



Puritan Bennett™
840 Ventilator
User's Pocket Guide



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INTRODUCTION

This pocket guide gives you a quick overview of how to set up and use the Puritan Bennett™ 840 Ventilator System.

As you read through this pocket guide, this symbol:

↪ asks you to take an action

This pocket guide is intended to supplement (not replace) the Puritan Bennett™ 840 Ventilator Operator's and Technical Reference Manual, which should always be available while using the ventilator.

Different versions of the Puritan Bennett™ 840 Ventilator can have minor variations in labeling (e.g., keyboard overlays and off-screen alarm status indicators).

For more detailed information on any of the topics covered in this pocket guide, please see the Puritan Bennett 840 Ventilator Operator's and Technical Reference Manual. (Also please see the Puritan Bennett™ 840 Ventilator Service Manual.)

THE PURITAN BENNETT™ 840 VENTILATOR

The Puritan Bennett 840 Ventilator includes a breath delivery unit (BDU) that controls ventilation, and a graphic user interface (GUI) that monitors and displays ventilator and monitored data (see Figure 1). The ventilator supplies mandatory (pressure or volume controlled) or spontaneous breaths (inspiratory flows of up to 200 L/min, with or without pressure support) with a preset oxygen concentration. Breaths can be pressure- or flow-triggered (using Flow-by).

Touch screens display monitored data separately from ventilator settings for easy assessment of your patient's condition. This allows you to preview settings before applying them to your patient, and the Alarm System helps you to quickly determine the urgency and root cause of alarm conditions.

The optional 806 Compressor provides compressed air to the BDU, and can be used in place of wall or cylinder air. The standard 802 Backup Power Source (BPS) provides DC power to the BDU and GUI in the event that AC power is lost. Puritan Bennett 840 Ventilator mounting options include a cart, pole mount or wall mount.



FIGURE 1.
Puritan Bennett 840 Ventilator components

CONNECTIONS

This section tells you how to connect the Puritan Bennett™ 840 Ventilator to AC power, air and oxygen supplies and the patient circuit.

Power

- ⇒ Plug the ventilator power cord to AC power (see Figure 2). The power cord retainer protects against accidental disconnection, and must always be in place during operation.

WARNING

To avoid electrical shock hazard, connect the ventilator power cord into a grounded AC power outlet.

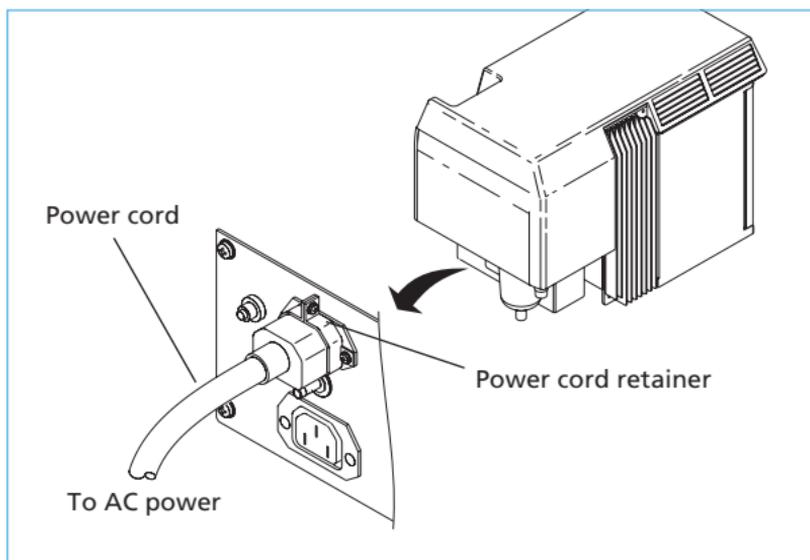


FIGURE 2.
Connecting the ventilator power cord

Normally, the Puritan Bennett™ 840 Ventilator System is mains-powered. The mandatory 802 Backup Power Source (BPS) operates the ventilator when AC power drops below a minimum level. The ventilator recharges the BPS during AC power operation.

NOTE:

The BPS is designed for short-term use only, and is not intended as a primary alternative power source. The BPS is intended to power the BDU and GUI only. In case of AC power loss, no power is available for the compressor or humidifier.

If you turn on the ventilator after it has been unplugged for an extended period, the LOW BATTERY alarm may become active. If so, recharge the BPS by leaving it connected to an operating ventilator for up to eight hours. If the LOW BATTERY alarm is still active or if the INOPERATIVE BATTERY alarm is active, the BPS battery must be replaced by a qualified service technician.

AIR AND OXYGEN SUPPLIES

- ⇒ Connect air and oxygen supplies to the ventilator (see Figure 3). The ventilator can use air and oxygen from cylinder or wall supplies. Supply pressures must be 35 to 100 psi (241 to 690 kPa).

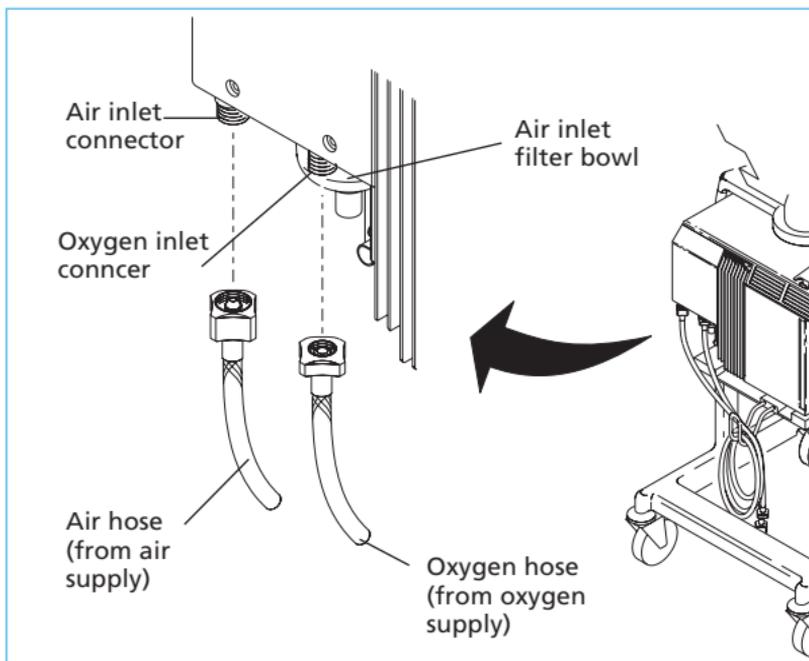


FIGURE 3.
Connecting the air and oxygen supplies

WARNING

Connect only air to the air inlet, and only oxygen to the oxygen inlet. Do not attempt to switch air and oxygen or connect any other gas.

WARNING

To ensure that a constant gas supply is available to the patient, always connect at least two gas sources to the ventilator. (There are three gas source connections: the compressor, air inlet and oxygen inlet.)

CAUTION

To prevent damage to the ventilator, ensure that the connections to the air and oxygen supplies are clean and unlubricated, and that there is no water in the air or oxygen supply gas. If you suspect water in the air supply gas, use an external wall air water trap to prevent water damage to the ventilator and its components.

PATIENT CIRCUIT

⇒ Connect the patient circuit to the ventilator (see Figure 4).

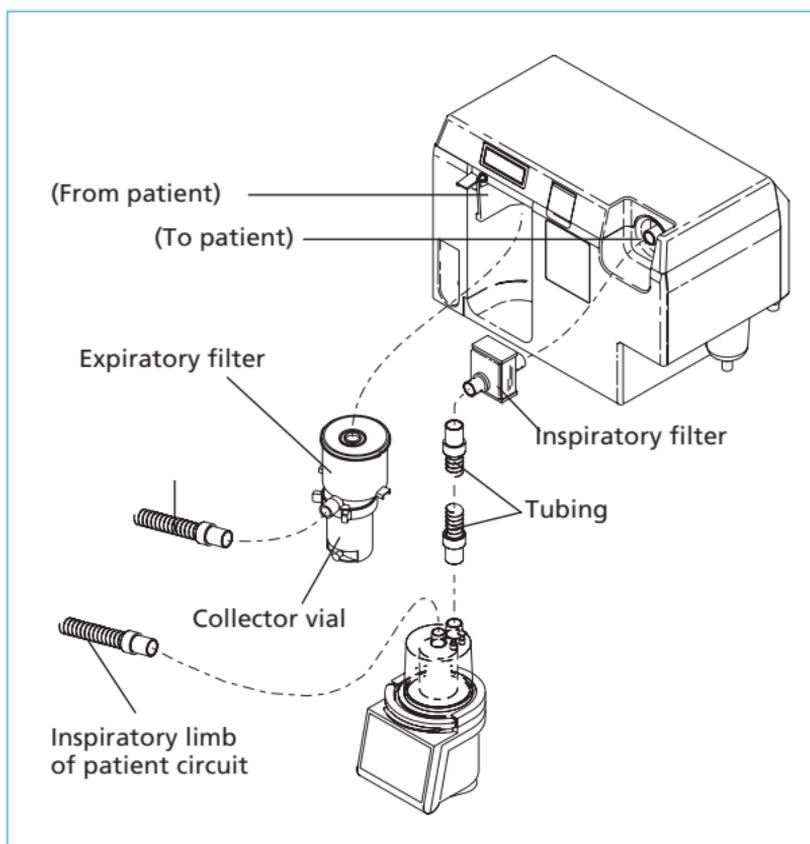


FIGURE 4.
Connecting the patient circuit

⇒ Figure 5 shows you how to install the expiratory filter and collector vial to the ventilator. Attach the expiratory limb of the patient circuit to the filter's expiratory limb connection.

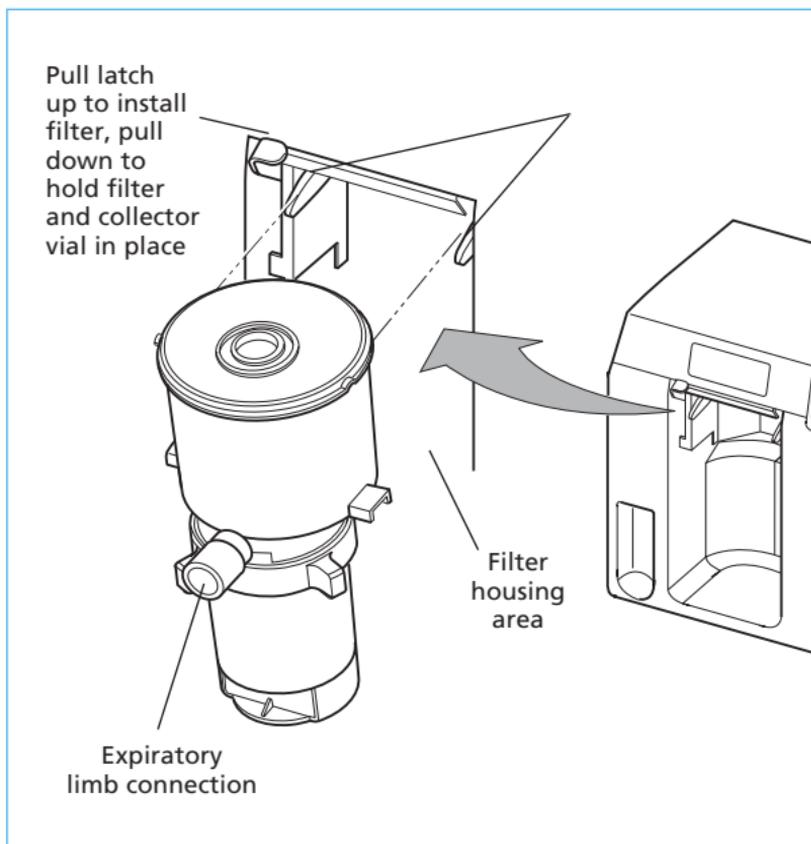


FIGURE 5.
Installing the expiratory filter and collector vial

- ⇒ Cap the collector vial drain port if you are not using the drain bag (see Figure 6).
- ⇒ If you are using the drain bag, install clamp on tubing. Uncap collector vial drain port and install tubing to collector vial drain port. Connect other end of tubing to drain bag. If the ventilator is mounted on the cart, place the drain bag in the cart drawer (see Figure 6). The drain bag is designed to lie flat, and is not designed to be suspended.

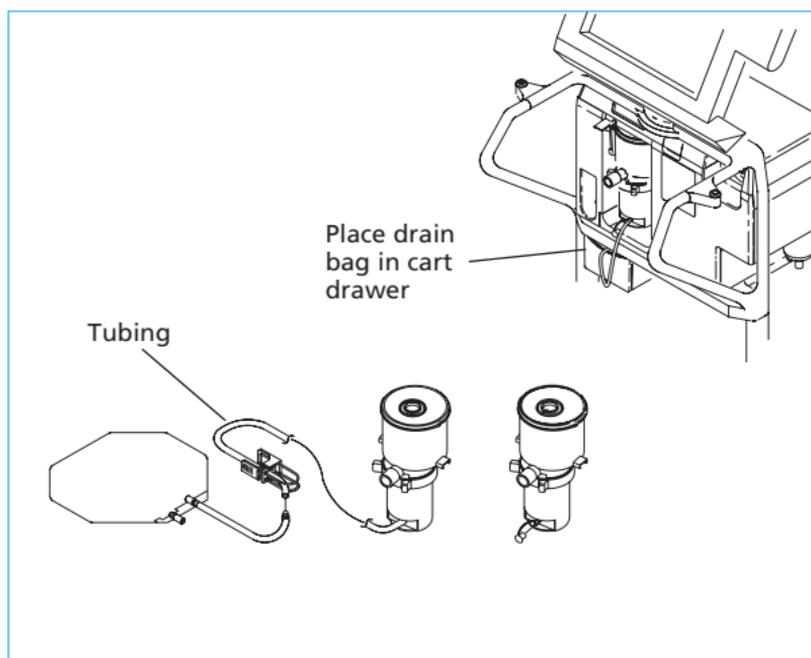


FIGURE 6.

Using the collector vial with or without drain bag

WARNING

Covidien recommends that you use one of the identified patient circuits (see the Puritan Bennett™ 840 Ventilator Operator's and Technical Reference Manual for patient circuit testing specifications). Using a circuit with a higher resistance does not prevent ventilation, but can cause an SST fault or compromise the patient's ability to breathe through the circuit.

NOTE:

To ensure optimum compliance compensation, Covidien recommends that you use low-compliance patient circuits. (For pediatric patients, the compliance compensation volume limit is four times the set tidal volume, in addition to the set tidal volume.)

NOTE:

To ensure optimum ventilation, use pediatric circuits for patients whose ideal body weight (IBW) is 24 kg (53 lbs) or less, and adult circuits for patients whose IBW is more than 24 kg.

PATIENT SETUP

Once you turn on the ventilator or run SST, the ventilator runs POST, then displays the Ventilator Startup screen (see Figure 7) on the lower screen.

NOTE:

If TC was used on the previous patient setup, a note emphasizing tube type and tube I.D. appears below the SAME PATIENT button explanation.

A/C	VC		P-TRIG	50 kg
f 16 $\frac{1}{\text{min}}$	V _T 363 mL	V _{MAX} 21.8 $\frac{\text{L}}{\text{min}}$	P _{SENS} 2.0 $\frac{\text{cm}}{\text{H}_2\text{O}}$	O ₂ 100 %
	T _{PL} 0.0 s	 SQUARE		PEEP 3.0 $\frac{\text{cm}}{\text{H}_2\text{O}}$

Ventilator Startup

SAME PATIENT	Ventilate with previous settings (shown above).
NEW PATIENT	Initiate new patient setup.
SST	Perform Short Self Test (SST) and calibrate circuit.

Make a selection.
Complete Ventilator Startup BEFORE attaching patient!

FIGURE 7.

Ventilator startup screen

- ➡ Touch SAME PATIENT, then press ACCEPT to continue ventilating with the most recent settings. Ventilation does not begin until a patient is connected.
- ➡ Touch NEW PATIENT to begin ventilating with new settings.

NOTE:

If you are unsure of the meaning of any symbol for ventilator settings, alarms or monitored data, touch the symbol on the screen; its definition will appear at the left bottom corner of the lower screen. (Figure 8 shows where symbol definitions appear on the GUI.)

New patient setup

- ⇨ Touch the IBW button, then turn the knob to adjust the IBW. (Many initial settings and setting limits are automatically determined based on the IBW.) The proposed value is shown in red.
- ⇨ Touch CONTINUE (this button does not appear until you touch IBW), or touch RESTART to return to the Ventilator Startup screen.
- ⇨ At the New Patient Setup screen, settings for mode, mandatory type (for manual inspirations, if the selected mode is SPONT), spontaneous type (if applicable) and trigger type appear. For any setting you want to change, touch its button, then turn the knob to select the value. When you are finished changing settings, touch CONTINUE.
- ⇨ At the New Patient Settings screen, more settings appear. Touch each setting you want to change, then turn the knob to select its value. (To cancel a highlighted change, press CLEAR.)
- ⇨ Press ACCEPT to put all settings into effect. Normal ventilation begins once a patient is connected. (Any time before you press ACCEPT, you can touch RESTART to restart setting changes.)

Apnea settings

Although you aren't required to change or confirm apnea settings, you should verify that they are appropriate for the patient. Apnea settings are automatically determined based on IBW, but can be changed.

- ⇒ If you selected NEW PATIENT, the Current Apnea Settings screen appears at the end of patient setup.
- ⇒ If you selected SAME PATIENT, touch the APNEA button at the bottom of the lower screen to view apnea settings.
- ⇒ If you change any apnea settings, press ACCEPT to put new settings into effect.

Calibrating the oxygen sensor

Press the 100% O₂ /CAL 2 MIN key. This causes the ventilator to deliver 100% oxygen (if available) for two minutes and calibrates the oxygen sensor.

The ventilator's oxygen monitoring feature is always active unless you disable the oxygen sensor (see the More Settings screen). The oxygen sensor is always enabled when you power up the ventilator.

Once patient setup is complete

Once the settings are accepted, you can attach a patient to the ventilator. Ventilation only begins when the ventilator senses that a patient is attached. (If you attach a patient before completing setup, the ventilator begins safety ventilation and declares a PROCEDURE ERROR alarm that resets once patient setup is complete.)

Inspiratory pause

Pressing the INSP PAUSE key causes the ventilator to schedule an automatic pause maneuver as follows (see Table 1).

- At the next scheduled inspiration, the inspiratory and expiratory valves close to allow pressure to equilibrate between the patient and the circuit.
- The inspiratory pause continues until a stable pressure is reached or until two seconds elapse, whichever comes first.
- The graphics screen will automatically be displayed (if it is not already active). The trace freezes and the values for compliance and resistance are displayed.
- You can extend the pause beyond two seconds to a maximum of seven seconds by holding down the INSP PAUSE key.

Expiratory pause

Pressing the EXP PAUSE key causes the ventilator to schedule an automatic expiratory pause maneuver as follows:

- Press EXP PAUSE key to schedule automatic expiratory pause maneuver.
- During the next exhalation, the inspiratory and expiratory valves close to allow pressure to equilibrate between the circuit and the patient.
- The expiratory pause continues until a stable pressure is reached or two seconds elapse, whichever comes first.
- The graphics screen will automatically be displayed (if it is not already active). The trace freezes and the values for intrinsic (auto) PEEP and total PEEP are displayed.
- You can extend the pause beyond two seconds to a maximum of 20 seconds by holding down the EXP PAUSE key.

TABLE 1. Inspiratory pause maneuver displays

When you see Compliance (C):	Or Resistance (R) (if displayed):	It means:	Do this:
C (*****)	R (*****)	C < 0.1 mL/cm H ₂ O or patient flow < 0.1 L/min. This points to questionable inputs to the C equation, which would in turn render R questionable. The low patient flow is below the threshold of reliable measurement.	Check the breathing waveforms and monitored patient data for clues about these questionable inputs.
C (*****)	R (*****)	The difference in pressure between end plateau and end exhalation < 0.1 cm H ₂ O. This is below the limits of reliable resolution. The R and C values are therefore questionable.	Check the breathing waveforms and monitored patient data for clues about these questionable inputs.
C (0) or C (500)	R () Message as dictated by other tests	C ≤ 0 mL/cm H ₂ O or C < 500 mL/cm H ₂ O. These measurements are outside of physiological limits.	Check the patient-ventilator interaction, the breathing waveforms, and the patient circuit for underlying causes.

TABLE 1. Inspiratory pause maneuver displays (continued)

When you see Compliance (C):	Or Resistance (R) (if displayed):	It means:	Do this:
C () Message as dictated by other tests	R (0) or R (500)	R \leq 0 cm H ₂ O/L/s or R < 500 cm H ₂ O/L/s. These measurements are outside of physiological limits.	Check the patient-ventilator interaction, the breathing waveforms, and the patient circuit for underlying causes.
C (xxx)	R (yyy)	Sub-threshold input value(s) C < 1/3 of ventilator breathing system compliance (derived from SST). Both C and R are questionable.	If the patient's IBW \leq 24 kg, consider installing a pediatric patient circuit.
C (xxx) Incomplete exhalation	R (yyy) Incomplete exhalation	Exhalation was not complete. This renders end-expiratory pressure and total exhaled flow values questionable.	Check for an insufficient expiratory interval. If possible, shorten inspiration time and reduce respiratory rate.

TABLE 1. Inspiratory pause maneuver displays (continued)

When you see Compliance (C):	Or Resistance (R) (if displayed):	It means:	Do this:
	R (yyy) No plateau	Plateau is not “flat” (lung and circuit pressures did not equilibrate) or pause pressure was excessively noisy. These problems render R and C questionable.	If plateau continues to decline, check for a leak in the breathing circuit, possibly around the cuff. If plateau is unstable, check for moisture condensing in a “lazy” loop or a breathing circuit being jiggled.
	R (yyy) Questionable measurement	C < 1.0 mL/cm H ₂ O. This results from questionable input data. This out-of-range value also renders R questionable.	Check the breathing waveforms and monitored patient data for clues about these questionable inputs.
	R (yyy) Out of range	R > 150 cm H ₂ O/L/s. This results from questionable input data, possibly C.	Check the breathing waveforms and monitored patient data for clues about these questionable inputs.

TABLE 1. Inspiratory pause maneuver displays (continued)

When you see Compliance (C):	Or Resistance (R) (if displayed):	It means:	Do this:
	R (yyy) Questionable measurement	The pressure rose slowly at the end of the square flow waveform. This suggests that the pressures, volumes and flows involved are minimal and questionable. This is not expected during normal ventilation.	Check the pressure-time waveform to see whether the patient delayed inspiration until the end of gas delivery.
	R (yyy) Questionable measurement	The difference between the circuit pressure at the end of the plateau and the pressure at the end of exhalation < 0.5 cm H ₂ O. This results in a questionable R value.	Check for a highly compliant lung inflated slightly. If the tidal volume can be safely increased, try that.

The top of the upper screen shows monitored data (data outside the normal range flashes). Once normal ventilation is in progress, ventilator settings are displayed across the top of the lower screen. (Figure 8 shows how information is displayed on the GUI.)

Upper screen:
monitored
information
(alarms,
patient data)

Lower
screen:
ventilator
settings



FIGURE 8.

Puritan Bennett™ 840 Ventilator graphic user interface (GUI)

ALARM SETTINGS

Most alarm settings are initially set based on the patient's IBW. You should review all alarm settings.

- ⇨ Touch the ALARM SETUP button (lower screen) to view the current alarm setup (see Figure 9).
- ⇨ Touch the alarm you want to change.
- ⇨ Turn the knob to set the value you want. Proposed values are shown in red. You can change several alarm settings in a batch change. To cancel a highlighted change, press CLEAR.
- ⇨ Review all settings.
- ⇨ Press ACCEPT to apply the new alarm settings. Press the ALARM SETUP button to cancel all alarm changes.

You can touch the ALARM SETUP button at any time during ventilation to show the current limits and monitored value for each alarm. If an alarm annunciates, the alarm slider on the Alarm Setup screen will turn a color indicating the urgency of the alarm state: red for high urgency, yellow for medium and low urgency.

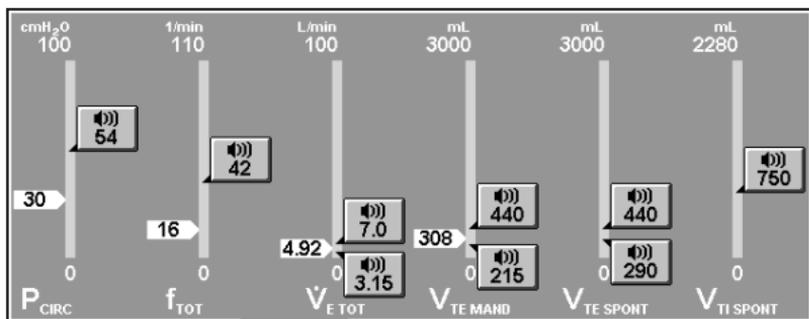


FIGURE 9.
Alarm setup

NOTE:

The upper limits for the spontaneous exhaled tidal volume and mandatory exhaled tidal volume alarms are always the same. Changing the upper limit of one alarm automatically changes the upper limit of the other.

MAIN SETTING CHANGES

Main settings are the buttons displayed at the top of the lower screen, and you can only change them individually. Follow these steps to change main settings:

- ⇒ Touch the setting you want to change
- ⇒ Turn the knob to the set value
- ⇒ Press ACCEPT to apply the new setting

Remember: touch, turn, ACCEPT!

MODE, BREATH TYPE AND BATCH (MULTIPLE) CHANGES

- ⇨ Touch the **SETUP** button on the lower screen. The Current Vent Setup screen appears.
- ⇨ To change ventilation setup (mode, mandatory breath type, spontaneous type or trigger type), touch its button, then turn the knob to set the value. Proposed changes are shown in red. (Press **CLEAR** to cancel a change you've just made.)
- ⇨ Once you've made all the changes you want (you don't have to make any changes at all), touch **CONTINUE**. Appropriate settings for the ventilation setup you've selected appear on the lower screen.
- ⇨ For each of the current ventilator settings you want to change, touch its button, then turn the knob to set its value. (Press **CLEAR** to cancel a change you've just made.)
- ⇨ Once you've made any changes you want, review the settings, then press **ACCEPT** to apply all the new settings at the same time. (Touch **SETUP** to cancel all changes.)

Previous setup

Once ventilator settings are in effect, the **PREVIOUS SETUP** button appears at the bottom of the lower screen when you press **SETUP**, and allows you to restore the entire previous setup (including alarm and apnea settings) that was in effect immediately before you made setting changes using the Ventilator Setup screen.

- ⇨ To restore the previous setup, touch **PREVIOUS SETUP**, then press **ACCEPT**.

Humidification type, humidifier volume, O₂ sensor enable/disable and disconnect sensitivity (D_{SENS})

To view or change:

- ⇒ Touch the OTHER SCREENS button, then touch the MORE SETTINGS button.
- ⇒ Touch each setting you want to change (you can change multiple settings), then turn the knob to set its value. To leave settings unchanged, touch the OTHER SCREENS button again.
- ⇒ Press ACCEPT to apply the new settings.

Constant during rate change

If you selected pressure control (PC), you can select one of three timing variables (inspiratory time, I:E ratio, or expiratory time) to be held constant when the respiratory rate setting changes.

- ⇒ Touch SETUP.
- ⇒ Touch CONTINUE. The breath timing bar appears in the lower screen (see Figure 10).
- ⇒ Touch one of the lock icons to select T_I , I:E, or T_E as the setting that remains constant when the rate setting changes.
- ⇒ Review settings and change if necessary, then press ACCEPT. The value displayed is the one held constant during rate changes, and becomes the only setting you can adjust directly.



FIGURE 10.

Constant during rate change (inspiratory time selected)

NOTE:

You can change the value of the constant setting at any time, but the value does not change as a result of changing the rate setting.

ALARM HANDLING

The SmartAlert Alarm System offers prioritized alarm annunciation that distinguishes primary alarms from secondary, dependent alarms (that is, alarms that arise due to the initial alarm condition) and indicates the urgency level of each alarm. An alarm log keeps a time-and-date-stamped record of alarms, alarm silences, and resets in order of occurrence.

Alarms on the Puritan Bennett™ 840 Ventilator are classified as high-, medium- or low-urgency (see Figure 11).

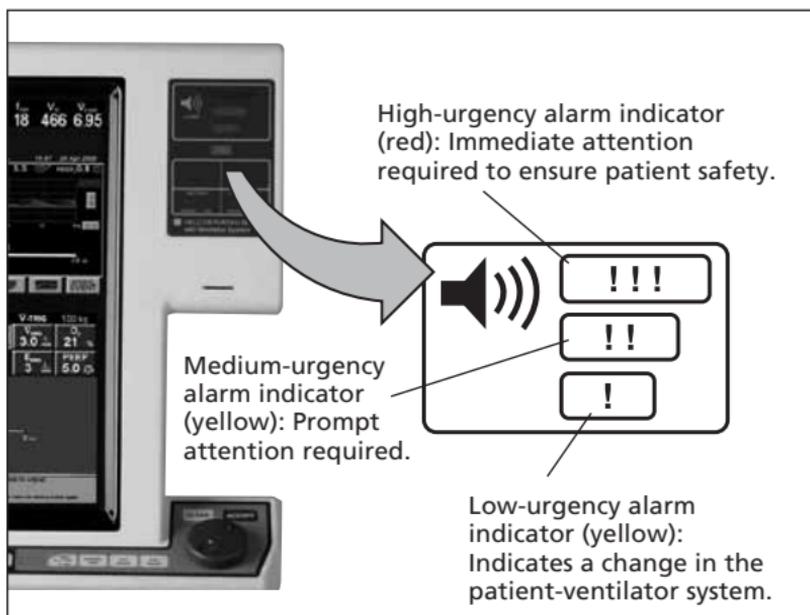


FIGURE 11.
Alarm indicators

NOTE:

You can always change an alarm setting even when alarms are active. You do not need to press ALARM RESET or wait for the alarm to autoreset.

Alarm silence

Pressing ALARM SILENCE mutes the alarm sound for two minutes. The key's LED lights during the silence period, and turns off if the alarm is reset. Every time you press ALARM SILENCE, the two-minute silence period restarts. An on-screen alarm silence notification appears on the display when alarm silence is active.

WARNING

Never leave patient unattended when ALARM SILENCE is activated. ALARM RESET will cancel silence.

Alarm reset

Pressing the off-screen ALARM RESET key resets the detection algorithms of all active alarms, except for these:

- AC POWER LOSS
- COMPRESSOR INOPERATIVE
- DEVICE ALERT
- O₂ SENSOR
- INOPERATIVE BATTERY
- LOW AC POWER
- LOW BATTERY
- NO AIR SUPPLY
- NO O₂ SUPPLY
- PROCEDURE ERROR

Pressing ALARM RESET has no effect on patient data. If an alarm condition persists, the alarm becomes active again, according to the detection algorithm for that alarm. For example, if the APNEA alarm is active, ALARM RESET resets the apnea detection algorithm to its initial state and returns the ventilator to normal ventilation.

Pressing ALARM RESET cancels alarm silence if active (this avoids silencing an alarm condition that arises shortly after pressing ALARM RESET). Pressing ALARM RESET clears any high-urgency alarm that has autoreset (and the steadily lit high-urgency alarm indicator turns off).

ALARM RESET gives you a way to return the ventilator to normal operation if an alarm condition has been resolved, without waiting for alarm detection algorithms to reset the alarm.

Alarm log

To view the alarm log, touch the ALARM LOG button on the upper screen. The alarm log shows alarm events (including time-and-date-stamped alarms, silences and resets) in order of occurrence, with the most recent event at the top of the list (see Figure 12). The alarm log can store up to 80 of the most recent entries. Completing a new patient setup clears the alarm log.

A question mark in a triangle appears on the ALARM LOG button if the log includes an event that hasn't been viewed yet. The question mark in a triangle disappears after you've viewed the event.

To scroll through the alarm log, move the scroll box up or down and turn the knob to page through the alarm log. An icon shows your relative position in the log.

Time	Event	Urgency	Alarm	Analysis
17:38:58 28 Aug 97	Autoreset	Normal	APNEA	
17:38:01 28 Aug 97	Detection	MEDIUM	APNEA	Apnea ventilation. Breath interval > apnea interval.
17:25:57 28 Aug 97	Autoreset	Normal	IV _{TE} SPONT	
17:25:22 28 Aug 97	Detection	LOW	IV _{TE} SPONT	2 of last 4 spont breaths ≤ set limit.
17:22:57 28 Aug 97	Autoreset	Normal	CIRCUIT DISCONNECT	
17:22:57 28 Aug 97	Detection	HIGH	CIRCUIT DISCONNECT	No ventilation.

Alarm log button

Indicates that log includes unread entries

Touch symbols to see definition at bottom of screen

Touch scroll box and turn rotary encoder to scroll through log

FIGURE 12.

Alarm log

Alarm messages

The upper screen displays the two highest-urgency active alarms. Alarms are color coded, both on the Alarm Setup screen and in the alarm status section on the upper screen. Red for high urgency; yellow for medium and low urgency. An alarm icon flashes on the MORE ALARMS button if there are other active alarms. Pressing the icon displays a full screen of up to eight active alarms.

Each alarm message consists of a base message, an analysis message (supplementary information that includes any associated alarm conditions) and a remedy message that suggests corrective actions (see Figure 13).

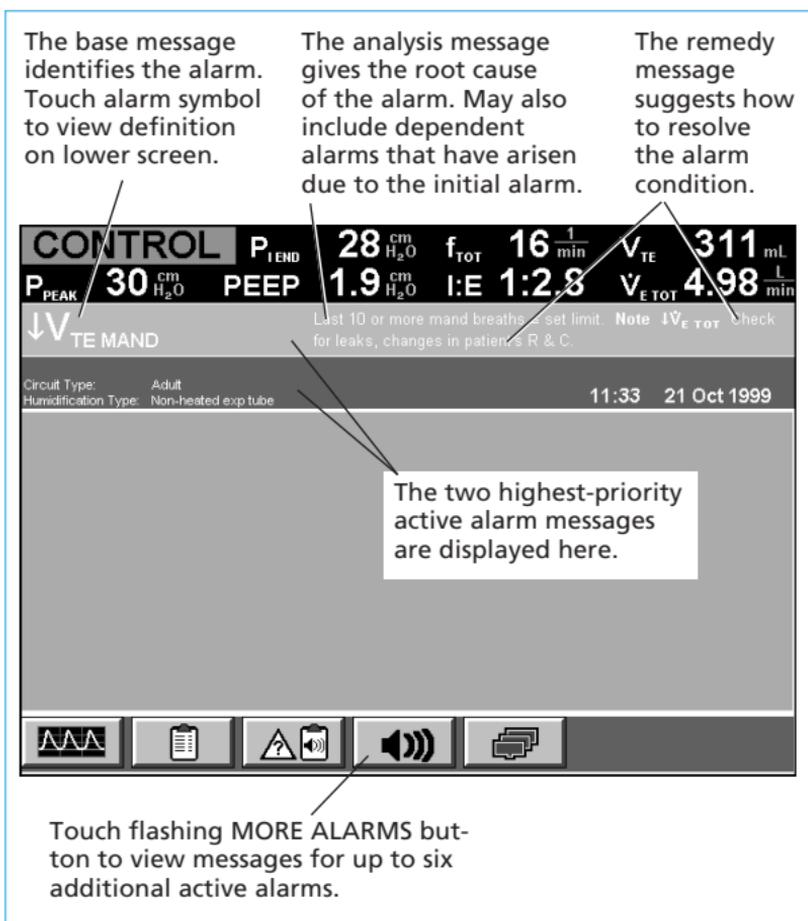


FIGURE 13.
Alarm message format

Table 2 lists possible alarm messages.

WARNING

When more than one alarm is active and the alarm messages vary in their degree of seriousness, you should assume that the most serious message is applicable.

TABLE 2. Alarm messages

When you see this message:	It means:	Do this:
AC POWER LOSS	The power switch is ON, AC power is not available, and the ventilator is being powered by the backup power source (BPS).	Prepare for power loss. Obtain alternate ventilation. Check integrity of AC power source. Contact service if necessary.
APNEA	The set apnea interval has elapsed without the ventilator, patient or operator triggering a breath.	Check patient and settings.
CIRCUIT DISCONNECT	There is a disconnection in the patient circuit before the patient wye or patient disconnect is detected following power restoration from an unintentional power loss with the power switch ON.	Check patient. Reconnect patient circuit. Press ALARM RESET.
COMPRESSOR INOPERATIVE	Compressor cannot maintain sufficient supply pressure.	Check patient. Obtain alternate ventilation. Remove ventilator from use and contact service.
DEVICE ALERT	A background test or power on self-test (POST) has detected a problem.	Check patient. If prompted to do so, obtain alternate ventilation or contact service.

TABLE 2. Alarm messages (continued)

When you see this message:	It means:	Do this:
O ₂ SENSOR	Background checks have detected a problem with the O ₂ sensor.	O ₂ sensor is out of calibration or has failed. Press 100% O ₂ CAL; replace or disable the sensor.
P _{CIRC} (High circuit pressure)	The measured airway pressure is equal to or greater than the set limit. Reduced tidal volume likely.	Check patient, patient circuit and endotracheal tube.
O ₂ % (High delivered O ₂ %)	The O ₂ % measured during any phase of a breath cycle is 7% (12% during the first hour of operation) or more above the O ₂ % setting for at least 30 seconds. (These percentages increase by 5% for four minutes following a decrease in the O ₂ % setting.)	Check patient, air and oxygen supplies, oxygen analyzer and ventilator.
V _{TE} (High exhaled tidal volume)	The patient's exhaled tidal volume for any breath is equal to or greater than the set limit.	Check patient and settings. Consider whether the patient's compliance or resistance has changed.
V̇ _{E TOT} (High exhaled total minute volume)	The patient's expiratory minute volume is equal to or greater than the set limit.	Check patient and settings.

TABLE 2. Alarm messages (continued)

When you see this message:	It means:	Do this:
\dot{V}_{ti} SPONT Alarm	The delivered volume of any tube compensated (TC) breath is equal to or greater than the inspired tidal volume limit. Ventilator transitions to exhalation.	Check patient. Check for leaks, tube type/I.D. setting.
f_{TOT} (High respiratory rate)	The breath rate from all breaths is greater than or equal to the set limit.	Check patient and settings.
P_{VENT} (High internal ventilator pressure)	The inspiratory pressure transducer has measured a pressure of at least 100 cm H ₂ O. Active only during volume-controlled breaths. Ventilator transitions to exhalation. Reduced tidal volume likely.	Check patient. Obtain alternate ventilation. Remove ventilator from use and contact service.
P_{COMP}	The target pressure of a tube compensated (TC) breath equals the P_{CIRC} limit. This limit is equal to the setting of P_{PEAK} . Inspiration pressure is limited during this alarm.	Check patient. Check for leaks, tube type/I.D. setting.
INOPERATIVE BATTERY	BPS is installed but not functioning.	Contact service.
INSPIRATION TOO LONG	IBW-based inspiratory time for a spontaneous breath exceeds ventilator-set limit.	Check patient. Check for leaks.

TABLE 2. Alarm messages (continued)

When you see this message:	It means:	Do this:
LOSS OF POWER	The ventilator power switch is on and there is insufficient power from the AC supply and the BPS. There may not be a visual indicator for this alarm, but an independent audio alarm sounds for at least 120 seconds.	Check integrity of AC power and BPS connections. Obtain alternate ventilation.
LOW AC POWER	Mains AC power has dropped below 80% of nominal voltage for at least one second. Warns that AC power has dropped significantly, and that a more severe power drop may be imminent. The ventilator turns off the compressor (if installed), and otherwise operates normally.	Check integrity of connection to AC power. Check AC power supply.
LOW BATTERY	The BPS has less than approximately two minutes of operational time remaining.	Replace BPS or allow it to recharge during normal ventilator operation.

TABLE 2. Alarm messages (continued)

When you see this message:	It means:	Do this:
↓O ₂ % (Low delivered O ₂ %)	The O ₂ % measured during any phase of a breath cycle is 7% (12% during the first hour of operation) or more below the O ₂ % setting for at least 30 seconds, or below 18%. (These percentages increase by 5% for four minutes following an increase in the O ₂ % setting.)	Check patient, air and oxygen supplies, oxygen analyzer and ventilator. Calibrate oxygen sensor (press 100% O ₂ /CAL 2 min key).
↓V _{TE MAND} (Low exhaled mandatory tidal volume)	The patient's exhaled mandatory tidal volume is less than or equal to the set limit.	Check patient. Check for leaks or changes in the patient's resistance or compliance.
↓V _{TE SPONT} (Low exhaled spontaneous tidal volume)	The patient's exhaled spontaneous tidal volume is less than or equal to the set limit.	Check patient and settings.
↓V̇ _{E TOT} (Low exhaled total minute volume)	The minute volume for all breaths is less than or equal to the set limit.	Check patient and settings.
NO AIR SUPPLY	Air supply pressure is less than the minimum required pressure for correct ventilator operation throughout its range of flows. Accurate O ₂ % delivery may be compromised. You cannot set or disable the NO AIR SUPPLY alarm.	Check patient and air source. Obtain alternate ventilation.

TABLE 2. Alarm messages (continued)

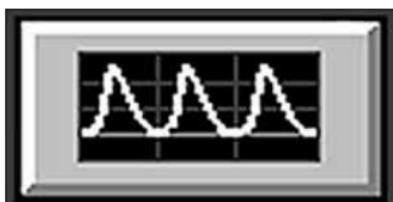
When you see this message:	It means:	Do this:
NO O ₂ supply	Oxygen supply pressure is less than the minimum required pressure for correct ventilator operation throughout its range of flows. Accurate O ₂ % delivery may be compromised. You cannot set or disable the NO O ₂ SUPPLY alarm.	Check patient and oxygen source. Obtain alternate ventilation.
PROCEDURE ERROR	Patient attached before ventilator startup is complete. Safety ventilation is active.	Provide alternate ventilation. Complete ventilator startup procedure.
SEVERE OCCLUSION	Patient circuit is severely occluded.	Check patient. Obtain alternate ventilation if necessary. Check patient circuit for crimps, blocked filter. If problem persists, remove ventilator from use and contact service.

GRAPHICS

The graphics function displays real-time patient data, including:

- Pressure-time curve
- Flow-time curve
- Volume-time curve
- Pressure-volume loop

Display



⇒ To display the most recently selected graphics, press the **GRAPHICS** button at the bottom of the upper screen.

- If the pressure-volume loop is selected, the loop for the next full breath is displayed, then updated every other breath. The inspiratory area is calculated based on the area inside the loop to the left of the baseline (see Figure 14).
- Curves (pressure-time, flow-time and volume-time) are drawn on the screen at the start of a breath, beginning with the last 0.5 second of the previous breath.

Color

Curves and loops are enhanced by color:

- Inspiration is green
- Expiration is yellow
- Spontaneous breaths are orange

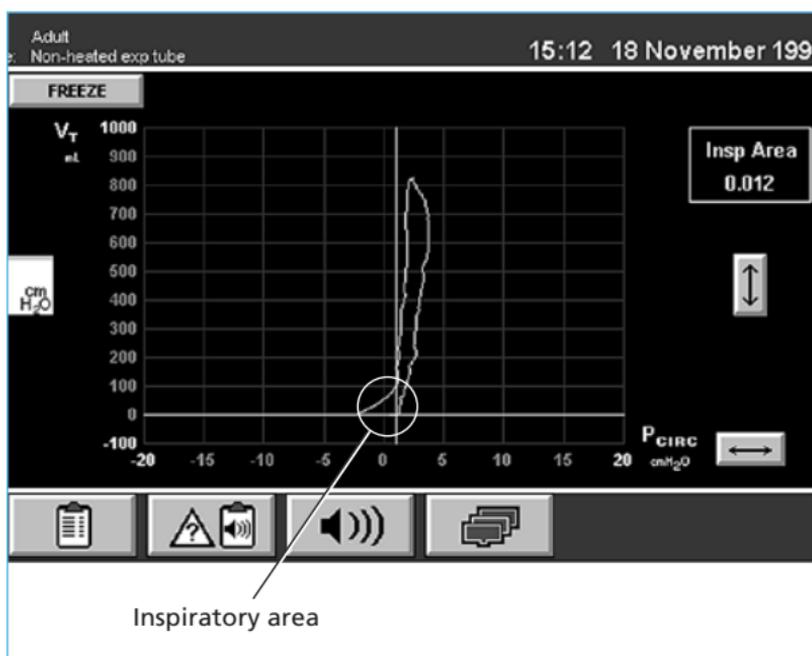


FIGURE 14.
Pressure-volume loop

Graphics are automatically displayed when you press the EXP PAUSE or INSP PAUSE key. The measured values for intrinsic and total PEEP are displayed at the end of the expiratory pause. The measured values for compliance and resistance (for VC with a square flow pattern) are displayed at the end of an inspiratory pause. During both the expiratory pause and inspiratory pause, the most recently selected graphics are displayed and frozen.

Graphics *won't* be displayed when:

- The ventilator begins apnea ventilation or safety ventilation. (However, you can choose to redisplay graphics by pressing the graphics button.)
- You touch the MORE PATIENT DATA, ALARM LOG, MORE ALARMS or OTHER SCREENS button.

Freezing

Follow these steps to freeze graphics on the screen:

- ⇨ Touch FREEZE. The screen flashes the message “FREEZING,” the UNFREEZE button appears, and the scaling buttons disappear. Plotting continues until the screen is full.
- ⇨ Once the screen is filled and frozen, the other onscreen scaling buttons reappear. You can now redo the plot setup and adjust the scales for the last 48 seconds of frozen data. (The pressure-volume display shows the most recent full breath within the 48-second freeze period.)
- ⇨ Press UNFREEZE at any time to resume real-time graphics display.

Graphics remain frozen even if you switch to another screen (for example, MORE ALARMS).

Plot setup

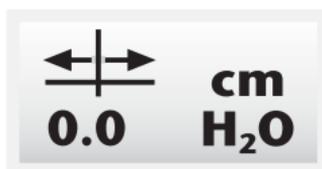
You can choose to display one or two time curves at a time. (The pressure-volume loop uses the entire screen, so no other waveform can be displayed at the same time.)

- ⇨ Touch the graphics button at the lower left of the upper screen. Graphics appear.
- ⇨ Touch PLOT SETUP at the upper left of the screen. Touch Plot 1, then turn the knob to select any one of the waveforms. (If you select pressure-volume, which uses the entire screen, Plot 2 disappears.)
- ⇨ Touch Plot 2, if applicable. Turn the knob to select either of the two remaining waveforms or none. If you select none, only one enlarged plot (with higher resolution) appears.
- ⇨ Touch CONTINUE to display the graphics you've selected. (You don't have to press ACCEPT.)

Once graphics are displayed

Setting baseline pressure:

- ⇒ To move the baseline on a pressure-volume loop, touch the baseline pressure button, then use the knob to position the baseline.



The default position of the baseline is the PEEP setting. If the PEEP setting changes, the baseline resets to PEEP.

Adjusting scales:

- ⇒ To adjust vertical and horizontal scales, touch the arrow buttons, then turn the knob to select.



THE ? KEY

The ? key on the GUI displays basic operating information about the Puritan Bennett™ 840 Ventilator, including:

- A few basics — information about screens, sounds, keys and symbols.
- Ventilator, alarm and apnea settings.
- New patient setup — how to configure the ventilator for a new patient.
- How to view patient data, including graphics.
- Graphics — setting up, viewing and freezing waveforms and loops.
- Alarm handling — what to do in case of alarm.
- Short self-test (SST).
- Service, including O₂ sensor calibration, cleaning, periodic maintenance and when to call for help.

BI-LEVEL

Bi-Level is a breath mode in which the patient has the ability to breathe spontaneously at two levels of PEEP. Its pressure waveform resembles pressure controlled ventilation but differs in its ability to allow unrestricted spontaneous breathing at both the upper and lower pressure levels. Therefore, only a minimally necessary degree of ventilatory augmentation needs to be applied.

Patient setup

To select Bi-Level ventilation:

- ⇒ Touch the SETUP button on the lower screen.
- ⇒ Touch the Mode button, then turn the knob to select Bi-Level.

NOTE:

Once you have selected Bi-Level, the PC mandatory breath type is selected and cannot be changed.

- ⇒ Select PS or none as the spontaneous type (or TC if this option is active), select P_{-TRIG} or V_{-TRIG} as your trigger type, then press CONTINUE.
- ⇒ Settings for Bi-Level are displayed. For each setting you want to change, touch its button and turn the knob to set its value.

NOTE:

$PEEP_H$ must always be set at least 5 cm H_2O greater than $PEEP_L$. Otherwise, the settings for $PEEP_H$ and $PEEP_L$ do not affect each other. When you have finished changing settings, press ACCEPT to put all settings into effect.

NOTE:

Rise time % determines the rise time to reach the pressure target in pressure support (P_{SUPP}) or transitions from $PEEP_L$ to $PEEP_H$.

NOTE:

Expiratory sensitivity (E_{SENS}) applies to all spontaneous breaths.

Constant during rate change

In Bi-Level ventilation as in pressure control, you can select one of three timing variables: inspiratory time (T_H), I:E ratio ($T_H:T_L$ ratio), and expiratory time (T_L) to be held constant when the frequency setting changes.

- ⇨ Touch SETUP.
- ⇨ Touch CONTINUE. The breath timing bar appears in the lower screen (see Figure 15).
- ⇨ Touch one of the lock icons to select T_H , $T_H:T_L$, or T_L as the setting that remains constant when the respiratory rate changes, and to determine which timing variable will be present on the timing button.
- ⇨ Review settings and change if necessary, then press ACCEPT. The value displayed is the one held constant during rate changes and becomes the only setting you can adjust directly.



FIGURE 15.
Bi-Level breath timing bar

NOTE:

You can change the value of the constant setting at any time, but the value does not change as a result of changing the respiratory rate setting.

Using pressure support with Bi-Level

Spontaneous breaths in Bi-Level mode can be augmented with pressure support according to these rules:

- Pressure support can assist spontaneous breaths at $PEEP_L$ and $PEEP_H$, and is always relative to $PEEP_L$.
- If $P_{SUPP} + PEEP_L$ is less than $PEEP_H$, all spontaneous breaths at $PEEP_L$ are augmented by the P_{SUPP} setting, and all spontaneous breaths at $PEEP_H$ are augmented by 1.5 cmH₂O.
- If $P_{SUPP} + PEEP_L$ is greater than $PEEP_H$, all spontaneous breaths at $PEEP_L$ are augmented by the P_{SUPP} setting, and all spontaneous breaths at $PEEP_H$ are augmented by $(P_{SUPP} + PEEP_L - PEEP_H)$.

For example, if $PEEP_L = 5$ cm H₂O, and $PEEP_H = 15$ cmH₂O, and $P_{SUPP} = 15$ cm H₂O:

- All spontaneous breaths at $PEEP_L$ are augmented by 15 cmH₂O of pressure support ($P_{SUPP} + PEEP_L$) for a total pressure of 20 cm H₂O.
- All spontaneous breaths at $PEEP_H$ are augmented by 5 cm H₂O of pressure support ($P_{SUPP} + PEEP_L - PEEP_H$) for a total pressure of 20 cm H₂O (see Figure 16).

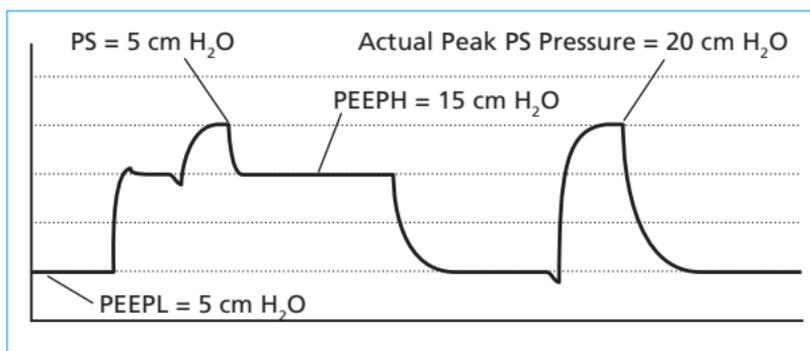


FIGURE 16.

Bi-Level with pressure support

Manual inspiration in Bi-Level mode

Pressing the MANUAL INSP key during Bi-Level mode causes the ventilator to:

- Switch from $PEEP_H$ to $PEEP_L$ if pressed during a $PEEP_H$ phase.
- Switch from $PEEP_L$ to $PEEP_H$ if pressed during a $PEEP_L$ phase.

TUBE COMPENSATION

Tube Compensation (TC) assists a patient's spontaneous breath by delivering positive pressure proportional to the inspired flow, which overcomes the estimated resistance of an artificial airway. TC supports all spontaneous breaths for patients with an ideal body weight ≥ 7.0 kg (15.4 lb), and for endotracheal/tracheostomy tubes with an inside diameter (I.D.) of ≥ 4.5 mm. TC can be used within SPONT, BI-LEVEL or SIMV. With the Bi-Level option selected, TC supports spontaneous breaths at both PEEP levels.

Patient setup

To select TC option:

1. Touch the VENT SETUP button on the lower screen.
2. Touch the MODE button and turn the knob to select either SPONT, BI-LEVEL or SIMV, all of which allow for TC to be selected as the spontaneous type.
3. Touch the SPONTANEOUS TYPE button and turn the knob to select TC.
4. Touch the CONTINUE button. The settings applicable to the selected mode, and for TC, appear on the lower screen.
5. Touch the on-screen button for each setting you wish to change, and then turn the knob to set the desired value (see Table 3 for tube I.D. and IBW). Proposed changes are highlighted. Press the CLEAR key above the knob to cancel any changes you've just made. Flashing arrows indicate TC settings.

NOTE:

If you select an I.D. that does not match the IBW, you must touch the OK button to continue. The tube type and tube I.D. indicators flash if TC is a new selection.

6. When you have made the settings you want, press the ACCEPT key above the knob to apply the new settings, or the CLEAR key to cancel the last change.

TABLE 3. Ideal body weight (IBW) and tube I.D.

IBW (kg)	IBW (lb)	ET/Trach I.D. (mm) (low)	ET/Trach I.D. (mm) (high)
7-10	15-22	4.5	4.5
11-13	23-29	4.5	5.0
14-16	30-35	4.5	5.5
17-18	36-40	4.5	6.0
19-22	41-49	5.0	6.0
23-24	50-53	5.0	6.0
25-27	54-60	5.5	6.5
28-31	61-68	5.5	7.0
32-35	69-77	6.0	7.0
36	78-79	6.0	7.5
37-42	80-93	6.5	7.5
43-49	94-108	6.5	8.0
50-53	109-117	7.0	8.0
54-59	118-130	7.0	8.5
60	131-132	7.0	9.0
61-69	133-152	7.5	9.0
70	153-154	7.5	9.5
71-79	155-174	8.0	9.5
80-100	175-220	8.0	10.0
101-130	221-287	8.5	10.0
131-150	288-330	9.0	10.0

VENTILATOR SELF-TESTS

The Puritan Bennett™ 840 Ventilator has three self tests to verify microprocessor, pneumatic and circuit integrity. The tests include:

- Power on self-test (POST): A several-second test that automatically checks microprocessor function when you power up the ventilator.
- Short self-test (SST): A short and simple sequence of tests that verify proper ventilator operation. SST checks the patient circuit for leaks and measures circuit compliance.
- Extended self-test (EST): A more exhaustive test of ventilator integrity, designed to be run by a qualified service technician.

Running SST

Use SST to check the patient circuit for leaks and to calculate circuit compliance and resistance. Always rerun SST whenever you change the circuit type or the humidification type, or when you install a new or sterilized exhalation filter.

WARNING

Incorrectly specifying the patient circuit type or humidification type (or changing either type after you've run SST) can affect the accuracy of compliance calculation and measured exhaled tidal volume. (You must rerun SST to change the circuit type. You can change the humidification type during ventilation by touching the OTHER SCREENS, then the MORE SETTINGS buttons.) Humidifier Volume allows you to minimize inaccuracies due to a change in humidifier type.

- ⇒ Ensure that the patient is not connected to the circuit and that the patient wye is unblocked.

WARNING

Disconnect the ventilator from the patient before running SST. Running SST while the ventilator is connected to the patient can injure the patient.

- ⇒ Turn the power switch (at the front of the ventilator) to the ON position. You can only run SST immediately after you turn on the ventilator.
- ⇒ At the Ventilator Startup screen, touch SST, then press the TEST button (on the side of the ventilator) within five seconds. (Waiting longer than five seconds cancels SST.)
- ⇒ At the Current SST Setup screen, select the patient circuit and humidification type (and humidifier volume, if applicable), then press ACCEPT.
- ⇒ The ventilator automatically starts the test sequence. Some tests (SST flow sensor, Expiratory filter and Circuit resistance) require your intervention and will wait indefinitely for your response. Otherwise, you don't need to do anything until a test result is ALERT or FAILURE, or SST is complete.
- ⇒ As each test is performed, the SST Status screen shows test results (see Table 4).

WARNING

To ensure reliable SST results, **DO NOT** repeat an individual test with a different patient circuit if the test result is FAILURE or ALERT. If you suspect a defective patient circuit, restart SST from the beginning with a different patient circuit.

TABLE 4. Individual test results in SST

If the test result is:	It means:	Do this:
Passed	No problems found.	Nothing, unless prompted by the ventilator.
ALERT	Test results not ideal, but not critical. SST halts.	Touch one of these buttons, then press ACCEPT: <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">RESTART SST</div> Repeat SST from the beginning. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">REPEAT</div> Repeat the test. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">NEXT</div> Skip to the next test.
FAILURE	A critical problem has been detected, and SST cannot complete until the ventilator passes the failed test.	Touch one of these buttons, then press ACCEPT: <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">RESTART SST</div> Repeat SST from the beginning. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">REPEAT</div> Repeat the test.

- ⇒ You can touch EXIT SST during SST to halt testing. You can touch EXIT SST again to resume testing, or press ACCEPT to restart the ventilator (if SST has not detected an ALERT or FAILURE).

WARNING

To ensure ventilation that correctly compensates for circuit resistance and compliance, do not exit SST and begin normal ventilation until the entire SST has been successfully completed with the circuit to be used attached.

When all of the tests in SST are complete, the SST Status screen displays all individual test results and SST outcome. Table 5 summarizes overall SST outcomes and how to proceed in each case.

- ⇒ To begin normal ventilation (if SST has not detected an ALERT or FAILURE), touch EXIT SST, then press ACCEPT. The ventilator reruns POST.
- ⇒ The ventilator displays the Ventilator Startup screen. Confirm or change the last valid settings.

TABLE 5. Overall SST results

If the test result is:	It means:	Do this:
Passed	All tests passed.	Touch one of these buttons, then press ACCEPT: <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-bottom: 10px;">EXIT SST</div> To exit SST and begin normal ventilation. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-bottom: 10px;">RESTART SST</div> To repeat SST from the beginning.
ALERT	One or more noncritical problems were detected. Follow your institution's protocol for overriding an ALERT. Immediate service not required.	Touch one of these buttons, then press ACCEPT: <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-bottom: 10px;">RESTART SST</div> To repeat SST from the beginning. <div style="border: 1px solid black; padding: 2px; display: inline-block; margin-bottom: 10px;">OVERRIDE</div> To override the alert, as allowed by your institution's protocol, touch EXIT SST. Then press ACCEPT to begin normal ventilation.

TABLE 5. Overall SST results (continued)

If the test result is:	It means:	Do this:
FAILURE	One or more critical problems were detected. The ventilator enters a ventilator inoperative state and cannot be used for normal ventilation until it passes SST. Service required.	Restart SST with a different patient circuit. Touch RESTART SST then press ACCEPT to repeat SST from the beginning. If the failure persists, contact a qualified service technician.

SAFETY MODES

The Puritan Bennett™ 840 Ventilator offers these safety modes:

Safety ventilation: If you attach a patient before completing setup, the ventilator alarms and begins safety ventilation. Safety ventilation delivers pressure control (PC) mandatory breaths with predetermined settings and a high pressure limit of 20 cm H₂O until the setup is complete.

Apnea ventilation: The ventilator monitors the time from the start of one breath to the start of the next. If that time exceeds the operator-set apnea interval, the ventilator begins apnea ventilation according to operator-determined settings. Apnea ventilation continues until the patient initiates two consecutive breaths and the exhaled volume is equal to or greater than 50% of the delivered volume (autoreset). May also be manually reset by the operator.

Occlusion status cycling (OSC): The ventilator checks the patient circuit for severe occlusions during all modes of breathing to protect the patient from excessive airway pressures. If the ventilator detects a severe occlusion, it opens the safety valve and enters OSC. In OSC, the ventilator periodically attempts to deliver a pressure-based breath while monitoring for a severe occlusion. Normal ventilation resumes once the occlusion is corrected.

Idle mode (disconnect detection): Once the ventilator detects a patient circuit disconnect, it enters *idle mode*, in which the exhalation valve opens, *idle flow* (5 L/min flow at 100% O₂, if available) begins, and breath triggering is disabled. The ventilator displays the length of time that the patient has been without ventilatory support. Once the ventilator confirms that the disconnect has been corrected, normal ventilation resumes.

The Puritan Bennett™ 840 Ventilator is also designed to enter emergency states (ventilator inoperative and safety valve open, SVO) under some circumstances. A ventilator inoperative condition always includes the SVO state, but an SVO state does not necessarily indicate a ventilator inoperative condition.

Ventilator inoperative: The ventilator declares a ventilator inoperative condition if a hardware failure or critical software error that could compromise safe ventilation occurs. In case of a ventilator inoperative condition, the ventilator enters the SVO state. To correct a ventilator inoperative condition, the ventilator must be turned off, then powered on again; at power on, a qualified service technician must run EST. The ventilator must pass EST before normal ventilation can resume.

SVO: The safety valve allows the patient to breathe room air unassisted when the ventilator is in the SVO state. The ventilator remains in the SVO state until the condition that caused the SVO state is corrected or, if the ventilator declared a ventilator inoperative condition, POST verifies that power levels to the ventilator are acceptable and that the major electronics systems are functioning correctly.

The ventilator enters the SVO state if a hardware or software failure occurs that could compromise safe ventilation, both air and oxygen supplies are lost or an occlusion is detected. In case of a malfunction that prevents software from opening the safety valve, there is also an analog circuit that opens the safety valve if system pressure exceeds 100 to 120 cm H₂O.

PREVENTIVE MAINTENANCE

Table 6 summarizes maintenance intervals and procedures.

TABLE 6. Maintenance summary

Procedure	Interval
<p>Check patient circuit for water buildup; empty and clean as necessary.</p> <p>Inspect and check the resistance across inspiratory and expiratory filters before every use, after 15 days of continuous use in the exhalation limb or if you suspect excess resistance. (SST checks the resistance of the expiratory filter.)</p> <p>Collector vial, water traps and drain bag: check and empty as needed.</p> <p>Air inlet filter bowl: if cracked, replace bowl. If any sign of moisture is visible, remove ventilator from use and contact service or maintenance.</p>	Several times a day or as required by your institution's policy
<p>Clean compressor inlet filter.</p>	250 hours (or more often, if required)
<p>Replace reusable inspiratory and expiratory bacteria filters. Sterilize between patients and circuit changes, or according to your institution's policy. Sterilize before nondestructive disposal.</p> <p>Replace oxygen sensor and BPS internal battery pack. (Must be replaced by a qualified service technician according to instructions in the Puritan Bennett™ 840 Ventilator Service Manual.)</p> <p>Use appropriate preventive maintenance kit (preventive maintenance must be performed by a qualified service technician according to instructions in the Puritan Bennett 840 Ventilator Service Manual).</p>	Annually or after 100 autoclave cycles Every two years or as necessary Every 10,000 hours



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