Spontaneous Breathing Trial and continue ventilation in the current ventilation mode.

Review spontaneous breathing trial data - neonatal

Review measured data on the SBT view to evaluate the patient after the completion or during a spontaneous breathing trial.

1. Access Clinical Decision Support > SBT.
2. If desired, select ***Guide*** and select one of the following data to plot on the timeline:
   - RR
   - MVexp
   - VTexp
3. Select the SBT timeline cursor and select a time period.
4. Position the SBT cursor to highlight the desired time period on the timeline.
5. Review the SBT trends data in the trends list.
6. Move the SBT trends list cursor as needed to view specific data points.
7. As desired, repeat steps 3-6.

Spirometry view

The Spirometry view shows spirometry loops and measured data. Use the Spirometry view to evaluate patient lung function.

Spirometry

The Spirometry view shows spirometry loops and related measured data. The spirometry loops shown can be customized on the spirometry Settings menu.

Figure 24-2 • Spirometry view

Spirometry settings menu

Select the spirometry loop field. The Settings icon appears in the upper right-hand corner. Select the Settings icon to access the Settings menu and select which loop type to show and how the loop is scaled.

The following loop types are available:

- Paw-Volume (P-V)
- Flow-Volume (F-V)
- Paw-Flow (P-F)

The following scaling options are available:

- Auto: The system scales the waveform to include the full range of the waveform curves or loop. The system continuously adjusts the scale as data is collected.

- Manual: Select the scaling controls to increase or decrease the scale of the waveform.

Spirometry loops

The Spirometry view can be set to show the following loops:

- Paw-Volume (P-V): Volume is shown on the Y axis and pressure on the X axis.
- Flow-Volume (F-V): Flow is shown on the Y axis and volume on the X axis.
- Paw-Flow (P-F): Flow is shown on the Y axis and pressure on the X axis.

Spirometry loops are drawn every other breath. Up to six spirometry loops can be saved simultaneously. When six sets of reference data have been saved, subsequent saves overwrite the second oldest set of reference data. The current loop is colored green. Reference loops are colored yellow. Move the cursor to view specific data points on the spirometry loops shown. When using the cursor to view specific data points on the loop, loops are not drawn.

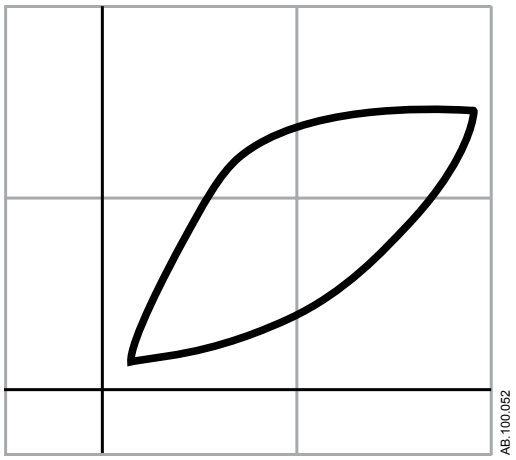


Figure 24-3 • Spirometry loop

Spirometry measured data

The Spirometry view shows the following data:

- Pplat
- Pmean
- Ppeak
- PEEPe
- I:E
- VTinsp
- VTexp
- MVinsp
- MVexp

- C
- Raw

This data is shown for the current breath and reference breaths when selected. Review this data to evaluate lung function.

Note Compliance and airway resistance may not be available for all breaths.

25 Neonatal cleaning and maintenance

In this section

Note See "*Cleaning and maintenance*" (shared information section for adult, pediatric, and neonatal patient types) for additional information.

Neonatal flow sensor (NFS)

To remove the neonatal flow sensor:

1. Disconnect the flow sensor from the patient circuit.
2. Disconnect the flow sensor from the flow sensor cable.
3. Disconnect the flow sensor cable from communications port 1 on the back of the vent.

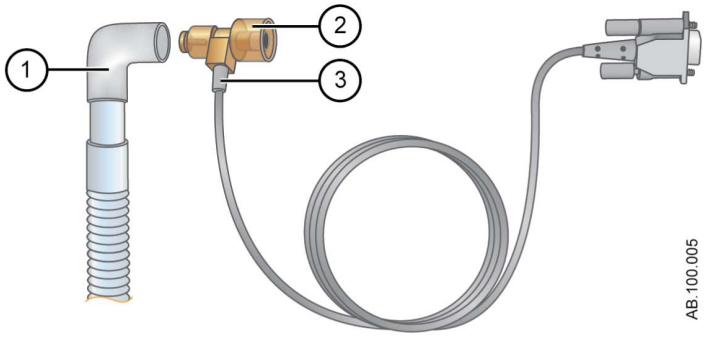


Figure 25-1 • Disconnecting the NFS (neonatal flow sensor)

1. Patient circuit
2. Neonatal flow sensor
3. Flow sensor cable

Note See the shared "*Cleaning and maintenance*" section for more information on cleaning. See "*Calibrating the neonatal flow sensor*" in "*Neonatal Cleaning and Maintenance*" for calibration information.

Processing the neonatal flow sensor

WARNING Calibrate the Neonatal Flow Sensor after every day of continuous use.

CAUTION Do not use compressed air or a water jet to clean the neonatal flow sensor.

- Do not use an automated washer to clean or disinfect flow sensors.
- Do not insert anything into the flow sensor to clean internal surfaces. Damage may occur to the flow sensor.

Note See the shared "*Cleaning and maintenance*" section for detailed cleaning instructions.

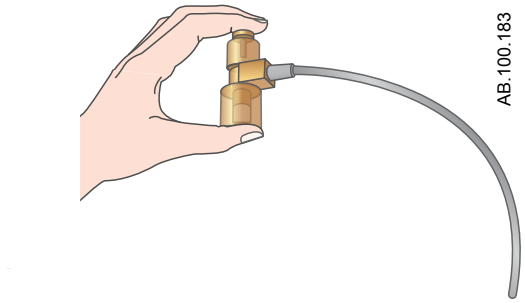
Calibrating the neonatal flow sensor

The neonatal flow sensor can be calibrated automatically through the System Check or manually through the System menu.

WARNING Calibrate the Neonatal Flow Sensor (NFS) after every day of continuous use.

Note The neonatal flow sensor can only be manually calibrated when the neonatal flow sensor is not set as the data source.

1. Select ***Menu*** > ***System***.
2. Under Data Source, select ***Ventilator***.
3. Hold the flow sensor between thumb and index finger to occlude both ports at the same time.



4. Under Calibration, select ***NFS***.

   When the calibration is complete, a green check mark (pass) or red X (fail) will appear next to NFS.
5. Under Data Source, select ***NFS***.
6. Connect the flow sensor to the patient circuit.

26 Neonatal specifications and settings

In this section

Overview

This section contains general ventilator specification information.

- Gas volumes and flows delivered by the ventilator to the patient along with ventilator leakage measurements are expressed at BTPS (Body Temperature Pressure Saturated). All other gas volumes, flows and leakage measurements are expressed at STPD (Standard Pressure Temperature Dry).
- The measurement uncertainty for each disclosed tolerance is included within the range of the specification.
- Unless stated otherwise, measured data is available 60 seconds after startup is initiated.

Neonatal ventilation settings

This table shows the ventilation settings with the available range and resolution for each setting when the patient type is Neonatal.

Setting	Range	Resolution
Backup Pinsp	1 to 98 cmH2O	1 cmH2O
Backup Tinsp	0.1 to 10 s	0.1 to 1 by 0.01 s 1 to 4 by 0.1 s 4 to 10 by 0.25 s
Bias Flow (nCPAP)	2 to 10 l/min (2 to 15 l/min)	0.5 l/min
Exp Trigger	5 to 80%	5%
FiO2	21 to 100%	1%
Flow	0.2 to 30 l/min	0.2 to 5 by 0.1 l/min 5 to 30 by 0.5 l/min
I:E	1:9 to 4:1	0.1
Insp Pause	0 to 75%	5%
Insp Trigger (nCPAP)	-10 to -0.25 cmH2O (-10 to -0.25 cmH2O, Off)	-10 to -3 by 0.5 cmH2O -3 to -0.25 by 0.25 cmH2O
	0.2 to 9 l/min (Off, 0.2 to 9 l/min)	0.2 to 1 by 0.05 l/min 1 to 3 by 0.1 l/min 3 to 9 by 0.5 l/min
Minimum Rate	Off, 1 to 60 /min	1 /min
PEEP (nCPAP)	Off, 1 to 50 cmH2O (2 to 15 cmH2O)	1 cmH2O
Phigh	1 to 98 cmH2O	1 cmH2O
Pinsp (nCPAP)	1 to 98 cmH2O (1 to 25 cmH2O)	1 cmH2O
Plimit	7 to 100 cmH2O	1 cmH2O
Plow	Off, 1 to 50 cmH2O	1 cmH2O

Setting	Range	Resolution
Pmax (nCPAP)	7 to 100 cmH2O (9 to 100 cmH2O)	1 cmH2O
Pmin	2 to 20 cmH2O	1 cmH2O
PS	0 to 60 cmH2O	1 cmH2O
PS Rise Time	0 to 500 ms	50 ms
Rate (BiLevel-VG and SIMV only)[1] (nCPAP)	3 to 150 /min (2 to 60 /min) (Off, 1 to 30 /min)	1 /min
Rise Time	0 to 500 ms	50 ms
Thigh	0.1 to 10 s	0.1 to 1 by 0.01 s 1 to 4 by 0.1 s 4 to 10 by 0.25 s
Tinsp (nCPAP)	0.1 to 10 s (0.1 to 2 s)	0.1 to 1 by 0.01 s 1 to 4 by 0.1 s 4 to 10 by 0.25 s
Tlow	0.25 to 18 s	0.25 to 1 by 0.01 s 1 to 4 by 0.1 s 4 to 18 by 0.25 s
Tpause	0 to 7.5 s	0 to 1 by 0.05 s 1 to 4 by 0.1 s 4 to 7.5 by 0.25 s
Tsupp	0.1 to 0.8 s	0.01 s
VT	2 to 50 ml	2 to 20 by 0.1 ml 20 to 50 by 0.5 ml
Weight	0.25 to 10 kg	0.25 to 1 by 0.01 kg 1 to 7 by 0.1 kg 7 to 10 by 0.5 kg
Height	15 to 100 cm	1 cm
[1]The range for Rate in backup for these modes is 3 to 60 /min.		

Neonatal alarm settings

The table shows the range for each neonatal parameter alarm and the factory default setting.

Note The actual default might be different from the factory default if the setting has been changed by the Super User.

Alarm	Range	Resolution
Apnea Time (nCPAP)	5 to 60 s Off, 5 to 60 s	5 to 20 by 1 s 20 to 60 by 5 s
Leak Limit	Off, 10 to 90%	5%

Alarm	Range	Resolution
Ppeak Low	1 to 97 cmH2O	1 cmH2O
Ppeak High (nCPAP)	7 to 100 cmH2O 9 to 100 cmH2O	1 cmH2O
MVexp Low (nCPAP)	0.01 to 40 l/min (Off, 0.01 to 40 l/min)	0.01 to 1.0 by 0.01 l/min 1.0 to 10 by 0.1 l/min 10 to 40 by 1 l/min
MVexp High	0.02 to 99 l/min	0.02 to 1.0 by 0.01 l/min 1.0 to 10 by 0.1 l/min 10 to 99 by 1 l/min
VTexp Low	Off, 1 to 1950 ml	1.0 to 20 by 0.5 ml 20 to 100 by 1 ml 100 to 350 by 5 ml 350 to 1000 by 25 ml 1000 to 1950 by 50
VTexp High	Off, 3 to 2000 ml	3.0 to 20 by 0.5 ml 20 to 100 by 1 ml 100 to 350 by 5 ml 350 to 1000 by 25 ml 1000 to 2000 by 50
RR Low	Off, 1 to 99 /min	1 l/min
RR High	Off, 2 to 150 /min	1 l/min
FiO2 Low	18 to 99%	1%
FiO2 High	Off, 24 to 100%	1%
PEEPe Low	Off, 1 to 20 cmH2O	1 cmH2O
PEEPe High	Off, 5 to 50 cmH2O	1 cmH2O
Paux	12 to 100 cmH2O	1 cmH2O

Alarm Option	Range	Factory Default
Alarm Light Brightness	1 to 5	4
Alarm Volume	1 to 5	3
High Alert Audio	Off, 0 to 30 s	30 s
Show Alarm Limits	Set or clear	Set

Waveform specifications

The waveform specifications table shows the type of filtering used when showing waveforms on the ventilator display.

Waveform	Filtering Technique
Paw	40 ms low pass filter
Flow	40 ms low pass filter
Volume	40 ms low pass filter

Neonatal tidal volume delivery

Accuracy	
with the NFS	± 10% of setting or ± 1 ml, whichever is greater
without the NFS	± 10% of setting or ± 5 ml, whichever is greater
1σ repeatability	
with the NFS	± 2% or ± 1 ml, whichever is greater
without the NFS	± 2% or ± 3 ml, whichever is greater
Change response time 90% full scale (FS)	Less than 6 breaths

Inspired pressure control

The values shown only apply to invasive pressure control ventilation modes.

Accuracy	± 2 cmH2O
1σ repeatability	± 1 cmH2O

PEEP control

The values shown only apply to invasive pressure control ventilation modes.

Accuracy	± 2 cmH2O
1σ repeatability	± 1 cmH2O

Oxygen-air mixture accuracy

Mixture accuracy is measured at one meter from the inspiratory port.

Accuracy	± 2.95% volume/volume of setting
1σ repeatability	± 1% volume/volume of setting
Mixture deviation greater than 75 ms within inspiratory phase of breath	± 5% volume/volume at steady state level
21% to 90% FiO2 response time at tidal volumes of 500 ml, 150 ml, and 30 ml	< 6 breaths or 30 seconds, whichever is longer

Ventilation breathing system compliance and resistance - Neonatal

The values in this table represent the ventilator breathing system compliance and reistance ranges for recommended circuit configurations.

Ventilator Breathing System Compliance (ml/cmH2O)		
	Minimum	Maximum
Neonatal	0.835	0.918

***Ventilator Breathing System Configuration Limits**	
Value	Neonatal
Total Resistance*	80 cmH2O/l/s
Inspiratory Resistance*	64 cmH2O/l/s
Compliance	< 2 ml/cmH2O
*Inspiratory resistance must be limited to 80% of the total VBS resistance.	

Ventilator Breathing System Resistance (cmH2O/l/s)		
Neonatal (15 lpm)		
Inspiratory	10.07	21.87
Expiratory	6.20	18.24

Ventilation monitoring specifications - Neonatal

The following specifications are monitoring measurements specific to the ventilator. Measurements with the same range, resolution, filtering technique, and accuracy are grouped together in the table.

Measurements	Range	Resolution	Filtering Technique	Accuracy
Ppeak Pmean Pplat PEEPe PEEPi PEEPe + i Paux Peak Paux Mean Paux Min	-20 to 120 cmH2O	1 cmH2O	Value from the last detected breath.	± 2 cmH2O

Measurements	Range	Resolution	Filtering Technique	Accuracy
MVexp MVinsp MVexp spont MVexp mech	0 to 99.9 l/min	0 to 1.0 by 0.01 l/min 1.0 to 99.9 by 0.1 l/min	Running value for the last one minute + one breath.	• with the NFS: ± 10% or ±1 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • without the NFS: ± 10% or ±5 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • with the NFS: ±15% or ±5ml with leak compensation on and steady/stable leak below leak compensation limits • without the NFS: ±15% or ±15ml with leak compensation on and steady/ stable leak below leak compensation limits • without the NFS: ±20% or 15ml with pneumatic nebulizer flow compensation On and compensation level set to flow being introduced into the circuit

Measurements	Range	Resolution	Filtering Technique	Accuracy
VTinsp VTexp VTexp spont VTexp mech	with the NFS: 0.5 - 1000 ml without the NFS: 1 -1000 ml	0.5 to 50 by 0.1 ml 50 to 1000 by 1 ml	Value from last detected breath.	• with the NFS: ± 10% or ±1 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • without the NFS: ± 10% or ±5 ml with leak compensation Off and no leak, pneumatic nebulizer flow compensation Off and no external flow introduced into the circuit • with the NFS: ±15% or ±5ml with leak compensation on and steady/stable leak below leak compensation limits • without the NFS: ±15% or ±15ml with leak compensation on and steady/ stable leak below leak compensation limits • without the NFS: ±20% or 15ml with pneumatic nebulizer flow compensation On and compensation level set to flow being introduced into the circuit
RR RRspont RRmech	0 to 150 /min	1 /min	Running value for the last one minute + one breath.	±10% or 1 /min, whichever is greater
C	0.1 to 150 ml/cmH2O	0.1 to 10 by 0.1 ml/ cmH2O 10 to 150 by 1 ml/cmH2O	Five breath median filter.	—

Measurements	Range	Resolution	Filtering Technique	Accuracy
Raw	1 to 500 cmH2O/l/s	1 cmH2O/l/s	Five breath median filter.	—
FiO2	10 to 100%	1%	10 s moving average.	± 2.95% volume/volume of setting, ±(2.5% volume/volume + 2.5% of gas value) of delivered value, with less than 30 s, 10 to 95% FS response. Drift: less than 0.4% over 24 h.

27 Neonatal parts and accessories

In this section

Note See "*Parts and accessories*" (shared information section for adult, pediatric, and neonatal patient types) for additional information.

Replacement parts and accessories

This section shows replacement parts and accessories that are validated for use with the CARESCAPE R860.

WARNING GE Healthcare CARESCAPE R860 ventilator specified cables, accessories, or transducers are not recommended for use with other ventilators or equipment, as it may result in increased emissions or decreased immunity of that equipment.

- Incorrect installation of components could result in barotrauma, hypoventilation, hyperventilation, incorrect FiO2, contaminated breathing gases, or fire hazards. Please follow the instructions contained in the Technical Reference Manual when servicing the ventilator.
- Only connect items to the ventilator that have been specified as part of the ventilator system or that have been specified as being compatible with the ventilator system. Incompatible parts can result in degraded performance.

Note Refer to the Technical Reference Manual for instructions on the correct replacement of interchangeable or detachable parts.

Note All parts of the ventilator are suitable for use within the patient environment.

Inspiratory safety guard

The inspiratory safety guard cannot be cleaned. It is used to prevent patient gas from contaminating the inspiratory gas path of the ventilator. The inspiratory safety guard does not have to be replaced between patients; it must be replaced when patient gas has passed through the safety valve. This can occur in the following situations:

- Excess or sustained pressure in the system, as indicated by the following alarm messages: Relief valve opened, Patient circuit occluded, Sustained airway pressure.
- Failure of the Air and O2 supply gases while connected to the ventilator.
- When the ventilator is ventilating and an internal error message displays; see "*Internal errors*" in the "*Alarms and troubleshooting*" section for a detailed list of error messages.

Neonatal flow sensor

Item	Description	Part Number
1	Neonatal flow sensor cable	1505-5604-000
2	Neonatal flow sensor	1505-3272-000

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Warranty

This Product is sold by Datex-Ohmeda under the warranties set forth in the following paragraphs. Such warranties are extended only with respect to the purchase of this Product directly from Datex-Ohmeda or Datex-Ohmeda's Authorized Dealers as new merchandise and are extended to the Buyer thereof, other than for the purpose of resale.

For a period of twelve (12) months from the date of the original delivery to the Buyer or Buyer's order, but in no event for a period of more than two years from the date of original delivery by Datex-Ohmeda to a Datex-Ohmeda Authorized Dealer, this Product, other than its expendable parts, is warranted against functional defects in materials and workmanship and to conform to the description of the Product contained in this User's Reference manual and accompanying labels and/or inserts, provided that the same is properly operated under the conditions of normal use, that regular periodic maintenance and service is performed and that replacements and repairs are made in accordance with the instructions provided. This same warranty is made for a period of thirty (30) days with respect to expendable parts. The foregoing warranties shall not apply if the Product has been repaired other than by Datex-Ohmeda, or altered by anyone other than Datex-Ohmeda, or if the Product has been subject to abuse, misuse, negligence, or accident.

Datex-Ohmeda's sole and exclusive obligation and Buyer's sole and exclusive remedy under the above warranties is limited to repairing or replacing, free of charge, at Datex-Ohmeda's option, a Product, which is telephonically reported to the nearest Datex-Ohmeda Customer Service Center and which, if so advised by Datex-Ohmeda, is thereafter returned with a statement of the observed deficiency, not later than seven (7) days after the expiration date of the applicable warranty, to Datex-Ohmeda Customer Service and Distribution Center during normal business hours, transportation charges prepaid, and which, upon Datex-Ohmeda's examination, is found not to conform with above warranties. Datex-Ohmeda shall not be otherwise liable for any damages including but not limited to incidental damages, consequential damages, or special damages.

There are no express or implied warranties which extend beyond the warranties hereinabove set forth. Datex-Ohmeda makes no warranty of merchantability or fitness for a particular purpose with respect to the product or parts thereof.

CARESCAPE™ R860
User's Reference Manual
English
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