GE Healthcare

Engström Carestation
Pocketguide
Software Revision 6.X

Refer to the User's Reference manual for step-by-step instructions.

Introduction

Engström Carestation

The ventilator is designed to be used with infant through adult patients with a body weight of 5 kg or greater. If the neonatal option is installed on the ventilator, patients weighing down to 0.25 kg may be ventilated with the Engström. The Engström is designed to maintain lung ventilation in the absence of spontaneous breathing effort as well as in support of the patient's existing spontaneous breathing effort. The system is designed for facility use, including within-facility transport, and should only be used under the orders of a clinician.

The Carestation consists of three main components: a display, a ventilator unit, and an optional module bay. The display allows the user to interface with the system and control settings. The ventilator unit controls electrical power, nebulization, and pneumatic gas flow to and from the patient. The module bay allows the integration of various patient monitoring modules with the ventilator.

Setting definitions

The following terms and settings are used in the system.
Not all settings are available for all modes of ventilation.

Setting	Definition
Bias Flow	The minimum flow that is delivered through the patient circuit during the expiratory phase of the breath cycle. It is used in the flow trigger mechanism and provides a reservoir of fresh gas for the patient. The bias flow may be automatically increased above this setting depending on the FiO2 setting.
End Flow	The percentage of peak flow at which the pressure supported breath terminates the inspiratory phase and enters the expiratory phase.
FiO2	The percentage of oxygen that is delivered to the patient from the ventilator.
Flow	Set only in volume modes, the flow setting allows the user to set the specific flow that the ventilator will use to deliver the set tidal volume to the patient during the inspiratory phase of the breath.
I:E	The ratio between the inspiratory and expiratory time.

Setting	Definition
Insp Pause	The percentage of inspiratory time at the end of the inspiratory phase in a volume mode, where the breath is held and there is no flow.
PEEP	The pressure held on the patient's lungs by the ventilator at the end of expiration.
Phigh	In BILevel mode, Phigh is the high pressure level at which the patient can spontaneously breathe.
Pinsp	The pressure above PEEP delivered to a patient in each pressure-controlled breath.
	In BiLevel mode, Pinsp is the pressure above Plow at which the patient can spontaneously breathe.
Plimit	The pressure at which the breath is limited and held for the set inspiratory time in a volume mode.
Plow	Set only in BiLevel mode, Plow correlates to the PEEP level in all other modes. It is the low pressure level at which the patient can spontaneously breathe.

Setting	Definition
Pmax	The maximum airway pressure allowed in the patient breathing circuit. Once reached, the inspiratory phase will be terminated and the ventilator will cycle immediately to the expiratory phase.
Psupp	The pressure above PEEP that is delivered during a pressure-supported breath.
PSV Rise Time	The time in milliseconds needed for the profiled pressure to reach 90% of the set pressure support level.
Pspont	The total amount of pressure that is delivered to the patient for a pressure-supported breath. Calculated as: PEEP + Psupp or Plow + Psupp.
Ptot	The total amount of pressure that is delivered to the patient for a mechanically delivered breath. Calculated as: PEEP + Pinsp, Plow + Pinsp, or Phigh.
Rate	The number of breaths delivered to the patient in one minute.
Rise Time	The time in milliseconds needed for the profiled pressure to reach 90% of the set Pinsp or volume-controlled flow.
Thigh	The amount of time in seconds that the ventilator will hold the high pressure level in BiLevel mode.

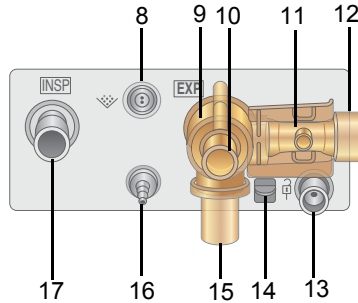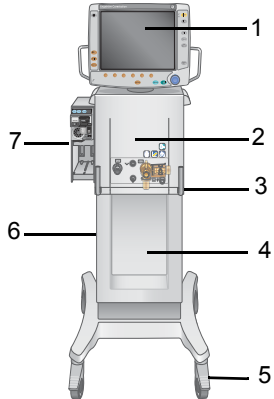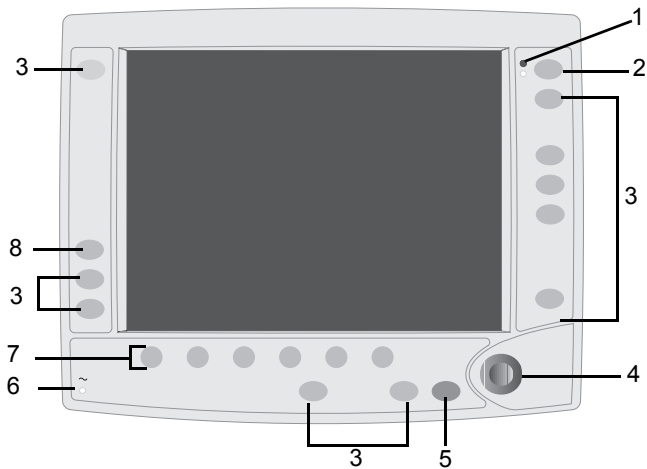| Setting	Definition
Tinsp	The time in seconds that the ventilator uses to deliver the inspiratory phase of the breath cycle.
Tlow	The amount of time in seconds that the ventilator will hold the low pressure level in BiLevel mode.
Tpause	The amount of time in seconds at the end of the inspiratory phase in a volume mode where the breath is held and there is no flow.
Tsupp	The maximum inspiratory time for PSV in NIV ventilation mode.
Trig Window	The percent of the exhalation time when the ventilator will synchronize the delivery of the mandatory breath. It is measured from the end of the expiratory phase back towards the end of the previous inspiratory phase. (Only in SIMV or BiLevel-VG modes).
Trigger	A signal that causes the ventilator to start the inspiratory phase of the breath. The trigger can use either a negative pressure deflection or a flow signal.
TV	The set volume of gas delivered from the ventilator on each volume controlled breath.

Ventilator overview

Ventilator overview

1. Display
2. Ventilator unit
3. Ventilator lock*
4. Cart (Trolley)
5. Caster*
6. Dovetail rails
7. Module bay (optional)
8. Nebulizer connection
9. Exhalation valve housing*
10. Expiratory inlet
11. Expiratory flow sensor
12. Gas exhaust port
13. Leak test plug
14. Exhalation valve housing latch*
15. Water trap*
16. Auxiliary pressure port
17. Inspiratory outlet

Display controls and indicators

AB.98.214

1	Alarm LEDs	The red and yellow LEDs indicate the priority of active alarms.
2	Silence Alarms key	Push to silence any active, silenceable high and medium priority alarms or to suspend any non-active high or medium priority alarms. Alarm audio is silenced for 120 seconds for Adult, Pediatric, and Neonatal patient types. Alarm Audio is suspended for 120 seconds for Adult and Pediatric patient types, and for 30 seconds for Neonatal patient type. Push to clear resolved alarms.
3	Menu keys	Push to show corresponding menu.
4	ComWheel	Push to select a menu item or confirm a setting. Turn clockwise or counterclockwise to scroll menu items or change settings.
5	Normal Screen key	Push to remove all menus from the screen.
6	AC mains indicator	The green LED lights continuously when the ventilator is connected to an AC mains source. The internal batteries are charging when the LED is lit.
7	Quick keys	Push to change corresponding ventilator setting. Turn the ComWheel to make a change. Push the Quick key or ComWheel to activate the change.
8	↑ O2 key	Push to deliver increased FiO2 for 2 minutes.

Ventilator display

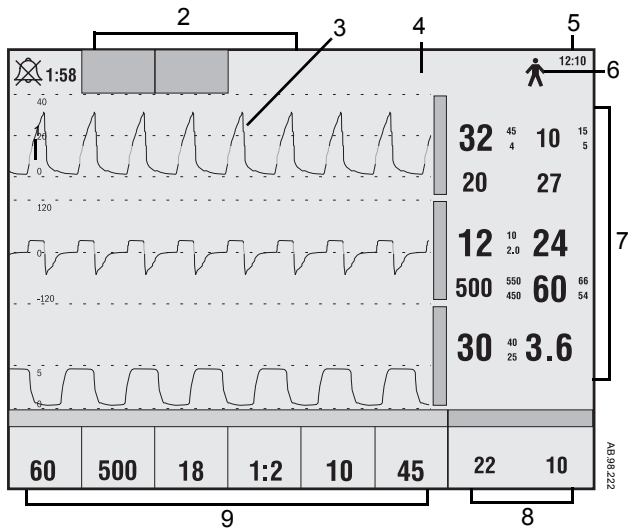There are two display interfaces to choose from: Full and Basic.

To select or change the display interface:

1. Push the ComWheel when no menus are shown.
   - The Select Layout menu displays.
2. Select *Full* or *Basic*.
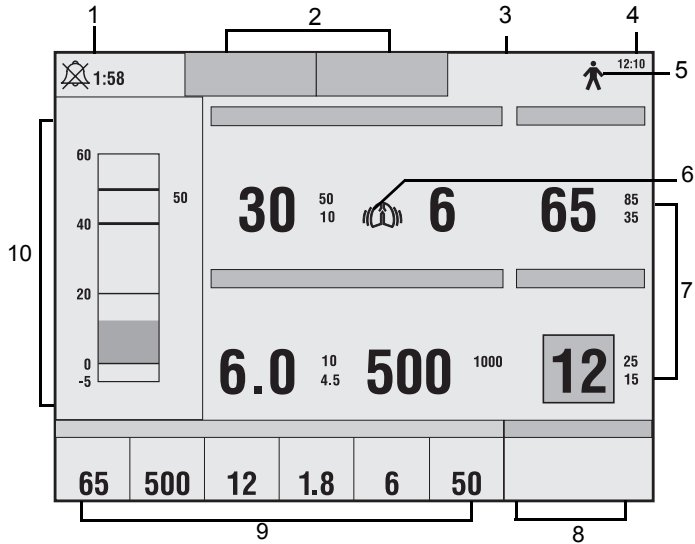3. Select *Previous Menu* or push **Normal Screen**.

Screen configuration

To change the ventilator display:

1. Push **System Setup**.
2. Select *Screen Setup*.
3. Select field to be changed.
4. Select parameter to be displayed.
5. Select *Previous Menu* when complete.

Diagram labels:

- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

Top left: ⊠ 1:58

Top right: 12:10

Waveform scale markings (left): 40, 0 / 120, 0, -120 / 5, 0

Right numeric displays (7):

- 32 45 4   10 15 5
- 20   27
- 12 10 2.0   24
- 500 550 450   60 66 54
- 30 40 25   3.6

Bottom row (9): 60 | 500 | 18 | 1:2 | 10 | 45

Bottom row (8): 22   10

Side label: AB 98.222

1	Alarm silence symbol and countdown	Displays the time remaining during an alarm silence or alarm suspend period.
2	Alarm message fields	Alarms will appear in order of priority. See *"Alarms and Troubleshooting"* for more information on alarm behavior.
3	Waveform fields	The top two waveforms are permanently set to Paw and Flow. The third waveform may be selected as CO_2, O_2, Vol, Paux, or Off.
4	General message fields	Displays informational messages.
5	Clock	The time may be set in 12 or 24 hour format in the Time and Date menu.
6	Patient type icon	Displays Neonatal, Pediatric, or Adult patient type mode.
7	Measured value fields	Displays current measured values corresponding to the waveforms.
8	Digit field	Displays information related to Volume, CO_2, O_2, Compliance, Metabolics, Spirometry, Current mode, Spontaneous ventilation, or Volume per Weight.
9	Ventilator settings	Displays several of the settings for the current mode of ventilation.

1

2

3

4

5

6

7

8

9

10

🔇 1:58

12:10

60
50
40
20
0
-5

50

30   50
     10

6

65   85
     35

6.0   10
      4.5

500   1000

12   25
     15

65 | 500 | 12 | 1.8 | 6 | 50

1	Alarm silence symbol and countdown	Displays the time remaining during an alarm silence or alarm suspend period.
2	Alarm message fields	Alarms will appear in order of priority. See *"Alarms and Troubleshooting"* for more information on alarm behavior.
3	General message fields	Displays informational messages.
4	Clock	The time may be set in 12 or 24 hour format in the Time and Date menu.
5	Patient type icon	Displays Neonatal, Pediatric, or Adult patient type mode.
6	Trigger icon	Displays patient's inspiratory triggered breaths.
7	Measured value fields	Displays current measured values corresponding to the waveforms.
8	Digit field	Displays current mode of ventilation.
9	Ventilator settings	Displays several of the settings for the current mode of ventilation.
10	Pressure bargraph	Displays patient's real-time airway pressure.

Using menus

Menu functionality is common across the ventilator interface. The following describes how to navigate through and select menu functions.

1. Push a menu key to display the corresponding menu.

2. Turn the ComWheel counterclockwise to highlight the next menu item. Turn the ComWheel clockwise to highlight the previous menu item.

3. Push the ComWheel to enter the adjustment window or a submenu.

4. Turn the ComWheel clockwise or counterclockwise to highlight the desired selection. Push the ComWheel to confirm the selection.

5. Select *Normal Screen* in the menu or push the **Normal Screen** key to exit the menu and return to the normal ventilation display. (Select *Previous Menu* to return to the last displayed menu, if available.)

Preparing the ventilator for a patient

Starting ventilation

Entering Standby

Monitoring

Changing settings while ventilating

Using snapshots

Viewing trends

Viewing spirometry Loops

Performing Vent Calculations

Performing procedures

Operation

Operation

Preparing the ventilator for a patient

Turning on the system

1. Plug the power cord into the wall outlet.
   - The green mains indicator on the display lights when AC power is connected.
   - The ventilator automatically switches to battery power if AC power fails.

2. Turn the System switch On.
   - A start-up screen appears while the ventilator is booting up and completing self tests.
   - Once the self tests pass, the system is in Standby and the display shows the *Select Patient* menu. This should occur within 60 seconds.
   - If the self tests fail, the display shows an alarm.
   - Ensure that two distinctly different audio alarm tones sound to ensure the backup audio buzzer is working.
   - Ensure alarm LEDs blink.
   - Ensure all water traps and filters are clean prior to using the ventilator.

WARNING
The ventilator is equipped with a backup audio buzzer. If both the primary and backup audio tones do not sound when the ventilator is powered up, take the ventilator out of service and contact a Datex-Ohmeda trained service representative.

⚠
Ensure system batteries are fully charged prior to use.

Select Patient

Patient Type may be set to either *Adult*, *Pediatric,* or *Neonatal*. Selecting a value will change the ventilation settings to the facility defaults for that patient type. The Patient Type selection is used internally by the ventilator to match the pneumatic response to a particular patient type.

Only settings for the selected patient type will be accessible. The system must be turned off and turned on again to select a new patient type and settings.

1. Select *Adult*, *Pediatric*, or *Neonatal*.

2. Enter *Patient Weight*.
   - See Patient Weight table for TV and Rate calculations.
   - The Patient Weight entered should be the patient's ideal body weight.

3. Select *Checkout* or *Bypass Checkout*.
   - Select *Checkout* to run pre-use checkout, then select the *Patient Setup* menu.
   - Select *Bypass Checkout* to access the Patient Setup menu without running the pre-use checkout.

Important

If Bypass Checkout is selected, the Checkout procedure will not be performed and the system will use the compliance and resistance data from the last completed Checkout procedure.

Patient weight

Changing the value of *Patient Weight* on the Select Patient menu will change the TV and Rate settings to values that are suggested starting points for the weight entered.

Calculations for TV and Rate values when patient weight is entered.	
Respiratory Rate	g = weight in grams RR = Respiratory Rate If g is less than or equal to 5,000, then RR = 30. If g is between 5,000 and 10,000, then RR = 30 - (10 x [{g - 5,000}/5,000]). If g is between 10,000 and 30, 000, then RR = 20 - (10 x [{g - 10,000}/20,000]). If g is greater than 30,000, then RR = 10.
Tidal Volume	kg = weight in kilograms (If kg is greater than 100, then kg = 100.) RR = Respiratory Rate dead space (ds) = kg/0.45 If kg is less than or equal to 45, then TV= ds + (ds x [1.35 + {100- ds} x 0.0135]/0.05/RR). If kg is between 45 and 100 or equal to 100, then TV = ds + (ds x [1.35/0.05/RR]).

Pre-use checkout

The ventilator is equipped with an automated checkout. Complete the checkout before using the ventilator on a new patient. The ventilator should be fully cleaned and prepared for a patient prior to performing the checkout.

Checkout includes the following checks:
- Paw Transducer Check

- Barometric Pressure Check

- Relief Valve Check

- Exhalation Valve Check

- Expiratory Flow Sensor Check

- Air Flow Sensor Check

- O2 Flow Sensor Check

- O2 Concentration Sensor Check

- Resistance Check

- Circuit Leak, Compliance, and Resistance

WARNING
To help ensure the proper function of the system, it is highly recommended to complete the pre-use Checkout between patients.

⚠
Breathing circuits and breathing circuit components are available in many different configurations from multiple suppliers. Attributes of the breathing circuits such as materials, tube length, tube diameter, and configuration of components within the breathing circuit, may result in hazards to the patient from increased leakage, added resistance, or changed circuit compliance. It is recommended that a Checkout be conducted prior to use with each patient.

⚠
Failure to complete Checkout may result in inaccurate delivery and monitoring. Checkout should be completed with the breathing circuit that will be used during ventilation.

⚠

If a Checkout is not completed, the system uses the compliance and resistance data from the last completed system test 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. This may result in risk to the patient.

⚠

Changing patient breathing circuits to a different compressible volume after the checkout will affect the volume delivery and exhaled volume measurements.

⚠

The patient must NOT be connected to the ventilator when completing the Checkout.

Checkout procedure

When in Standby, the *Patient Setup* menu will be displayed on the normal screen.
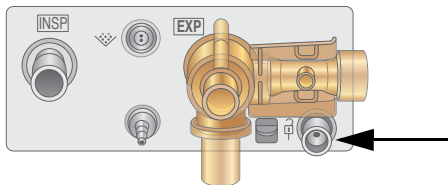
To begin the Checkout procedure:

1.   Select *Checkout*.

Important

If Bypass Checkout is selected, the Checkout procedure will not be performed and the system will use the compliance and resistance data from the last completed Checkout procedure.

2.   Attach the breathing circuit that will be used for ventilating the current patient.

3.   Occlude the patient wye using the occlusion port.

4. Select *Start Check*.
    - The results appear next to each check as they are completed.
    - During the checkout process, the *Resistance Check* menu appears on the display and a tone sounds.
        — Remove the occlusion from the patient wye. The system will detect the occlusion removal and automatically continue the checkout.
    - When the entire checkout is finished 'Checkout complete' will appear and the highlight will move to *Delete Trends*.
5. Select *Yes* to erase trends or *No* to retain the saved trends.
6. If one or more checks failed, select *Check Help* for troubleshooting tips.
    - Perform Super User calibrations if Check Help is not successful.
7. If all tests passed, select *Patient Setup Menu*.

Note

The circuit leak is measured at 25 cmH_2O. The resistance that is displayed is only from the inspiratory side.

If the circuit leak is greater than 0.5 l/min or Resistance or Compliance cannot be calculated, the Circuit Check will fail.

Important

If the circuit leak is greater than 0.5 l/min or if the exhalation flow sensor is changed after Checkout, the expiratory tidal volume measurement may have decreased accuracy.

Important

If the Relief valve failure alarm activates after system check then system will not ventilate.

Testing alarms

The alarms may be tested after the Checkout has been completed. Connect a patient circuit and a test lung to the ventilator to complete tests.

Before completing any of the tests:

1. Select **Standby -** *Standby*.

2. When testing is complete, remove test lung, then select **Standby -** *Start Ventilation*.

Note

Resolved alarms appear as white text on a black background and will remain on the screen until **Silence Alarms** is pushed.

Setting up for test

1. Select **Vent Setup -** *VCV - Confirm*.

2. Start ventilation by selecting **Standby -** *Start Ventilation*.

3. Ensure that no alarms are present. If necessary, modify current alarm limits.

Pmax alarm test

1. If not already in VCV mode, select **Vent Setup -** *VCV - Confirm*.

2. Change *Pmax* to violate the alarm condition.

3. Use the following indicators to verify that the alarm is working correctly:
   - The next complete breath does not rise more than 2 cmH_2O above Pmax.
   - The 'Ppeak high' alarm appears and sounds.
   - The Ppeak measurement appears in a flashing red box.
   - The red LED flashes.

4. Increase Pmax to remove alarm condition.
   - The Ppeak alarm message changes to white text on a black background indicating that the alarm has been resolved.
   - The alarm tone no longer sounds and the LED turns solid red until **Silence Alarms** is pushed to clear the alarm.

5. Change *Plimit* to below Ppeak.

6. Verify the following:
   - Breaths are limited at Plimit.
   - The 'Plimit reached' alarm appears and sounds.

7. Change Plimit to above Ppeak to remove alarm condition.

Minute volume alarms test

1. If not already in VCV mode, select **Vent Setup -** *VCV - Confirm*.

2. Select **Alarms Setup -** *Adjust Settings*.

3. Change MVexp lower limit to violate the alarm condition and keep the menu open.

4. Use the following indicators to verify that the alarm is working correctly:
    *   The 'MVexp low' alarm appears and sounds.
    *   The MVexp measurement appears in a flashing red box.
    *   The red LED flashes.

5. Change the MVexp lower limit to remove alarm condition.
    *   The 'MVexp low' alarm message changes to white text on a black background indicating that the alarm has been resolved.
    *   The alarm tone no longer sounds and the LED turns solid red until **Silence Alarms** is pushed to clear the alarm.

Apnea alarm test

1. If not already in VCV mode, select **Vent Setup - *VCV - Confirm***. The default settings may be used for this testing.

2. Disconnect the expiratory side of the patient circuit from the ventilator.

3. Use the following indicators to verify that the alarm is working correctly:
   - The 'Apnea' alarm appears and sounds.
   - The Respiratory Rate measurement displays 'APN' in a flashing red box.
   - The red LED flashes.
   - 'Apnea' is displayed in red text in the Paw waveform.

4. Connect the expiratory side of the patient circuit to the ventilator.
   - Verify the 'Apnea' alarm message changes to white text on a black background indicating that the alarm has been resolved.
   - The alarm tone no longer sounds and the LED turns solid red until **Silence Alarms** is pushed to clear the alarm.

Low O2 alarm test

1. If not already in VCV mode, select **Vent Setup -** *VCV - Confirm*.
2. Using the quick key, change *FiO2* to 50%.
3. Select **Alarms Setup -** *Adjust Settings*.
4. Change the FiO_2 upper alarm limit to 70% and the FiO_2 lower alarm limit to 60% and keep the menu open.
5. Use the following indicators to verify that the alarm is working correctly:
   - The 'FiO2 low' alarm appears and sounds.
   - The FiO_2 measurement appears in a flashing red box.
   - The red LED flashes.
6. Change the FiO2 upper and lower alarm limits to 56% and 44%.
   - Verify the 'FiO2 low' alarm message changes to white text on a black background indicating that the alarm has been resolved.
   - The alarm tone no longer sounds and the LED turns solid red until **Silence Alarms** is pushed to clear the alarm.

Important

Make sure the alarm limits are set to the desired values before using the ventilator on a patient.

Patient ID

Use the *Patient ID* menu item to enter an alphanumeric Patient ID code up to 10 characters.

WARNING

To protect patient privacy, do not use the patient's name as the patient ID. Consider institution privacy policies when entering patient's ID.

1. Select the desired characters and push the ComWheel to confirm.

2. If less than 10 characters are entered, select *SAVE* and push the ComWheel to confirm the patient ID entered.
   - It is necessary to select *SAVE* if the *CLR* or *DEL* menu items were used while entering Patient ID.
   - If ten characters are entered, the system automatically saves and returns the highlight to *Patient ID*.

Note

Patient ID is removed 24 hours after a system power down.

To remove Patient ID, select **Patient Setup** - *Checkout* - *Delete Trends.*

Vent Setup

Ventilator setup selections are made in the *Vent Setup* menu. The Vent Setup menu can be accessed through the **Vent Setup** key or through the *Patient Setup* menu.

Ventilation mode

Modes may be changed in Standby or while the ventilator is operating.

To change modes:

1. Select *Vent Setup*.

2. Select desired mode.
   - The arrow identifies the current mode.

3. Select *Confirm*.

Ventilation soft limit indicators

When adjusting ventilation settings, visual indicators (or soft limits) show the parameters are approaching their setting limits.

Quick key and menu item boxes will show in yellow or red as a warning of high values when ventilation settings are selected. The user will be allowed to set the limit. It is only a visual cue that the parameter is approaching the setting limit. The parameters with soft limits are Pmax, PEEP, Pinsp, Psupp, Tinsp, RR, I:E, Thigh, Tlow, Phigh, Plow.

Ventilation settings

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

To change the settings for the current mode:

1. Select *Vent Setup*.
2. Select *Adjust Settings*.
3. Scroll to the desired setting.
4. Select setting, change the value, and push the ComWheel to confirm the setting.
5. Select *Exit* when complete.

Ventilation preferences

Ventilation preferences are set through the *Vent Preferences* menu.

To adjust the ventilation preferences during ventilation:

1. Push **System Setup.**
2. Select *Patient Setup*.
3. Select *Vent Preferences*.

Selecting a Backup mode

Ventilation modes to which backup ventilation apply are established by facility defaults.

WARNING

Ensure that all users at the facility have been trained and notified of the facility default settings relating to Backup mode.

Backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases to below 50% of the set low MVexp alarm. Backup settings may be changed for each patient.

To select a Backup Mode:

1.   Select **Vent Setup** *- Backup Mode* or select *Vent Preferences - Backup Mode*.

2.   Select the ventilation mode to be used if the system goes into backup ventilation.

3.   Use the ComWheel to navigate through the adjustment window and to change a value. Grayed-out values are carried over from the current ventilation mode.

4.   Push the ComWheel to confirm the setting.

Note

Backup mode can be set to any mode except CPAP/PSV.

Changing Backup mode settings

To adjust the settings of a selected Backup mode:

1.   Select **Vent Setup** *- Backup Mode* or select *Vent Preferences - Backup Mode*.

2.   Select *Adjust Settings*.

3.   Scroll to the desired setting.

4.   Select setting, change the value, and push the ComWheel to confirm the setting.

5.   Select *Exit* when complete.

Airway Resistance Compensation (ARC)

Airway Resistance Compensation (ARC) adjusts the target delivery pressure to compensate for the resistance caused by the endotracheal tube or tracheostomy tube used. The compensation is applied to the inspiratory phase of all pressure-controlled, CPAP, and pressure-supported breaths.

To set airway resistance compensation:

1. Select *Vent Preferences - ARC*.

2. Select desired settings.
   - Type and size of tube.
   - Compensation. The compensation setting determines for what percentage of the total tube resistance is compensated.

3. Select *Previous Menu*.

Note

ARC settings of 75% and higher may result in brief minor overshoots of target lung pressure depending on patient conditions, including low airway resistance and low lung compliance. Ensure proper Pmax setting when using ARC. ARC control is limited to Pmax - 4 cmH_2O.

Assist control

Assist control is available in VCV, PCV, and PCV-VG modes.

To Activate assist control through the *Vent Preferences* menu:
- Set to *On* to deliver a controlled breath during the expiratory phase when a patient trigger is detected.

- Set to *Off* to support spontaneous patient breathing at the PEEP pressure level during the expiratory phase.

When Assist Control is set Off, the ventilator will allow spontaneous inspirations from the PEEP level to be completed, and delay the delivery of the next controlled breath in order to minimize breath stacking. Under certain conditions such as high spontaneous breathing rates or high leakage, the delivered rate of controlled breaths may fall below the set rate. To ensure that the rate of delivery of controlled breaths meets or exceeds the set rate, Assist Control should be set On.

Leak compensation

Leak compensation automatically adjusts ventilation delivery and monitoring for breathing circuit and patient airway leaks to maintain desired tidal volume delivery in the presence of leaks. Activate leak compensation through the *Vent Preferences* menu.

The system calculates the instantaneous leak rate by using the leak volume over the previous 30 seconds and the instantaneous and mean airway pressures:

- V_{leak} = Leak volume from previous 30 seconds

- Leak rate = V_{leak} x (instantaneous Paw / mean Paw from the previous 30 seconds)

- Leak compensated patient flow = measured Flow - Leak rate

Leak compensation provides the following benefits to the clinician when leaks are present:

- Leak compensated volume delivery: The vent engine's delivered tidal volume is compensated upwards to ensure the patient receives the set tidal volume. Leak compensated volume delivery is available in VCV, PCV-VG, SIMV-VC, and SIMV-PCVG, BiLevel-VG, and VG-PS if installed.

- Leak compensated waveforms and measured values: Adjusts the flow and volume waveforms and measured values for the effects of leaks in the breathing circuit (when the internal ventilator sensors are in use) and patient airway. The Leak Compensated Patient Flow is used for the flow and volume waveform displays, and measured values (TVinsp, TVexp, MVinsp, MVexp). Leak compensated waveforms and measured values are only displayed when their Data Source is "Vent".

- Measured value Leak %: Indicates the amount of leak from the previous breath and is calculated as: Leak % = (actual TVinsp -actual TVexp)* 100 / (actual TVinsp). Leak % is displayed whenever *Vent* is selected as the data source.

Example:

Given the following settings and measured values and assuming there are no water vapor and temperature effects:

- TV = 300 ml

- RR = 10

- I:E = 1:2

- measured leak volume during previous inspiratory phase = 55 ml

- measured leak volume during previous expiratory phase = 25 ml

During the next breath, the vent engine delivers 355 ml during inspiration. The patient will receive 300 ml. The expiratory flow sensor will measure 275 ml. Measured TVinsp and TVexp will report 300 ml. Assuming this same breath profile repeats itself, MVinsp and MVexp will report 3.0 l/min. The Leak % will report (355-275) / 355 => 23%.

This example demonstrates a leak compensated volume delivery of 55/300 => 18%. The system limits volume control leak compensation to 25% of set tidal volume for adult patients and 100% or 100 ml, whichever is less for pediatric and neonatal patients.

Note

Leak rate is based on the average leak from the previous breath, it may take up to 30 seconds for the system to fully respond to changes in patient leak rates.

Note

While the 'Circuit leak?' alarm is active, leak compensated volume delivery will not exceed the compensation level that existed at the time the alarm became active.

Alarms setup

Alarm limits, alarm volume, and other alarm settings are adjusted in the Alarms Setup menu. Alarm history is also accessed through this menu. Selecting Default Limits loads the default settings as set by the Super User or the factory defaults if no Super User settings have been entered.

Setting alarm limits

These alarm limits can be changed:
- Low and High Ppeak

- Low and High MVexp

- Low and High TVexp

- Low and High RR

- Low and High $EtCO_2$

- Low and High EtO_2

- Low and High FiO_2

- Low and High PEEPe

- High PEEPi

- High Paux

To set alarm limits:

1. Push **Alarms Setup**.

2. Select *Adjust Limits*.

3. Scroll to the desired alarm.

4. Select alarm limit and change value.

5. Select *Previous Menu* when complete.

Note

The low Ppeak alarm limit is not active for pressure-supported breaths in CPAP/PSV mode.

Leak limit

The *Leak Limit* setting determines what size leak is allowed before a leak alarm condition is activated. The setting is a percentage of the total volume delivered to the patient and may be set to Off.

To set leak limit:

1. Push **Alarms Setup**.

2. Select *Leak Limit* and change the value.

3. Select *Previous Menu* when complete.

Apnea time

The *Apnea Time* setting determines how much time is allowed between patient breaths before the Apnea alarm is activated.

To set apnea time:

1. Push **Alarms Setup**.

2. Select *Apnea Time* and change the value.

3. Select *Previous Menu* when complete.

Alarm volume

The volume at which alarms are annunciated may be selected as a value from 1 (low) to 5 (high).

To set alarm volume:

1. Push **Alarms Setup**.

2. Select *Alarm Volume* and change the value.

3. Select *Previous Menu* when complete.

High alert audio

If a high priority alarm has not been resolved the alarm volume can be set to elevate to a higher volume after a specific amount of time. The High Alert Audio can be set to be activated between 0 and 30 seconds of an alarm activating and may also be turned Off.

To set high alert audio:

1. Push **Alarms Setup**.

2. Select *High Alert Audio* and change the value.

3. Select *Previous Menu* when complete.

Alarm history

The most recent 200 medium and high-priority alarms activated since the last power cycle are displayed with the date and time in the Alarm History menu.

To access alarm history:

1. Push **Alarms Setup**.

2. Select *Alarm History* to scroll and view recent alarms.

3. Select *Previous Menu* when complete.

FiO2 alarm limits

The Low and High FiO_2 alarm limits are based on current settings. The FiO_2 alarm limits are set by default to ±6 from the current FiO_2 setting. The differential alarm limits may be changed manually. If an alarm limit is changed, the ventilator will maintain the difference between the alarm limit setting and the FiO_2 setting, even if the FiO_2 setting is changed.

For example, if the current setting for FiO_2 is 65%, the default of the High FiO_2 alarm limit would be 71%, a difference of 6%. A change to the FiO_2 setting to 75% will result in the alarm limit being raised to 81%, maintaining the 6% difference. If the alarm limit is manually changed to 85%, creating a 10% difference from the setting, subsequent FiO_2 setting changes will maintain the new 10% alarm limit difference.

Note

The High FiO2 alarm is disabled when set FiO2 = 100%.

Selecting a data source

Several monitoring parameters may be obtained from either the ventilator or the airway module. These include Ppeak, Pmean, PEEPe, Pplat, TVinsp, TVexp, RR, MVexp, MVinsp, Compl, and Raw. Information that is retrieved from the airway module is identified with the module data indicator.

To select a data source:

1. Push the **System Setup** key.

2. Select *Parameters Setup - Data Source*.

3. Select *Vent* or *Mod* as the primary source for information.
   - If *Vent* is selected, the internal sensors of the ventilator will be the first source for information.
   - If *Mod* is selected, the airway module will be the first source for information. If information is not available through the airway module, information will come from the internal ventilator sensors.

Note

If Mod is selected and the airway module is warming up, information from the Vent will be used until the airway module information is available. Warm up can take up to 2 minutes.

Note

The internal sensors of the ventilator are used as the data source to determine Spontaneous measured values.

Starting ventilation

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

⚠

The ventilator shall not be covered in such a way that fans and exhaust ports are compromised or positioned in such a way that the operation or performance is adversely affected.

⚠

Ensure that an alternate means of ventilation is available any time the ventilator is in use.

To start ventilation:
1. Push **Standby**.
2. Select *Start Ventilation*.
3. Connect the circuit to the patient.

Entering Standby

Monitoring and ventilation will cease when the ventilator is placed into Standby. Follow the method for "*Starting ventilation"* to exit Standby.

WARNING

The patient will not be ventilated when in Standby.

To enter Standby:

1. Disconnect the patient from the circuit.

2. Push **Standby**.

3. Select *Standby*.

Turning the system off

The system may only be turned off when in Standby. Follow the procedure for *"Entering Standby,"* and turn the system switch off.

Monitoring

The ventilator with an airway module installed may be used as a CO_2, O_2, and metabolic monitoring device. Ventilation will cease when the ventilator is placed into Monitoring Only.

WARNING

The patient will not be ventilated when in Monitoring Only.

To enter Monitoring Only:

1.   Push **Standby**.
2.   Select *Monitoring Only*.

Park Circuit

Use this function to allow the patient circuit to be occluded without the ventilator alarming while in standby. This function allows the patient circuit to be hygienically protected while waiting to connect the patient. Removing the circuit occlusion will clear the Park Circuit status.

The message "Circuit Parked" appears on the screen while in this mode.

WARNING

The patient will not be ventilated while the circuit is parked.

To Park the Circuit:

1. Push **Standby**.
2. Select *Standby.*
3. Occlude the patient circuit using the occlusion port shown below.
4. Select *Park Circuit*.

Changing settings while ventilating

Ventilation settings

Method 1:

1. Push a quick key.
2. Change the value.
3. Confirm the setting.

Method 2:

1. Push **Vent Setup**.
2. Select *Adjust Settings*.
3. Scroll to the desired setting.
4. Select setting, change the value and push the ComWheel to confirm the setting.
5. Select *Exit* when complete.

Ventilation preferences

To access ventilation preferences:

1. Push **System Setup**.
2. Select *Patient Setup - Vent Preferences*.
3. Adjust the desired selections and push the ComWheel to confirm the setting.
4. Push **Normal Screen**.

Alarm limits

To set alarm limits:

1. Push **Alarms Setup**.
2. Select *Adjust Limits*.
3. Scroll to the desired alarm.
4. Select setting, change the value and push the ComWheel to confirm the setting.
5. Select *Exit* when complete.

Auto Limits

Selecting **_Auto Limits_** will change the following alarm limit settings based on current measured values. Alarm limits that are set to Off will not change if Auto Limits is selected.

- Low and High MVexp

- Low and High TVexp

- Low and High RR

- Low and High $EtCO_2$

- Low and High PEEPe

This table explains how the auto limits are calculated from the measured values.

Alarm Setting	Upper Limit	Lower Limit
MVexp	(2.5)(current MVexp)	(0.5)(current MVexp)
TVexp	(2.5)(current TVexp)	(0.5)(current TVexp)
RR	current RR + 30	current RR - 2
$EtCO_2$ (% or kPa)	current $EtCO_2$ + 1	current $EtCO_2$ - 1
$EtCO_2$ (mmHg only)	current $EtCO_2$ + 6	current $EtCO_2$ - 6
PEEPe (cmH2O, mbar)	current PEEPe + 5	current PEEPe - 5
PEEPe (kPa)	current PEEPe + 0.5	current PEEPe - 0.5

Default limits

Selecting *Default Limits* will change the alarm limits to the facility default settings if the default limits do not conflict with the current ventilation settings.

Using snapshots

Taking a snapshot

Use the Take Snapshot feature to capture the waveform clips, active alarms, measured parameters, and ventilator settings that are currently on the display. The ten most recent shapshots are stored in memory. When an eleventh snapshot is saved, the oldest snapshot is deleted. A message in the general message field indicates the snapshot recorded. Three pages of information are recorded for each snapshot.

Push **Take Snapshot** to record a snapshot.

Viewing a snapshot

To view a snapshot:

1. Push **Trends**.

2. Select *Snapshot*.

3. The most recent snapshot will show in the right side menu.
   - Select *Next Page* to scroll through the three pages of snapshot information.
   - Continue to scroll to the next page to view additional snapshots that have been saved to the memory.
   - Select *Cursor* to view the waveform values stored in memory.

Viewing trends

The views for patient trends are graphical, snapshot, measured, and settings. The settings view will show SBT in the mode column when the Spontaneous Breathing Trial (SBT) is active, S-PCVG when SIMV-PCVG is active, and BiLev-VG when Bilevel-VG is active.

Trend information will automatically be saved every minute for the most recent 12 hours of data, every 5 minutes for data from 12 to 48 hours, and every 30 minutes for data from 48 hours to 14 days.

Trend information can be deleted in the Checkout menu or will be deleted if the system is powered down and has not been powered on for 24 hours.

To view Trends:

1. Push **Trends**.

2. Select the desired view.
   - The arrow identifies the current trend view.

3. Select *Cursor* to scroll through the current trend view.

4. Push the ComWheel to return the highlight to *Cursor*.

5. Select *Next Page* to view additional parameters or snapshots.

Trends split screen

Trends are also available as a split screen view. Split screen trends will show a small graphic trend of the measured parameters for 120 minutes of data.
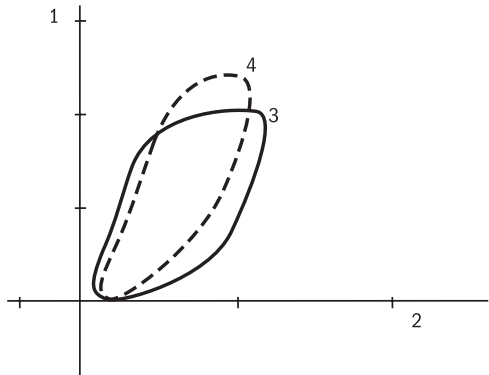
Displayed waveform	Trend displayed
Paw	Ppeak, Pplat
Flow	MVexp, Rate
Volume	Spont MV, Spont RR
Paux	Paux peak
CO2	EtCO2
O2	EtO2, FiO2

Viewing spirometry Loops

There are three types of spirometry loops:
- Pressure-Volume (P-V)
- Flow-Volume (F-V)
- Pressure-Flow (P-F)

Spirometry loops may be viewed through a menu or as a split screen. The loop type displayed may be selected in the *Spirometry* or *Spirometry Setup* menu.

1. Volume axis
2. Pressure axis
3. Real time loop
4. Reference loop (appears on display in white)

Sensor type

Sensor Type refers to the style of airway adapter used with the airway module. If spirometry data is to be obtained from the airway module, ensure the Sensor Type matches the airway adapter used. If an airway module is not installed, *Sensor Type* will not be selectable.

If the Sensor Type is not set correctly the information displayed may not be accurate.

To select the sensor type:

1. Push **Spirometry**.

2. Select *Spiro Setup- Sensor Type*.

3. Select *Adult* or *Pedi* depending on the sensor used.
   - Adult refers to the D-lite sensor.
   - Pedi refers to the Pedi-lite sensor.

Spirometry menu

Loops may be saved, viewed, and erased in the *Spirometry* menu.
* Push **Spirometry**.

  * To view a specific loop type; select *Loop Type* and the desired view.
  * To store a loop to memory; select *Save Loop.*
  * To view a saved loop; select *Reference Loop* and the time at which the loop was saved.
  * To erase a saved loop; select *Erase Loop* and the time at which the loop was saved.

Using the cursor

The cursor is an easy way to quickly read the volume and pressure of the spirometry loop.

1. In the *Spirometry* menu, select *Cursor*.

2. Turn the ComWheel to move the cursor across the graph.
   * The volume points of intersection show in top to bottom order at the left of the graph.
   * The pressure point of intersection shows below the graph.

3. Push the ComWheel to remove the cursor from the graph.

Spirometry split screen

Spirometry loops may be viewed alongside the waveforms on the normal screen.

To set up the split screen:

1. Push **Spirometry**.
2. Select *Spiro Setup*.
3. Select *Split Screen - Spiro*.
4. Push **Normal Screen**.

Lower spiro split screen

Measured values or an additional spirometry loop may be viewed on the lower portion of the split screen. Spiro must be selected as the *Split Screen* to set *Lower Spiro Split Screen*.

To set up the lower spiro split screen:

1. Push **Spirometry**.
2. Select *Spiro Setup*.
3. Select *Split Screen - Spiro*.
4. Select *Lower spiro split screen*.
5. Select *Digits*, *P-V*, *F-V*, or *P-F*.
6. Push **Normal Screen**.

Performing Vent Calculations

Vent calculations is used to automate calculations for patient lab data and may only be used for Adult and Pediatric patients.

To calculate patient values:

1. Select **Trends** - *Vent Calculations*.
   - The Lab Values menu displays.

2. Select *Enter Values*.

3. Select *Sample Time* and enter the correct time the patient sample was collected.

4. Enter the desired patient lab data values and push the ComWheel to confirm lab values.

5. Select *Calculate*.
   - Vent calculations automatically display in the Ventilation Calculations menu.

To view completed lab data calculations:

1. Select *History*.
   - The Vent Calcs History menu displays showing the sample dates and times the calculations were made.

2. Select *Next Page* to view additional history pages or *Previous Page*.
   - When a vent calculation is entered and the Vent Calcs History contains the maximum number of entries (45), the oldest vent calculation is deleted.

Vent Calcs	Lab Values	
Enter Values	Sample Time	
History	Hb	g/l, g/dl, mmol/l
Next Page	SaO2	%
Previous Page	SvO2	%
Previous Menu	PaO2	kPa, mmHg
	PvO2	kPa, mmHg
	PaCO2	kPa, mmHg
	Calculate	

Parameter	Calculation
PAO2	FiO2/100 *(ATMP-47) - PaCO2 *(FiO2/100+(1-FIO2/100)/ RQ)
AaDO2	PAO2 - PaO2
Pa/FiO2	PaO2/FiO2 *100
PaO2/PAO2	PaO2/PAO2 *100
CO	VO2/(CaO2 - CvO2)
Vd/Vt	(PaCO2 - ExpCO2 Wet)/(PaCO2 - FiCO2 Wet) *100
Vd	(Vd/Vt /100) * TVexp
VA	(VCO2/1000)/(PaCO2/ATMP - 47) * 1.212

Increase O2

Nebulizer

Pneumatic nebulizer

Manual Breath

Suction

P 0.1

Negative Inspiratory Force (NIF)

Vital Capacity (VC)

Intrinsic PEEP

PEEPi Volume

Inspiratory Hold

Expiratory Hold

Spontaneous Breathing Trial (SBT)

Rapid Shallow Breathing Index (RSBI)

Performing procedures

Performing procedures

Increase O2

Increased oxygen may be delivered for two minutes. A general message appears with the time remaining. If delivery is not manually stopped it will automatically end after two minutes.

1. Push ↑ **O2**.
   - The O2 countdown time is displayed in the general message field.
2. The O_2 concentration can be adjusted to a level less than 100% by turning the ComWheel and confirming the setting.
3. Push ↑ **O2** to resume the previous setting for O_2 before the two minutes has elapsed.

Nebulizer

The system operates with the Aeroneb Pro and Aeroneb Solo Nebulizer Systems by Aerogen.

CAUTION

Do not insert an airway module into the module bay until at least one minute after a nebulizer procedure. Aerosolized medication may damage the D-fend or interfere with the airway module measurements.

Note

Gas sampling and monitoring is suspended while the nebulizer is in use.

Nebulization can be set for a specific delivery time or for the volume of medication delivery. The nebulizer will begin and continue for the length of time or volume selected. A general message appears with the amount of nebulization time remaining.

Note

If the nebulizer is dry, it may start and stop intermittently for up to the first minute of operation. To prevent this, turn the nebulizer off when the medication has been completely dispensed.

Follow these steps to deliver nebulized medications to the patient:

1. Push **Nebulizer**.

2. Select *Volume* or *Time* and change to the desired value.

3. To deliver multiple nebulizer cycles, set the number of *Cycles* and the *Pause Time* between cycles.

4. Select *Start*.

5. To end before selected time, select **Nebulizer** - *Stop*.

Pneumatic nebulizer

The Engström system can compensate for additional flow introduced by a pneumatic nebulizer into the patient circuit.

WARNING

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

⚠

When the Pneumatic Nebulizer Flow Compensation is On, volume monitoring and delivery accuracy is decreased.

⚠

Use of an external pneumatic nebulizer may significantly modify the volume of gas that is delivered to the patient if external flow is introduced and Pneumatic Nebulizer Flow Compensation is not used.

⚠

Leaks and flow sensor alarms may not be identified by the ventilator when Pneumatic Nebulizer Flow Compensation is On.

To set the ventilator for pneumatic nebulizer use:

1. Push **Nebulizer**.

2. Select *Pneumatic Nebulizer*.

3. Select *Flow* and adjust the flow value to match the amount of flow that will be introduced into the circuit, then push the ComWheel to confirm the setting.

4. Select *Flow Compensation* - *On*.

5. Introduce the pneumatic nebulizer into the patient circuit.
   • For best results, introduce the pneumatic nebulizer into the patient circuit within approximately 15 seconds of selecting Flow Compensation On.

To end pneumatic nebulizer use:

1. Push **Nebulizer**.

2. Select *Pneumatic Nebulizer*.

3. Turn pneumatic nebulizer flow source off.

4. Select *Flow Compensation - Off*.

5. Press *Previous Menu* or **Normal Screen** to exit.

Manual Breath

An additional breath may be delivered to the patient by selecting **Procedures** - *Manual Breath*. The system requires a 0.25 second pause between delivery of manual breaths. This breath will be based on the settings for the current mode. Manual Breath is not available in CPAP/PSV mode.

Suction

When the Suction procedure is activated the system delivers 100% O2 in Adult and Pediatric patients or a user-set increase over current setting for Neonatal patients for 2 minutes, or until the patient is disconnected. The system then goes into Standby for 2 minutes or until the patient is reconnected. Next, the system resumes ventilating at the current settings delivering the increased O2 value for 2 minutes.

Note

If the patient is not disconnected during the first increased O_2 phase, the suction procedure will cancel.

Note

The suction procedure is not meant for in-line suction because it requires that the patient be disconnected in order for the procedure to move to the next phase.

To begin Suction procedure:

1. Push **Procedures**.

2. Select *Suction*.

3. The system will deliver increased O_2 for 2 minutes or until the patient is disconnected.

4. Disconnect the patient. Suction the patient.
   - A medium priority alarm will sound once with no message.
   - The system will enter Standby mode for 2 minutes or until the patient is reconnected.
5. Reconnect the patient to resume ventilation. The system will deliver increased O_2 for 2 minutes.

Note

To stop an active suction procedure during increased O_2 delivery, push **Procedures** and select *Suction* or push ↑ **O2**.

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

P 0.1

This procedure reflects neuromuscular activation of the patient during spontaneous breathing. P 0.1 measures the airway occlusion pressure 0.1 second after beginning an inspiratory effort against an occluded airway.

The result will appear in the Lung Mechanics menu along with a time stamp. It will remain here until the procedure is selected again, or until the ventilator is put into Standby.

To obtain a P 0.1 measurement:

1. Push **Procedures**.

2. Select *Lung Mechanics - P 0.1*.

Note

To stop an active P 0.1 procedure, push the ComWheel.

Negative Inspiratory Force (NIF)

The Negative Inspiratory Force procedure is used to measure a patient's most negative airway pressure (as measured by the expiratory pressure sensor) during the set NIF time.

If NIF is more negative than -(20 cmH2O + PEEP) the ventilator will display "< -(20 + PEEP)".

WARNING

Patient is not ventilated during a NIF procedure.

To begin NIF procedure:

1. Push **Procedures**.

2. Select *Lung Mechanics - NIF Time*.
   - Use the ComWheel to select a NIF time up to 30 seconds.

3. Select *NIF*.

Note

To stop an active NIF procedure before the set NIF time period, push the ComWheel.

Vital Capacity (VC)

The Vital Capacity procedure is used to measure a patient's (TVexp) expired Tidal Volume.

WARNING

Patient is not ventilated during a VC procedure.

To begin Vital Capacity measurement:

1. Push **Procedures**.
2. Select *Lung Mechanics - Vital Capacity*.

Note

To stop an active Vital Capacity procedure, push the ComWheel.

Intrinsic PEEP

The Intrinsic PEEP procedure will stop the flow of gas at the end of expiration and measure the airway pressure when the lung equilibrates with the circuit pressure. Intrinsic PEEP is the amount of pressure remaining above the PEEP value.

The result will appear in the Procedures menu along with a time stamp. It will remain here until the procedure is selected again, or until the ventilator is put into Standby.

To obtain an Intrinsic PEEP measurement:

1. Push **Procedures**.

2. Select *Intrinsic PEEP*.
   - The system will attempt to measure Intrinsic PEEP at the end of each controlled breath during a 30 second time period. If unsuccessful, then the procedure is cancelled.
   - Spontaneous breath triggers or activation of other procedures may cause an unsuccessful measurement.
   - The effects of breathing circuit compliance are accounted for in the Intrinsic PEEP measurement.

Note

To stop an active Intrinsic PEEP procedure, push the ComWheel.

PEEPi Volume

Selecting Intrinsic PEEP will also calculate the PEEPi Volume. This is the approximate volume of air trapped in the lungs at the time the Intrinsic PEEP procedure is activated. PEEPi Volume is calculated from the current compliance and PEEPi measurement.

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

PEEPi Volume is abbreviated as P Vol in the trend pages.

Inspiratory Hold

When Inspiratory Hold is selected, the inspiratory and expiratory valves close at the end of the next inspiratory phase. The duration of the inspiratory hold can be selected. This function can be used during x-ray procedures or to determine plateau pressure and static compliance calculations. The inspiratory hold cannot be repeated until the patient triggers a spontaneous breath or the ventilator delivers a mandatory breath.

To start an Inspiratory Hold:

1. Push **Procedures**.

2. Select *Inspiratory Hold Time*.
   - Use the ComWheel to select an inspiratory hold time between 2 and 15 seconds.
   - The total Tinsp + Hold Time is limited to 15 seconds.

3. Select *Inspiratory Hold*.

Note

To stop an active inspiratory hold, push the ComWheel.

Expiratory Hold

When Expiratory Hold is selected, the inspiratory and expiratory valves close at the end of the next expiratory phase. The duration of the expiratory hold can be selected. This function can provide the ability to measure the end expiratory lung pressure and may be used for static compliance measurements. The expiratory hold cannot be repeated until the patient triggers a spontaneous breath or the ventilator delivers a mandatory breath.

To start an Expiratory Hold:

1. Push **Procedures.**

2. Select *Expiratory Hold Time.*
   - Use the ComWheel to select an expiratory hold time between 2 and 20 seconds.

3. Select *Expiratory Hold*.

Note

To stop an active expiratory hold, push the ComWheel.

Spontaneous Breathing Trial (SBT)

This procedure will place the ventilator in CPAP / PSV mode at the settings defined in the SBT menu. Alarm limits for tidal volume, apnea time, minute volume, respiratory rate can also be set in this menu.

If the minute volume or respiratory rate alarm limits are exceeded during the SBT, the trial will immediately end and the ventilator will return to the previous mode and settings. A window will appear with a selection to return to the SBT or to continue ventilation with current settings (previous to SBT).

If the apnea alarm limit is exceeded during the SBT, the trial will immediately end and the ventilator will return to the previous mode and settings.

The SBT Split Screen displays the MVexp, RR, and $EtCO_2$ for the trial. The trial results will remain in the split screen until the next trial is run.

A general message appears while the SBT is running indicating the amount of time remaining in the trial.

The trial will automatically end at the time set and the ventilator will return to the previous mode and settings. An informational alarm will appear when there are 2 minutes remaining in the SBT.

The Ppeak Low alarm for SBT is not based on the set value in the Alarms Setup menu. The Ppeak Low alarm will occur if the Pexp or Pinsp is less than 1 cmH2O for 15 continuous seconds.

Note

The Ppeak low setting displayed during SBT is based off of the PEEP/Ppeak low parameters set in the SBT menu, prior to starting the SBT procedure. When the SBT procedure is terminated, the system reverts back to the previous Ppeak low.

Start SBT

To start SBT:

1. Push **Procedures**.
2. Select *Spont. Breath. Trial*.
3. To change the ventilation settings and alarm limits, select *Adjust Settings*.
4. Ensure the time is correct. Time may be set from 2 to 120 minutes.
5. To view a SBT trend, select *Split Screen* - *SBT*.
6. Select *Start* to begin.

Stop an active SBT

To stop an active SBT before the time expires:

1. Push **Procedures**.
2. Select *Spont. Breath. Trial*.
3. To return to the previous mode and settings, select *Stop*.
4. To continue with the current CPAP / PSV settings, select *Adopt Settings*.

Rapid Shallow Breathing Index (RSBI)

The Rapid Shallow Breathing Index (RSBI) is used to assess whether the patient is ready to begin the weaning process. The RSBI can be displayed in the Volume measured value field or in the Volume digit field. RSBI is calculated using spontaneous breath rate/TV (averaged over 1 minute).

To access RSBI:

1. Push **System Setup**.

2. Select *Screen Setup*.

3. Set the *Wave Field 3* or *Digit Field* to *Vol*.

Using menus

Select Patient	**System Setup**	**Patient Setup**
Patient Type:	Patient Setup	Checkout
Adult	Screen Setup	
Pediatric	Neo Flow Sensor Setup	Start Ventilation
Neonatal	Parameters Setup	Standby
Patient Weight 70 kg	System Status	Monitoring Only
Checkout	Data Transfer Setup	Non-invasive Off
Bypass Checkout	Install/Service	Patient Weight 70 kg
	Normal Screen	Patient ID
		Vent Setup
		Vent Preferences
		Previous Menu

Checkout	**Standby**	**Vent Setup**
Start Check	Start Ventilation	Adjust Settings
Stop Check	Standby	Backup Mode
Delete Trends Yes	Monitoring Only	Mode:
Check Log	Park Circuit	VCV
Check Help	Normal Screen	PCV
Patient Setup		PCV-VG
		SIMV-VC
		SIMV-PC
		BiLevel
		CPAP/PSV
		SIMV-PCVG

NIV Setup	
FiO2	50
PEEP	3
Psupp	5
Trigger	6
Rise Time	200
End Flow	25
Tsupp	4
Bias Flow	8
Minimum Rate	10
Backup Pinsp	5
Backup Tinsp	1.7

Vent Preferences	
Backup Mode	
ARC	
Assist Control	On
Leak Compensation	Off
Trigger Compensation	Off
TV Based on	ATPD
Previous Menu	

Backup Mode
Adjust Settings
Mode:
VCV
PCV
PCV-VG
SIMV-VC
SIMV-PC
BiLevel
SIMV-PCVG
Previous Menu

ARC		**Screen Setup**		**Select Layout**
Endotrach. Tube	Off	Wave Field 1	Paw	Screen:
Trach. Tube	Off	Wave Field 2	Flow	Full
Diameter	7.5	Wave Field 3	Vol	Basic
Compensation	35	Digit Field	Compl	Vent Modes:
Previous Menu		Split Screen	None	All
		Sweep Speed	Fast	Selected
		Brightness	4	Previous Menu
		Select Layout		
		Previous Menu		

Parameters Setup

Data Source   Vent
Scaling
CO2 Setup
O2 Setup
Paux Setup
Spirometry Setup
Gas Exchange Setup
Gas Calibration
Previous Menu

Scaling

Scaling   AUTO
Vol Scale   1200
Paw Scale   40
Flow Scale   60
Previous Menu

CO2 Setup

Scale   6%
CO2 Alarm
Previous Menu

O2 Setup

Scale   100%
O2 Alarm
Previous Menu

Paux Setup

Scale   40
Purge Flow   Off
Paux Zero
Paux Alarm
Previous Menu

Spirometry Setup

Sensor Type   Adult
Loop Type   P-V
TV or MV   TV
Split Screen   None
Lower Spiro Split Screen   Digits
Paw Alarm
MVexp Alarm
Previous Menu

Gas Exchange Setup

EE Average Time 2h
Patient Height
Patient Weight
BSA
Previous Menu

Gas Calibration

CO2 Zero
O2 Zero

Previous Menu

Last Calibration:

Data Transfer Setup

Data to Transfer:
Snapshots
Vent Data
Time Period 4 hr
Sample Interval 15 min
Waveforms On
Patients All
Previous Menu

Spirometry		**Procedures**		**Lung Mechanics**	
Loop Type	P-V	Manual Breath		P 0.1	
Cursor		Suction		NIF	
Scaling		Lung Mechanics		NIF Time	5
Spiro Setup		Intrinsic PEEP		Vital Capacity	
Save Loop		PEEPi Volume		Previous Menu	
Reference Loop	None	Inspiratory Hold			
Erase Loop	None	Inspiratory Hold Time	5		
FRC INview		Expiratory Hold			
SpiroDynamics		Expiratory Hold Time	5		
Normal Screen		Spont. Breath. Trial			
		Normal Screen			

SBT		**Nebulizer**		**Alarms Setup**	
Adjust Settings		Start		Adjust Limits	
Time	30	Stop		Auto Limits	
Start		Volume	3.0	Default Limits	
Stop		Time	15	Leak Limit	50
Adopt Settings		Cycles	1	Apnea Time	30
Split Screen	None	Pause Time	1 min	Alarm Volume	3
Previous Menu		Start		High Alert Audio	30
		Pneumatic Nebulizer		Tdisconnect	30
		Normal Screen		Patient Effort	50
				Alarm History	
				Previous Menu	

Trends

Cursor
Next Page
Previous Page
View:
Graphical
Snapshot
Measured
Settings
Time Scale 2 h
Vent Calculations
Normal Screen

Troubleshooting

Troubleshooting

Symptom	Problem	Solution
Mains indicator is not on.	The electrical power cord is not properly connected.	• Connect the power cord. • Loosen the power cord retaining clamp and ensure 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 the power cord connects to has no power.	• Use a different electrical outlet.
	An internal fuse is open.	• Have a Datex-Ohmeda trained service representative repair the system.
	Display unit cable is loose.	• Turn system switch off and disconnect from AC mains power. • Check and tighten the display unit connectors.

Symptom	Problem	Solution
System cannot be turned off.	Ventilator is not in Standby.	• Set the ventilator to Standby and turn system switch off.
No communication with the compact airway module.	Airway module is not properly installed.	• Remove and replace module in the module bay.
	Cable connecting the module bay to the ventilator chassis is loose.	• Check and tighten the module bay connectors.
Backup audio alarm sounds.	System failure.	• Have a Datex-Ohmeda trained service representative repair the ventilator.
	Display unit cable is loose.	• Turn system switch off and disconnect from AC mains power. • Check and tighten the display unit connectors.

Symptom	Problem	Solution
An alarm appears when the data is within range.	Alarm is from the ventilator but the value displayed is from the airway module.	• Calibrate the airway module. • Change selection for *Data Source* in the *Parameters Setup* menu.
	'Ppeak high' alarm conditions are checked before the display is updated.	• No action required. • In certain situations the ventilator will react to a transient high pressure situation before the data can be sampled for display.
Ventilator does not deliver set TV in VCV or SIMV-VC modes.	Plimit setting prevents the full TV from being delivered in the inspiratory period.	• Change TV settings. • Change the Plimit setting.
Ventilator does not deliver set TV in PCV-VG, SIMV-PCVG, BiLevel-VG modes.	Pmax alarm limit is limiting delivered inspiratory pressure.	• Change Pmax setting. • See Section 8 for more detailed information.
	Ventilator is at minimum allowed delivery.	• Change ventilation settings.
Ventilator transitions to Backup mode.	'MVexp low' or 'Apnea' alarm and insufficient patient ventilation.	• Change ventilation settings.

Symptom	Problem	Solution
Short delay in the breath cycle at the PEEP pressure level.	Automatic pressure transducer zeroing interference.	• No action required. • Situation will be corrected when zeroing is complete.
	Automatic flow sensor zeroing interference.	• No action required. • Situation will be corrected when zeroing is complete.
Ventilator is automatically triggering a breath.	The breathing circuit leak rate is higher than the flow trigger level.	• Check the breathing circuit for leaks. • Increase the Flow triggering level or change from Flow triggering to Pressure triggering. • Ensure the Patient Type is set correctly.
TV, compliance and resistance values are inaccurate.	The Checkout was not done with the current patient circuit.	• Complete the Checkout with the same breathing circuit that will be used on the patient.

Symptom	Problem	Solution
The Checkout fails.	Water trap on the exhalation valve is not on tightly.	• Ensure the water trap is screwed on tightly.
	Patient circuit not connected to the ventilator.	• Attach patient circuit to inspiratory and expiratory ports.
	Patient wye is not properly occluded.	• Ensure the patient wye is occluded completely with the leak test plug.
	Expiratory flow sensor has failed.	• Clean or replace the flow sensor. Ensure flow sensor is properly connected.
	Exhalation valve and seals are not properly seated.	• Remove exhalation valve and replace.
	A connection port on the patient circuit is open.	• Ensure all connection ports are occluded.
	Leak in patient circuit is very large.	• Check the breathing circuit for leaks.
	Checkout was stopped before it completed	• Allow Checkout to complete.

Volume controlled ventilation (VCV)

Pressure controlled ventilation (PCV)

Pressure controlled ventilation - volume guaranteed (PCV-VG)

Synchronized intermittent mandatory ventilation - volume controlled (SIMV-VC)

Synchronized intermittent mandatory ventilation - pressure controlled (SIMV-PC)

BiLevel airway pressure ventilation (BiLevel)

Constant positive airway pressure/pressure support ventilation (CPAP/PSV)

Synchronized intermittent mandatory ventilation - pressure controlled volume guaranteed (SIMV-PCVG)

BiLevel airway pressure ventilation - volume guaranteed (BiLevel-VG)

Ventilation modes

Ventilation modes

Volume controlled ventilation (VCV)

In VCV, a set amount of volume is delivered during each mandatory breath. The volume is delivered using a constant flow over a specified amount of time. The amount of pressure required to deliver the tidal volume will vary according to the compliance and resistance of the patient's lungs and thorax.

In VCV, the gas flow to the patient is kept constant during inspiration as long as the airway pressure is below the Plimit setting. Once the Plimit setting has been reached, the flow is reduced to maintain the Plimit level. During the expiratory phase, spontaneous breaths can be drawn from the set PEEP level.

Assist control is available in VCV, PCV, and PCV-VG modes. Activate assist control through the *Vent Preferences* menu.
- Set to *On* to deliver a controlled breath during the expiratory phase when a patient trigger is detected.

- Set to *Off* to support spontaneous patient breathing at the PEEP pressure level during the expiratory phase.

1. Paw waveform
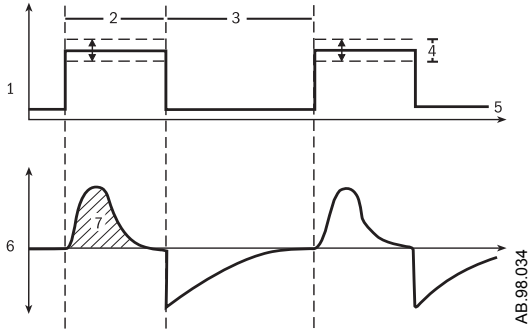2. Tinsp
3. Insp Pause
4. Texp
5. PEEP
6. Flow waveform
7. TV

AB.98.036

Pressure controlled ventilation (PCV)

In PCV, a set pressure level is delivered during each mandatory breath. The pressure is delivered using a decelerating flow and the breath is held for a set amount of time. The amount of volume provided will vary according to the compliance of the patient's lungs.

During the inspiratory phase, spontaneous breaths can be drawn from the set inspired pressure level. During the expiratory phase, spontaneous breaths can be drawn from the set PEEP level.

Assist control is available in VCV, PCV, and PCV-VG modes. Activate assist control through the *Vent Preferences* menu.

- Set to *On* to deliver a controlled breath during the expiratory phase when a patient trigger is detected.

- Set to *Off* to support spontaneous patient breathing at the PEEP pressure level during the expiratory phase.

1. Paw waveform
2. Tinsp
3. Texp
4. Pinsp
5. PEEP
6. Flow waveform

AB.98.037

Pressure controlled ventilation - volume guaranteed (PCV-VG)

In PCV-VG, a tidal volume is set and the ventilator delivers that volume using a decelerating flow and a constant pressure. The ventilator will adjust the inspiratory pressure needed to deliver the set tidal volume breath-by-breath so that the lowest pressure is used. The pressure range that the ventilator will use is between the PEEP + 2 cmH_2O level on the low end and 5 cmH_2O below Pmax on the high end. The inspiratory pressure change between breaths is a maximum of ±3 cmH_2O. If a high airway pressure alarm is active due to the current breath, the next breath's pressure target will be 0.5 cmH_2O less than the current breath's pressure target.

This mode will deliver breaths with the efficiency of pressure controlled ventilation, yet still compensate for changes in the patient's lung compliance. PCV-VG begins by delivering volume controlled breaths for 10 seconds or two breath periods, whichever is longer. The patient's compliance is determined from this period of volume controlled ventilation and the inspiratory pressure level is then established for the next PCV-VG breath.

Activate assist control through the *Vent Preferences* menu.

- Set to *On* to deliver a controlled breath during the expiratory phase when a patient trigger is detected.

- Set to *Off* to support spontaneous patient breathing at the PEEP pressure level during the expiratory phase.

AB.98.034

1. Paw waveform
2. Tinsp
3. Texp
4. Variable pressure to deliver desired TV
5. PEEP
6. Flow waveform
7. TV

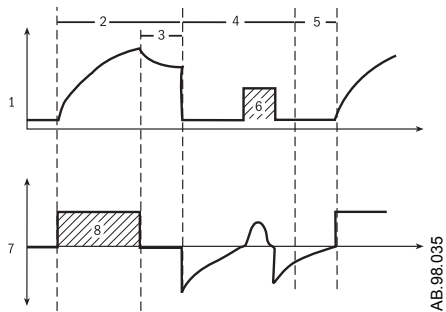## Synchronized intermittent mandatory ventilation - volume controlled (SIMV-VC)

In SIMV-VC, a set number of volume control breaths are delivered to the patient each minute. The patient can breathe spontaneously between mandatory breaths. Pressure support can be used to support the spontaneous breaths.

A portion of the exhalation phase is defined as the trigger window. If a spontaneous breath is detected in this window, a new volume controlled breath is initiated. If a spontaneous breath is detected outside of this window, support for this breath is provided according to the set pressure support. The remainder of the trigger window is added to the next non-triggered phase.

The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (PEEP + Psupp + 2.5 cmH$_2$O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

Ventilation modes to which backup ventilation apply are established by facility defaults.

If selected to be active in SIMV-VC, backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases to below 50% of the set low MVexp alarm. Backup settings may be changed for each patient.

AB.98.035

1. Paw waveform
2. Tinsp
3. Insp Pause
4. Spontaneous breathing period
5. Trig Window
6. Pressure supported breath
7. Flow waveform
8. TV

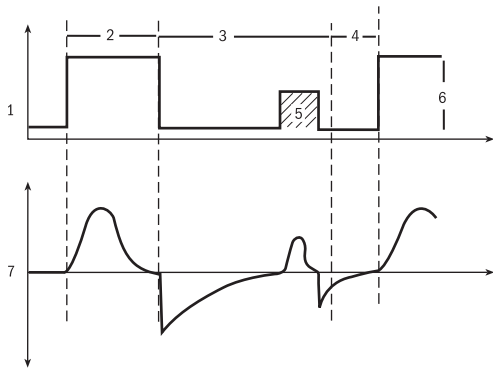## Synchronized intermittent mandatory ventilation - pressure controlled (SIMV-PC)

In SIMV-PC, a set number of pressure control breaths are delivered to the patient each minute. The patient can breathe spontaneously between mandatory breaths. Pressure support can be used to support the spontaneous breaths.

A portion of the exhalation phase is defined as the trigger window. If a spontaneous breath is detected in this window, a new pressure controlled breath is initiated. If a spontaneous breath is detected outside of this window, support for this breath is provided according to the set pressure support. The remainder of the trigger window is added to the next non-triggered phase.

The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (PEEP + Psupp + 2.5 cmH$_2$O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

Ventilation modes to which backup ventilation apply are established by facility defaults.

If selected to be active in SIMV-PC, backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases to below 50% of the set low MVexp alarm. Backup settings may be changed for each patient.

AB.98.038

1. Paw waveform
2. Tinsp
3. Spontaneous breathing period
4. Trig Window
5. Pressure supported breath
6. Pinsp
7. Flow waveform

BiLevel airway pressure ventilation (BiLevel)

In BiLevel, the ventilator switches between two pressure levels at set times. The patient can breathe spontaneously while at either of the pressure levels.

The ventilator synchronizes spontaneous breathing with changes in pressure level. The system has a set trigger window of 80% or 4 seconds whichever is less. If a spontaneous breath is detected within this window, the breath is delivered by an increase to Pinsp + Plow, or Phigh. If a spontaneous breath is detected outside the window, a PSV breath is delivered.

Note

The level of inspiratory pressure provided during a spontaneous breath taken within the high pressure period (Thigh) will be equal to the pressure difference between Psupp and Phigh if Psupp is greater than Phigh. If Phigh is greater than Psupp then no additional support will be provided. See Figure 8.6.

If the patient triggers a spontaneous breath just before the end of Thigh, the system will continue to deliver at Phigh (or Psupp if Psupp is more than Phigh) until the end flow is detected or PSV times out. Then, the system will transition to Plow.
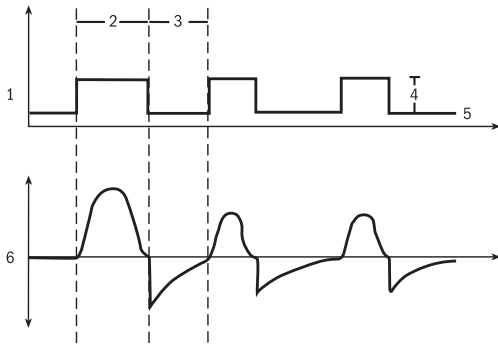
The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (Plow + Psupp + 2.5 cmH_2O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

Ventilation modes to which backup ventilation apply are established by facility defaults.

If selected to be active in BiLevel, backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases to below 50% of the set low MVexp alarm. Backup settings may be changed for each patient.

AB.98.151

1. Paw waveform
2. High pressure period (Thigh)
3. Low pressure period (Tlow)
4. Plow + Psupp
5. Plow
6. Flow waveform

Constant positive airway pressure/pressure support ventilation (CPAP/PSV)

This mode offers the features from both CPAP and PSV modes and is used on spontaneously breathing patients. In CPAP, a pressure above ambient pressure is maintained on the patient's airway.

In PSV, the ventilator provides a set pressure level on top of the CPAP level during the inspiratory phase of the patient's breath. The patient determines their own rate, tidal volume, and inspiratory timing.

The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (PEEP + Psupp + 2.5 cmH_2O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

Ventilation modes to which backup ventilation apply are established by facility defaults. See *"Installation Mode,"* section 10.

If selected to be active in CPAP/PSV, backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases to below 50% of the set low MVexp alarm. Backup settings may be changed for each patient.

Rate, Pinsp, and Tinsp can be added to the CPAP/PSV menu when CPAP Rate is turned On by the Super User using the *Ventilator Settings* menu. These settings apply mechanical breaths during CPAP/PSV ventilation.

When Rate is set in CPAP, the ventilator will deliver backup breaths to the patient if the patient fails to breathe spontaneously over two breath periods. Backup breaths will be PCV breaths at the set Pinsp, Tinsp, and Rate settings.

AB.98.033

1. Paw waveform
2. Tinsp
3. Texp
4. Psupp
5. PEEP
6. Flow waveform

Synchronized intermittent mandatory ventilation - pressure controlled volume guaranteed
(SIMV-PCVG)

This is an optional mode on the Engström Carestation.

In SIMV-PCVG, a set number of pressure control breaths with a guaranteed volume are delivered to the patient each minute. The patient can breathe spontaneously between mandatory breaths. Pressure support can be used to support the spontaneous breaths.
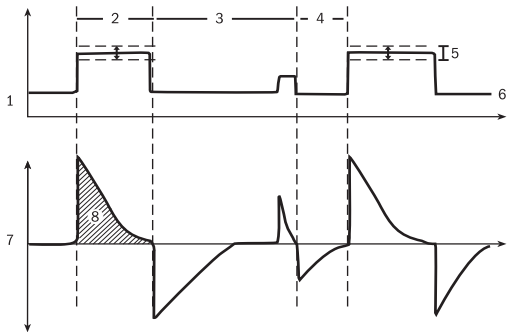
The mandatory breaths will deliver the set tidal volume using a decelerating flow and a constant pressure. The ventilator will adjust the inspiratory pressure needed to deliver the set tidal volume breath-by-breath so that the lowest pressure is used. The pressure range that the ventilator will use is between the PEEP + 2 cmH2O level on the low end and 5 cmH2O below Pmax on the high end. The inspiratory pressure change between breaths is a maximum of +/- 3 cmH2O. If a high airway pressure alarm is active due to the current breath, the next breath's pressure target will be 0.5 cmH_2O less than the current breath's pressure target.

SIMV-PCVG begins by delivering volume controlled breaths for 10 seconds or two breath periods, whichever is longer. The patient's compliance is determined from this period of volume controlled ventilation and the inspiratory pressure level is then established for the next PCVG breath. The remaining mandatory breaths will be pressure controlled with a guaranteed volume.

A portion of the exhalation phase is defined as the trigger window. If a spontaneous breath is detected in this window, a new mandatory PCVG breath is initiated. If a spontaneous breath is detected outside of this window, support for this breath is provided according to the set pressure support. The remainder of the trigger window is added to the next non-triggering phase.

The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (PEEP + Psupp + 2.5 cmH$_2$O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

If selected to be active in SIMV-PCVG, backup ventilation will be initiated if the apnea alarm is triggered or if the patient's minute ventilation decreases below 50% of the set low MVexp alarm limit. Backup settings may be changed for each patient.

AB.98.153

1. Paw waveform
2. Tinsp
3. Spontaneous breathing period
4. Trig Window
5. Variable pressure to deliver desired TV
6. PEEP
7. Flow waveform
8. TV

BiLevel airway pressure ventilation - volume guaranteed (BiLevel-VG)

This is an optional mode on the Engström Carestation.

BiLevel-VG combines the "open valve" technology of BiLevel with the benefits of volume guarantee. The base mode of BiLevel ventilation is united with the volume guarantee system of Pressure Controlled Volume Guaranteed that ensures the set tidal volume is delivered during the high-pressure level. The volume guarantee automatically sets the inspiratory pressure to the lowest possible level to provide the set tidal volume. This inspiratory pressure level becomes the Phigh level of the BiLevel breath.
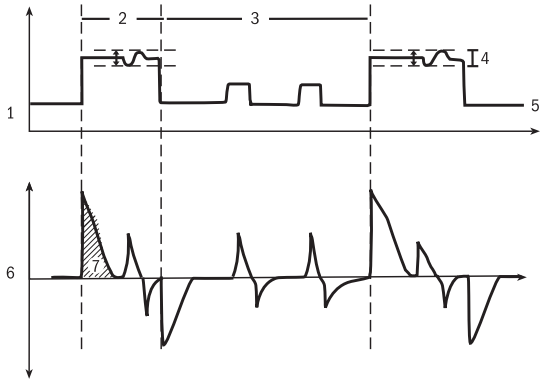
The volume guarantee is determined by the set tidal volume that results from the difference between the PEEP level and the inspiratory pressure level. The pressure range that the ventilator will use is between PEEP + 2 cmH_2O on the low end and 5 cmH_2O below Pmax on the high end. The inspiratory pressure change between breaths is a maximum of +/- 3 cmH_2O. If a high airway pressure alarm is active due to the current breath, the next breath's pressure target will be 0.5 cmH_2O less than the current breath's pressure target.

BiLevel-VG begins by delivering volume controlled breaths for 10 seconds or two breath periods, whichever is longer. The patient's compliance is determined from this period of volume controlled ventilation and the inspiratory pressure level is then established for the next BiLevel breath. The remaining mandatory breaths will be pressure controlled with a guaranteed volume.

A portion of the exhalation phase is defined as the trigger window. If a spontaneous breath is detected in this window, a new mandatory BiLevel breath is initiated. If a spontaneous breath is detected outside of this window, support for this breath is provided according to the set pressure support level. The remainder of the trigger window is added to the next non-triggering phase.

The inspiratory phase of supported breaths will end if the set End Flow is reached, if the airway pressure exceeds (PEEP + Psupp + 2.5 cmH$_2$O), or if the max Tinsp is reached. Supported breaths have a maximum inspiratory time of 4 seconds for adults, 1.5 seconds for pediatrics, and 0.8 seconds for neonates.

If selected to be active in BiLevel-VG, backup ventilation will be initiated if the Apnea alarm is triggered or if the patient's minute ventilation decreases below 50% of the set low MVexp alarm limit. Backup settings may be changed for each patient.

1. Paw waveform
2. Tinsp
3. Spontaneous breathing period
4. Variable pressure to deliver desired TV
5. PEEP
6. Flow waveform
7. TV