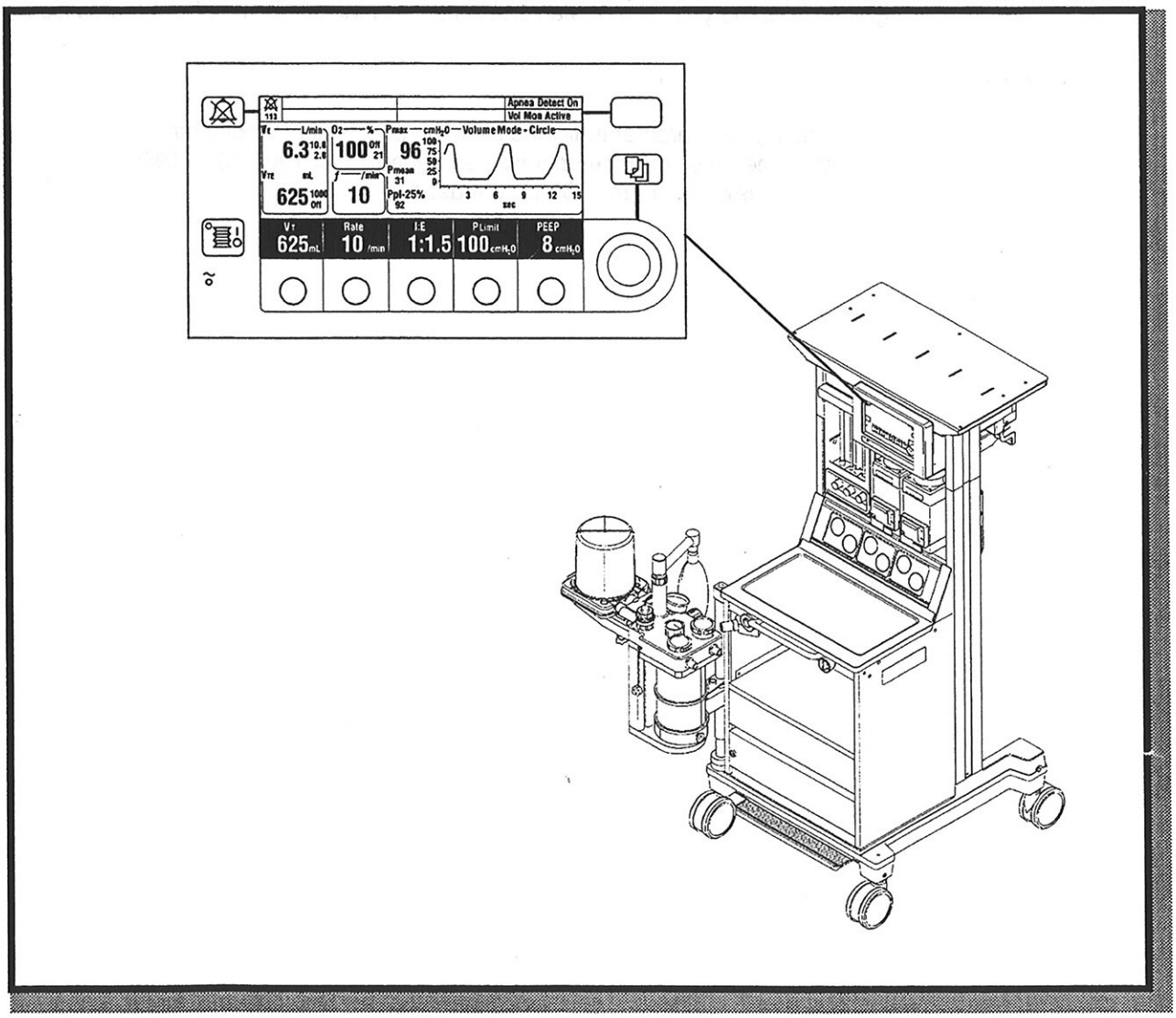
OHMEDA

THE BOC GROUP



7900 Ventilator

Operation and Maintenance Manual

Supplemental to the Ohmeda Excel and Modulus SE Anethesia Gas Systems. Applicable to software version 2.X

User Responsibility

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

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

AAA A 12345

This alpha character indicates the year of product manufacture and when the serial number was assigned: "Y" = 1995; "Z" = 1996; "A" = 1997; etc. "I" and "O" are not used.

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How to use this manual

What the manual's symbols mean

Warnings ⚠ and Cautions ⚠ list dangerous conditions that can occur if you do not obey all the instructions in this manual.

WARNINGS ⚠ are conditions that can be dangerous to patient or operator.

CAUTIONS ⚠ tell about conditions that can damage the equipment. Read and obey all warnings and cautions.

Other symbols replace common terms on the equipment or in Ohmeda manuals. No one piece of equipment has all the symbols in the table that follows.

Note: The possible 7900 Ventilator menu and alarm displays are too numerous to all be covered in this O&M Manual. Displays other than the displays and messages illustrated in this manual may appear from time to time.

The Ohmeda 7900 Ventilator

- The 7900 Anesthesia Ventilator provides mechanical ventilation for patients during surgery, as well as monitoring and displaying various patient parameters--

  Patient breathing waveform during volume mode or pressure mode

$\dot{V}_E$	Exhaled minute volume
V_{TE}	Exhaled tidal volume
O_2	Percent of oxygen inspired
f	Breath rate per minute
Pmax	Maximum airway pressure during a patient breath
Pmean	Mean airway pressure, calculated every patient breath or 10 seconds whichever occurs first
Ppl (Pplateau)	Airway pressure measured at the end of inspiratory pause time

- The 7900 is always a part of the Ohmeda Excel SE or Modulus SE Anesthesia Gas System.
- Read the Ohmeda Excel SE or Modulus SE Anesthesia Gas System Operation and Maintenance Manuals.
- Read the user responsibility and warranty.

7900 General

- Is a microprocessor based, electronically controlled, pneumatically driven ventilator with a built in monitoring system for inspired oxygen, airway pressure and exhaled volume.
- Sensors in breathing circuit are used to control and monitor patient ventilation as well as measure inspired oxygen concentration. This allows for compensation of compression losses in the absorber and bellows, fresh gas contribution, and small leakage in the breathing absorber, bellows and system.
- User settings and microprocessor calculations control breathing patterns.
- User interface keeps settings in memory. The user may change settings with a simple and secure setting sequence.
- A bellows contains breathing gases to be delivered to the patient.
- Positive End Expiratory Pressure (PEEP) is regulated electronically.
- Positive pressure is maintained in the breathing system at all times so that any leakage that occurs is outward.
- An RS-232 serial digital communications port connects to and communicates with external devices.

WARNING: ⚠ **Do not use the Ohmeda Excel Anesthesia System unless you have read each component operation manual and fully understand**

- **All system connections**
- **All warnings and cautions**
- **How to use each system component**
- **How to test each system component**

On (power)

OFF (power)

Stand-by

Stand-by or preparatory state for a part of the equipment

ON only for part of the equipment

"OFF" only for part of the equipment


Direct Current


Alternating Current


Protective earth ground


Earth ground


Frame or chassis ground


Alarm silence button


Equipotential


Variability


Variability in steps


This way up


Plus, positive polarity

Minus, negative polarity


Lamp, lighting, illumination


Movement in one direction


Movement in two directions


Lock


Unlock

134°C Autoclavable


non-autoclavable

Type B equipment

Type BF equipment

Type CF equipment

Warning or Caution, ISO 7000-0434

Attention, consult accompanying documents, IEC 601-1

Dangerous voltage

Input

Output

REF. **Stock Number**

SN **Serial Number**

Systems with this mark agree with European Council Directive (93/42/EEC) for medical devices when they are used as specified in their Operation and Maintenance Manuals. The xxxx is the certification number of the Notified Body used by Ohmeda's Quality Systems

Read top of float

Definitions, Acronyms, and Abbreviations

ABA	Autoclavable Bellows Assembly
AudiTorr™	Trade name for "audible waveforms" feature
Breath	A mechanical delivery of a volume of gas to the patient or A spontaneous inspiration (or expiration) by the patient
Control Settings	User adjustable settings of V_T or $P_{inspired}$, rate, I:E, Plimit, and PEEP; associated selector switches allow the user to change a particular setting
CMS	Hewlett Packard Component Monitoring System
DCGO	Dual common gas outlet (used in French anesthesia machines)
DPL switch	Drive pressure limit switch; mechanical pressure switch that relieves pressure at 103 cm H_2O without software intervention (and closes the GIV)
F_I	Flow output from the flow valve; calculated from the other user inputs such as V_T, Pinspired, rate, and I:E
f	Respiratory frequency; calculated from expiratory flow sensor output, breaths/min
GIV	Gas inlet valve (open and closed state is under software control) turns on and shuts foddering gas from the system to the ventilator pneumatics
GMS	Ohmeda Gas Management System absorber
Heliox Mode	A setting in the Ventilation Setup menu; selected when helium is a major component of the anesthetic gas mixture
I:E	Inspiration to expiration time, I to E ratio, (no units)
Inactive	Pertaining to alarms; alarm conditions are not tested or alarms are forced off
Manual Ventilation	A mode of ventilation where the clinician squeezes the bag to deliver gas volume to the patient; also called "Bag Mode"
Mechanical Ventilation	Electronically controlled ventilation of patient using a bellows to force gas into the patient's lungs

Pressure Control	A mode of mechanical ventilation where closed loop control of patient airway pressure during inspiration (Pinspired), inspiratory pause (Pplateau) and expiration (PEEP)
Minimum System	A state where the ventilator enters if a non-correctable error occurs and monitoring is still available
N/A	Not applicable
O_2	Oxygen concentration measured in the inspiratory limb of the breathing system
O_2 Flush	Button on the anesthesia machine; creates a high flow of oxygen (35-75 L/min) into the breathing system from the fresh gas outlet
Open Loop Control	As pertaining to volume ventilation—the output of the flow valve is calculated from the control settings only (i.e. the flow output from the ventilator shall equal V_T, but it will not account for compliance losses and fresh gas flow gains)
Paw	Patient airway pressure
PEEP	Positive end expiratory pressure; it may be used to improve oxygenation of the patient
Pinspired	Desired inspiratory airway pressure (set pressure) in pressure control ventilation
Plimit	Maximum airway pressure limit setting
Pmax	Maximum patient airway pressure during a patient breath
Pmean	Mean airway pressure is updated every patient breath for past 10 seconds (i.e. a running mean)
Pmin	Minimum patient airway pressure during a patient breath (note: assuming no spontaneous breathing by the patient, Pmin will equal PEEP during mechanical ventilation)
Ppl	Symbol (on the display) for plateau pressure, e.g. Ppl–60% is the plateau pressure at the current setting of t_{IP} = 60%
Pplateau	Patient airway pressure measured at the end of inspiratory pause time
PSV	Pressure support ventilation; the delivery of a specific pressure level in response to a patient's inspiratory effort
Patient Monitoring	Sampling, displaying, and testing alarm conditions on O_2, airway pressure, and exhaled volume

Powerup	A cold reset of the ventilator, i.e. application of electrical power to the ventilator from the electrical off state using the system ON/OFF switch
Rate	Frequency of mechanically delivered breaths
RGM	The Ohmeda Respiratory Gas Monitor (model 5250)
Save	Pertaining to the rotary encoder–after the user changes a value by turning the encoder (or selects a menu item), a push of the encoder enters (or saves) it Pertaining to the selector switch—after the user changes a control setting by turning the encoder, a push of the (corresponding) selector switch enters (or saves) it
Selected	Pertaining to the rotary encoder—when the cursor is positioned on a menu parameter, a push of the encoder selects that parameter
Selector Switch	One of 5 switches that allows the user to select and change the control settings of V_T/Pinspired, rate, I:E, Plimit, and PEEP
SIB	Sensor interface board; O_2 and flow sensors plug into the user interface panel which is connected in the anesthesia machine to the sensor interface board. The sensor interface board in turn is connected to the ventilator
SmartVent™	Trade name for volume compensation
System Monitoring	Sampling of (and alarming on) system signals such as flow valve current, battery status, etc...and performing safety tests on hardware and software
t_E	Expiration time (for a mechanically delivered breath), t_E = 1/rate/(1+I:E)
t_I	Inspiration time (for a mechanically delivered breath), t_I = 1/rate/[1 + (1/I:E)]
t_{IP}	Inspiratory pause time = 5-60% of t_I (i.e. the time is part of t_I so the I:E ratio remains the same); increases inspiration time near Pmax to facilitate increased patient oxygenation
Vdelivered	Integration of flow dispensed by the flow valve and compensated by the amount of flow lost through the bleed resistor
$\dot{V}_E$	Exhaled minute volume, calculated from expiratory flow sensor output

V_T	Tidal volume of mechanically delivered breaths
V_T Compensation Off	A mode of mechanical ventilation where open loop control of volume delivered from the ventilator to the patient breathing circuit (SmartVent™ control disabled)
V_{TE}	Exhaled tidal volume, calculated from expiratory flow sensor output
V_{TI}	Inhaled tidal volume, calculated from inspiratory flow sensor output
Volume Control	A mode of mechanical ventilation where closed loop control of inspired volume to the patient (SmartVent control enabled)

2/General Information

General

This section of the manual is an overview of the Ohmeda 7900 Ventilator, section 5 is the Operation section. Read all of this section and refer to section 5 for operation.

Theory of Operation

WARNING ⚠ **To help ensure proper operation of the patient disconnect alarms, an expiratory flow sensor must be used. Failure to do so may result in patient injury.**

The 7900 Ventilator consists of a pneumatic engine, a transducer section, a computer control system with a user interface, and displays. The pneumatic engine uses compressed gas, supplied by the anesthesia machine to control the flow and pressure of the gases delivered to the patient. Since pressure and flow can be controlled by the ventilator, the ventilator can deliver a volume or a pressure set inspiration. During the exhalation phase, the ventilator controls PEEP by regulating the exhalation pressure.

The ventilator monitors the patient's breathing system by signals from flow, pressure and oxygen transducers. Exhaled tidal volume, minute volume, airway pressure, breathing frequency and inspired oxygen concentration are all measured and constantly displayed. The ventilator also monitors its own operation through its built-in software. If the control system detects a malfunction, it shuts down the affected sections and alerts the operator. In some cases, the display describes the functions that continue to be available for use.

A precision control valve controls the gas flowing toward the patient. This flow of gas exerts a control pressure on the exhalation valve diaphragm. During inspiration the expiratory valve is held closed by the flow of gas to the patient. During expiration, the exhalation pressure (PEEP) is controlled by a very small flow from the same precision control valve acting on the exhalation valve. A small amount of gas is exhausted through a pneumatic resistor to stabilize control of the exhalation valve.

Note: At certain settings, especially when the ventilator operates at higher airway pressures, the operator may hear a slight hissing sound during mechanical inspiration. This sound is normal and comes from gas released through the pneumatic resistor.

WARNING: ⚠ **Do not occlude the pneumatic "bleed" resistor. This can cause the ventilator to malfunction and may cause harm to the patient.**

Inspiratory and expiratory flow sensors measure the flow of gas to and from the patient. The sensors are located on the inspiratory outlet and expiratory inlet of the breathing system. Each flow sensor connects to the anesthesia machine by a pair of small tubes. The tubes connect to sensitive pressure transducers inside the anesthesia machine through an interface panel. Through these tubes the flow of gas in the breathing circuit is monitored by sensing small pressure drops across the flow sensors. Breathing circuit breathing pressure is monitored by the proximal line of the inspiratory flow sensor.

WARNING: ⚠ **The flow sensor must be mounted so that the sensing tubes (small tubes) are vertical. This prevents the tubes from being occluded by water that may condense and accumulate in the breathing circuit.**

By comparing the operator set value versus the actual delivered inspired tidal volume, the ventilator can correct for gas compression losses and contributions due to anesthesia machine fresh gas flow. Tidal volume, as set by the operator, is delivered to the patient circuit. This procedure is referred to as tidal volume compensation.

Important Operator set volume is delivered to the patient circuit by the ventilator. Since the inspired flow transducer is located at the inspiratory outlet, compression losses experienced in the patient circuit itself are not compensated. Compression losses in the patient circuit are typically between 0.75 and 1.25 milliliters per centimeter of water. Compression loss depends on the internal volume and expandable characteristics of the patient tubing being used. This small compression loss is usual and not significant with adult patients. However, when the 7900 ventilator is used on pediatric and infant patients, the operator must consider this loss when making tidal volume adjustment decisions.

Pressure mode ventilation on the 7900 is selectable by the operator, via the "Ventilation Setup" menu, to deliver a pressure targeted breath. During inspiration, the ventilator delivers the required high initial flow to achieve the set inspiratory pressure. Once the inspiratory pressure is reached the ventilator regulates the inspiration pressure to remain constant for the length of inspiration time. In this way the user can be assured that the ventilator is delivering the maximum tidal volume possible at the desired pressure level.

System Power ON

Power ON the control module (Turn the system switch to ON).

This mains power indicator light on the ventilator is ON when the system a-c power cord is connected to a wall outlet. (The LED on the mechanical ventilation ON/OFF switch will remain dark until the switch is pushed to turn on mechanical ventilation.)

Note: Battery charging occurs as long as the Mains Power LED is lighted. You may get an alarm message "Low Battery Charge." This alarm should go away within 40 minutes. If it does not, the battery may need replacement.

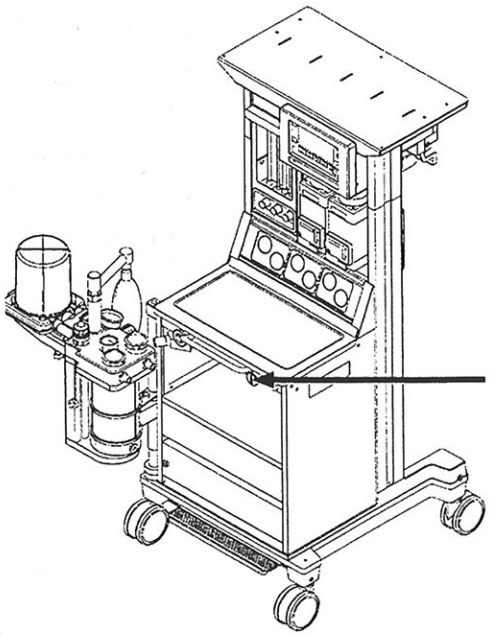


Figure 2-1
Power On ventilator with system switch, Ohmeda Excel SE

Front Panel

The 7900 Ventilator is a part of the Ohmeda Excel SE and Modulus SE Anesthesia Gas Systems. Control adjustments are as follows:

1. Push the selection switch, a box flashing on and off highlights the selection readout. (See items 3 through 7, Figure 2-2.)
2. Use the adjustment knob to change setting. (See item 8, Figure 2-2.)
3. Read the new value in the display window above the parameter select switch.
4. When a new desired setting is reached, push the adjustment knob to confirm. See section 5 for operation details.

Operator Controls

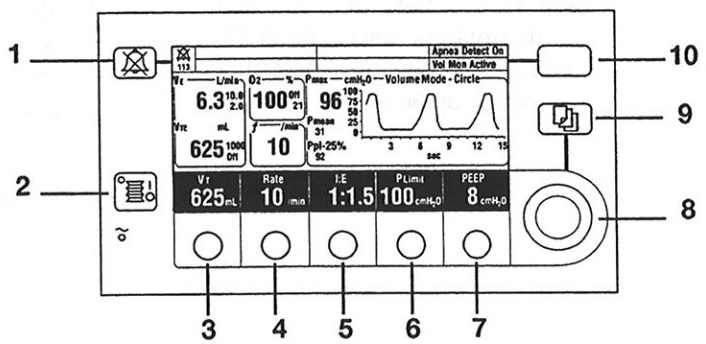


Figure 2-2
Front Panel Control Identification

See Figure 2-2

1.Alarm silence and reset switch
2.Mechanical ventilation ON/OFF switch and LED
3.V_T select (in volume mode) or Pinspired select (in pressure mode)
4.Breathing rate select
5.I:E ratio select
6.Airway pressure limit select
7.PEEP select
8.Adjustment knob
9.Menu select switch
10.Apnea Detect ON/ OFF and Volume Monitor Active/Standby switch

See figure 2-2

Item 1. Alarm silence and reset switch

- Silences audio alarms that are on.
- Starts a 120 second count down timer to show remaining silence time.
- Push the switch to reset the alarm back to 120 seconds.

Note: Apnea, High Airway Pressure, Low O_2 Pressure are not silencable alarms.

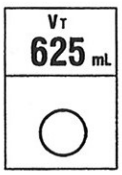
Parameter Select Switches

OFF position
LED off

Item 2. Mechanical ventilation switch

When system is first turned ON, mechanical ventilation is OFF and the LED is dark.
Push to start Mechanical ventilation: the LED lights and mechanical ventilation begins.
Breathing circuit should be set in "ventilator" position to begin mechanical ventilation.

Note: The following left margin illustrations represent the display windows immediately above the select switches. The windows are accessed by pushing the select switch under each display. The value displayed indicates parameter changes as you turn the adjustment knob.

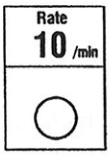


Item 3. V_T, Tidal volume; select/read in mL

- V_T range 20 to 1500 mL.
- This control has two functions, it is the tidal volume set during VOLUME MODE, or Pinspired set during PRESSURE MODE. See section 5, Ventilation Setup Menus.

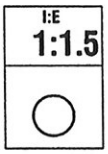
Item 3. Pinspired, Airway pressure

- Pinspired set range 5 to 60 cm H_2O, 1 cm H_2O steps.



Item 4. Breathing rate

- Can be adjusted continually from 4 to 100 breaths per minute in one breath steps.
- Pressure waveform display time axis varies with the breath rate setting:
  4 to 25/min.- 0 to 15 sec.
  26 to 75/min. - 0 to 5 sec.
  greater than 75 /min. - 0 to 3 sec.



Item 5. I:E ratio

- I:E - set range 2:1 to 1:8.
- steps of 0.5.

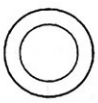
Item 6. Airway pressure limit

- Plimit - set range 12 to 100 cm H_2O, 1 cm H_2O steps.
- Waveform display pressure axis varies with the Plimit value.

Note: Plimit is set airway pressure limit, Pmax is sensed peak airway pressure.

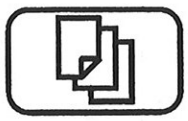
Item 7. PEEP

- Electronically controlled.
- Set range OFF, or between 4 and 30, 1 cm H_2O steps.



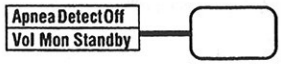
Item 8. Adjustment knob

- Changes set values on selected ventilation controls.
- Selects various functions on menus.
- Changes set values on selected menus.
- Push knob to confirm and keep selections in memory.



Item 9. Menu select switch

- View and change parameters not frequently changed.
- Change at startup or during operation.
- Menu switch displays main menu, also can be pushed to exit to the waveform display.
- Each menu has an exit option to a different menu.



Item 10. Apnea Detect and Volume Monitor

- Pushing the switch selects four different states of volume monitoring: Volume Monitor Standby or Active, and Apnea Detect ON or OFF.
- Apnea and volume monitor functions are always enabled during mechanical ventilation.
- Resets from Volume Monitor Standby/Apnea Detect OFF to Volume Monitor Active/Apnea Detect ON when a breath is detected in non-mechanical ventilation.

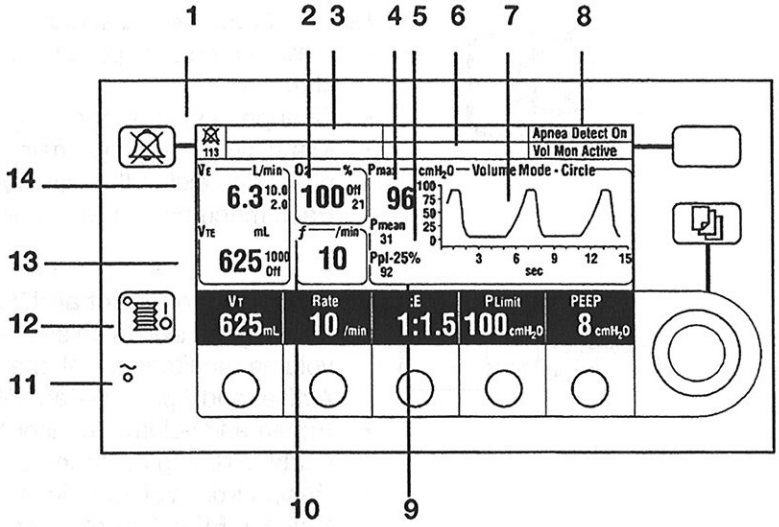
WARNING:

⚠ **When in the manual ventilation mode and Apnea Detect Off is selected, the ventilator will not detect the patient's loss of breath.**

⚠ **When Vol Mon Standby is selected, loss of breath will be detected but small or large breaths will not cause alarms.**

⚠ **A breath is defined as an inspiration of 5 mL or more.**

Front Panel Displays



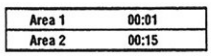
1. Alarm silence countdown
2. Oxygen concentration (percent)
3. Alarm areas 1 & 2
4. Pmax
5. Pmean
6. Alarm areas 3 & 4
7. Waveforms/menus
8. Apnea Detect and Volume Monitor status indicator
9. Ppl = Pplateau pressure if inspiratory pause is on
10. *f* (respiratory rate or frequency)
11. Mains power/battery charge indicator
12. Mechanical vent ON/OFF switch/indicator
13. Measured tidal volume (V_{TE})
14. Measure minute volume ($\dot{V}_E$)

Figure 2-3
7900 Front Panel Displays

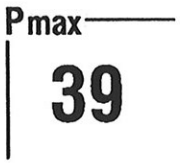
Refer to Figure 2-3

Item 1. Alarm Silence countdown timer
120 to 0 seconds.

Item 2. O_2- display
Percent of oxygen measured in the inspiratory limb of the breathing system, 5 to 110% — upper and lower alarm limits are also shown.

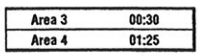


Item 3. Alarm areas 1 and 2

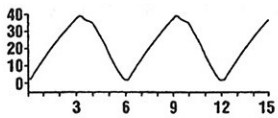


Item 4. Pmax - display
Maximum patient airway pressure during a patient breath, 0 to 120 cm H_2O.

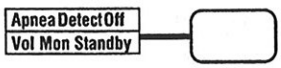
Item 5. Pmean - display
Mean (running mean) airway pressure during patient breath, -20 to 120 cm H_2O.



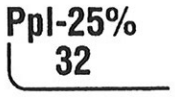
Item 6. Alarm areas 3 and 4



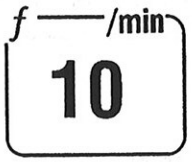
Item 7. Waveform/menu display area
Vertical axis in cm H_2O. Horizontal axis in seconds.



Item 8. Apnea Detect ON/OFF, Volume Monitor Active/Standby indicator
See section 5 for detail.

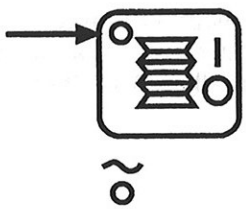


Item 9. Pplateau - display
Patient airway pressure measured at the end of inspiratory pause time, 0 to 120 cm H_2O, percentage indicated is percentage of respiratory time.



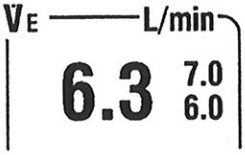
Item 10. Respiratory breaths/min. - display
monitored frequency of patient breaths delivered breaths, 0 to 105 breaths/min.

Item 11. Mains power/battery charge indicator
LED lights when connected to mains power.
LED dark when unplugged from mains power.



Item 12. Mechanical ventilation ON/OFF LED indicator
LED comes on when mechanical ventilation is ON.
LED dark when mechanical ventilation is OFF.

Item 13. V_{TE} - display
Exhaled tidal volume–calculated from expiratory flow sensor output, 5 to 9999 mL — upper and lower limits are also displayed.



Item 14. V_E - display
Exhaled minute volume, calculated from expiratory flow sensor output, 0 to 99.99 L/min. – upper and lower limits are also displayed.

Menus

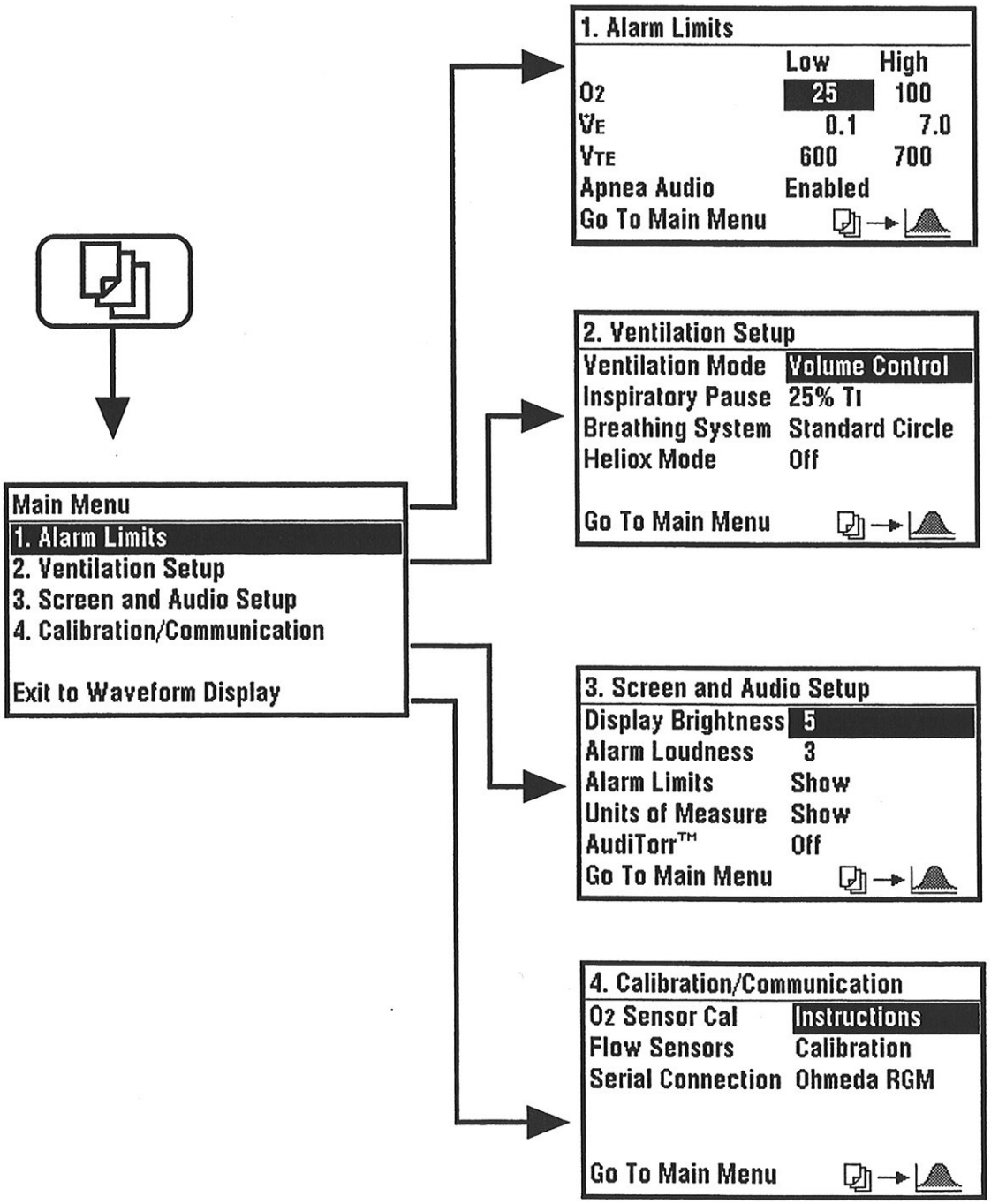


Figure 2-4
Menu overview block diagram, see section 5 for adjustments

Notes:

This manual is supplemental to the Ohmeda Excel SE and Modulus SE Anesthesia Gas System Operation and Maintenance Manual. See that manual for pneumatic circuit connections and other system setup data.

Some ventilator alarms may be caused by transitory electrical interference that devices such as electrocautery instruments can generate. Although the ventilator will disable mechanical ventilation during certain of these alarms, causes may be transitory and the ventilator will attempt to maintain mechanical ventilation.

WARNING:

⚠ **The use of electrosurgical units or other devices that radiate high-intensity electrical fields can affect the operation of the ventilator and monitors attached to the patient. Maintain as much distance as possible between the electrosurgical leads and the cables to the flow and oxygen sensors. Do not drape the electrosurgical leads across the absorber or the anesthesia machine. Do not let the electrosurgical leads rest on any surface of the anesthesia system. Constant surveillance of all monitoring and life support equipment is mandatory whenever electrosurgical devices are in operation, on, or in the vicinity of the patient.**

⚠ **Manual ventilation must be performed when electrical interference causes interruption of ventilator delivered mechanical ventilation. Manual ventilation must be continued until the ventilator resumes normal operation or an alternate anesthesia system can be used.**

System installation

During initial installation, the following procedures must be completed by a fully trained Ohmeda Representative.

Note: The front panel display has a protective mylar shield to help prevent scratching during shipment. Remove this shield prior to conducting the following checks and calibration procedures.

During installation of anesthesia systems using the 7900 Ventilator it is important to perform the following system checks and calibrations to ensure that the system operates according to specifications. Test equipment required to perform these checks are a short (approximately one-half meter) length of 22 mm patient tubing or a 22 mm plug. (Ohmeda test plug stock number 2900-0001-000.)

5. Set the 7900 ventilator in the Service Mode. The Main Menu - Service Calibration Mode displays.
6. Select the correct drive gas.
7. Select the correct altitude.
8. Perform the flow sensor calibration.
9. Attach a short piece of 22 mm tubing between the inspiratory and expiratory flow sensors or plug the breathing circuit at the "Y" piece. Place the Bag/Vent switch to the Vent position.
10. Perform the Cal Flow Valve routine, following the instructions displayed on the menu. (The short hose used in step 5 effectively occludes the breathing circuit.)

11. Perform the Cal Bleed Resistor routine, following the instructions displayed on the menu.
12. Run the Test Press. Limit Switch Routine.
13. After completion of Test Press. Limit Switch Routine, exit the Service mode.
14. Perform both the 21% and 100% O_2 sensor calibrations. (Refer to Section 6.)
15. Perform the preoperative checkout per the Excel or Modulus SE/7900 Operation and Maintenance Manual.

4/Preoperative Checkout Procedures

This manual is supplemental to the Ohmeda Excel SE and Modulus SE Anesthesia Gas System Operation and Maintenance Manuals. See those Operation and Maintenance manuals for Preoperative Checkout Procedures on the entire system as well as the 7900 Ventilator.

WARNING:

⚠ **Carry out the preoperative checkout procedures, as applicable, in the Excel SE or the Modulus SE Anesthesia System Operation and Maintenance Manual.**

⚠ **Always carry out the preoperative checkout procedures before putting the system back in use. Failure to make sure of correct setup and operation before use can result in patient injury.**

Notes:

Pre-use check list

Prior to each case check all the ventilator settings to ensure they are appropriate for the patient.

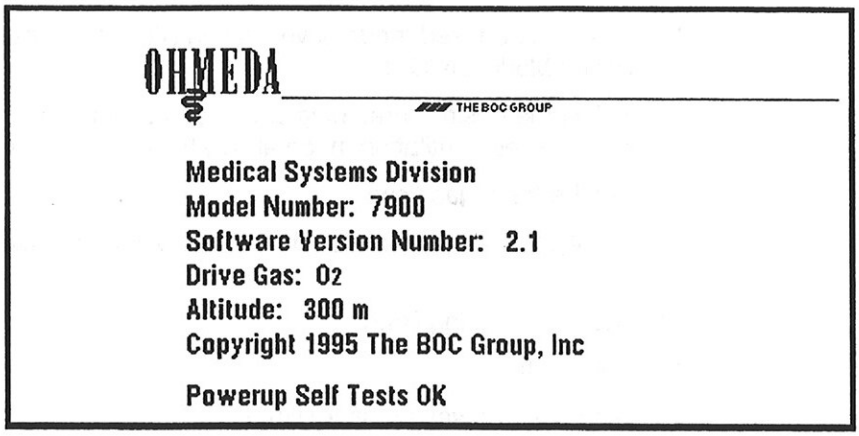
16. Check that the mains electrical indicator is lighted.
17. Turn on the anesthesia system power switch. (If system power is already ON, cycle the power switch ON and OFF, then back ON to allow the system power-up self test to run.)
18. Ensure the proper drive gas is displayed on the power up menu.
19. Unplug the system power cord from mains power.
20. Ensure the ventilator functions and indicates the use of battery backup power.
21. Reconnect the system power cord to the system mains power.
22. Select the desired mode of ventilation (Volume Mode or Pressure Mode and Heliox Mode ON/OFF).
23. Select the desired breathing circuit and ensure it is displayed to the right of the selected ventilation mode above the pressure wave form.
24. Set the fresh gas flow.
25. Set V_T, to the appropriate tidal volume value or Pinspired to the appropriate level.
26. Set the breathing Rate.
27. Set I:E Ratio.
28. Set Plimit (Airway pressure limit).
29. Set PEEP.
30. Check and adjust alarm settings to ensure they are appropriate for the ventilator settings and the case at hand.
31. Run the 21% Oxygen Sensor Calibration Check, see section 6.

System Power ON

The ventilator is turned on and off with the system. To power on the ventilator, turn the system power switch to ON (see figure 2-1). This mains power indicator light on the ventilator is ON when the system a-c power cord is connected to a wall outlet.

Note: The illustrations that follow; the front panel and the menus are not accurate reproductions. They are facsimiles for location and identification only.

The following illustration is a representative "Power Up Screen. It displays when the Anesthesia System ON/OFF switch is turned ON (see section 2).



Mechanical Ventilation Start

WARNING

⚠ **To help ensure proper operation of the patient disconnect alarms, an expiratory flow sensor must be used. Failure to do so may result in patient injury.**

⚠ **Do not occlude the pneumatic "bleed" resistor. This can cause the ventilator to malfunction and may cause harm to the patient.**

Push the mechanical ventilation ON/OFF switch to turn ON. The ventilator sounds an audible "BEEP" to confirm mechanical ventilation ON. Push again to turn OFF. When ON, the LED indicator on the switch is illuminated on. When OFF the LED is dark.

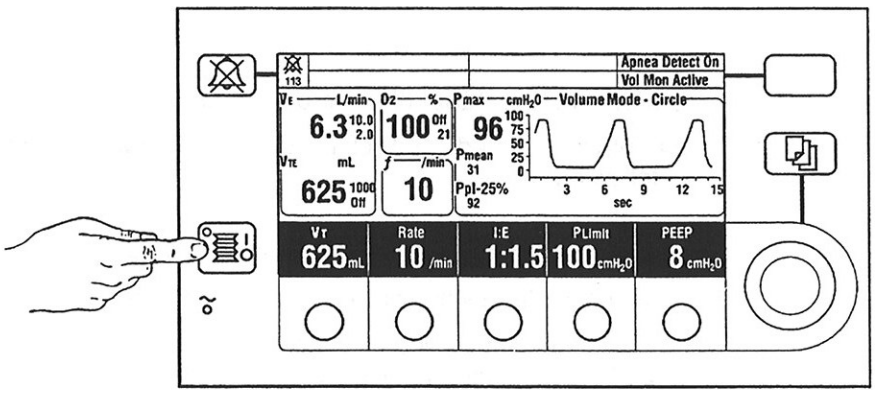


Figure 5-1
Mechanical Ventilation ON/OFF

User Adjustable Ventilation Controls

Tidal Volume (V_T), inspired pressure (Pinspired), and I:E ratio are the primary ventilation controls. To make selection easier, the primary control switches are darker in color. Alarm limits and other parameters are adjusted through menus.

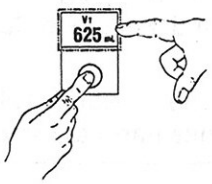
Settings

- V_T (Pinspired during pressure mode), Rate, I:E, Plimit and PEEP, each have a selection switch with an adjustment readout shown on the display immediately above.

Note: If the ventilator has a menu shown, and a selector switch is pushed to change a value, the cursor selection box forms around the selected control setting. Changes can then be made and confirmed. After the new adjustment is con-

firmed, or a time out occurs, control goes back to the menu in its former position and you can continue menu changes.

Push the selection switch



- A box that flashes on and off displays around display window.
- Units and numerical value are shown on the display.
- Ventilator sounds an audible "BEEP" to confirm pushing the selection switch.

When a selection is made

- Use adjustment knob to change shown value.
- Confirm new adjustment by pushing in knob.
- An audible "BEEP" sounds to let you know the new value was confirmed and stored in memory.
- The flashing box is removed.

Unconfirmed setting, change or adjustment

If a selection is made and you fail to set a value with the adjustment knob, one of following occurs if:

- 8 seconds passes, the selection is unselected.
- You push the same selection switch again, the parameter is unselected.
- You choose another control parameter, the first parameter is unselected and the new parameter is selected for change.
- You push the menus switch, the first parameter is unselected and the main menu is shown.
- You push the volume monitor switch, the first parameter is unselected and the Volume Monitor Active/Standby Switch causes the ventilator to move through the various stages of Volume Monitor Standby/Active and Apnea Detect ON/OFF.

If a selection was made and a value set, but was not confirmed, one of the subsequent items occurs if:

- 8 seconds goes by without adjustment changes, an audio tone occurs and the confirm display is shown, see Figure 5-2.
- A different selector switch is pushed, an audio tone sounds and the confirm display is shown, see Figure 5-2, top line only is displayed.
- You push the menus switch, an audio tone sounds and the confirm display is shown, see Figure 5-2, top line only is displayed.
- You push the Volume Monitor Active/Standby Switch an audio tone sounds and the confirm display is shown, see Figure 5-2, top line only is displayed.

If you haven't confirmed an adjustment and you push a different switch, the display reads "Push knob to confirm change." To escape this condition, push the knob to confirm or turn the knob to change and then confirm.

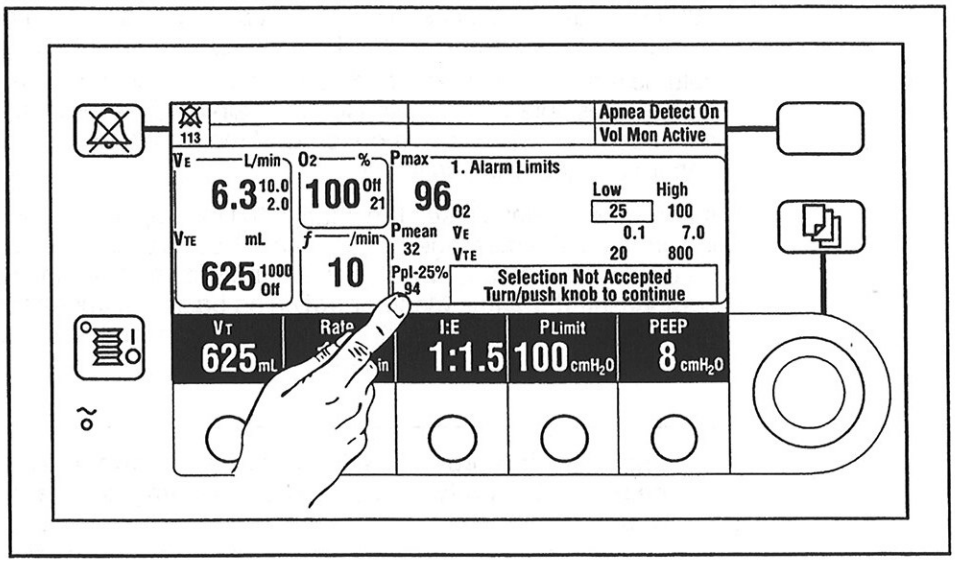


Figure 5-2
Failure to confirm display

Ventilation Modes

Volume Control ventilation

Volume Control ventilation is a mechanical ventilation mode that delivers a tidal volume set by the user into the patient tubing, This delivered volume is independent of the compression losses in the absorber, bellows, and associated hoses. It is also independent of any small leakages that may occur in the bellows, absorber, and associated hoses. Fresh gas flow into the breathing circuit will not cause a permanent change in the volume delivered into the patient tubing. If changes in the fresh gas flow rate or airway pressure occur, during the course of ventilation, the ventilator re-targets and, within 5 or 6 breaths, the volume returns to the correct tidal volume.

Pressure Control ventilation

Pressure Control ventilation is a time cycled mode where the ventilator strives to produce the user set inspiration pressure as soon as possible. To accomplish this goal, the inspiratory flow is changed by the ventilator to quickly achieve the inspiratory pressure without overshooting the desired pressure. This normally results in a decelerating inspiratory flow. The user is then assured that the ventilator is introducing the largest tidal volume possible given the inspiration time (rate and I:E ratio) and the inspiratory pressure (set by the user).

Volume Compensation Off

In the unlikely event of failure or malfunction of the SmartVent™ system, the 7900 ventilator continues to ventilate a patient in an uncompensated volume mode "V_T Compensation Off". The uncompensated volume mode is similar to volume mode excepting no compensation will occur for changes in gas flow or for compressible volume. Monitoring of airway pressure and volume should continue along with visual monitoring of the patient and physiological signs to ensure adequacy of ventilation.

If the problem that caused the change to Uncompensated Volume Ventilation is corrected, the message "Volume and Pressure Control Mode Available" will be displayed. The user will then have the option of continuing in the this uncompensated Volume Mode or switching back to compensated Volume Control or Pressure Control mode. It is not possible for the user to select Volume Compensation Off from the menu.

WARNING ⚠ **The following procedure is not to be performed with a patient connected. It is purely for non-patient training and demonstration purposes.**

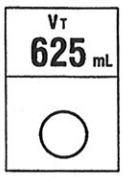
It is possible to induce Volume Compensation Off for the purposes of learning how the mode works.

- Open the exhalation valve locking lever. This lever is found on the rear of the ventilator where the drive gas tubing attaches to the ventilator. This will create a large leak in the delivery system.
- After 6 breaths have been delivered with this large leak, the ventilator will switch to Volume Compensation Off. It is then possible to explore the changes in delivered volume that are created by changes in fresh gas flow and compression due to airway pressure.
- Close the exhalation valve locking lever and ensure that all connections are secure. Return to Volume Control Mode or Pressure Control Mode before attaching the 7900 ventilator to a patient or clinical use.

Tidal Volume Set, V_T (or Pressure Set, Pinspired)

The left most primary control has two functions

- Set Tidal Volume (V_t) if Volume ventilation mode is selected
- Set airway pressure (Pinspired) if Pressure ventilation mode selected



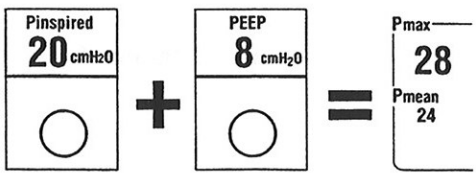
- Volume control mode
  . . tidal volume set range: 20-1500 mL.

Set V_T Range	Increment
20-100	5 mL
100-300	10 mL
300-1000	25 mL
1000-1500	50 mL

In the volume mode, this switch is V_T set, display in mL units.

- Pressure control mode
  . . Pinspired set range 5 to 60 cm H_2O, 1 cm H_2O steps.
  . . In pressure mode the label changes to Pinspired, display is cm H_2O.

In the PRESSURE MODE, Pinspired is always added to the PEEP setting.



Example case above set Pinspired is 20 cm H_2O;

- PEEP is set at 8 cm H_2O,
- PEEP (8) plus Pinspired (20) are equal to inspiratory pressure (Pmax) 28 cm H_2O.

The waveform area is in a set position on the display;

- x-axis (horizontal line) is time in seconds,
- y-axis (vertical line) is airway pressure in cm H_2O.
- A waveform erase bar moves across the display and erases existing data as it moves from left to right and displays new data.
- Area below the curve is shaded.

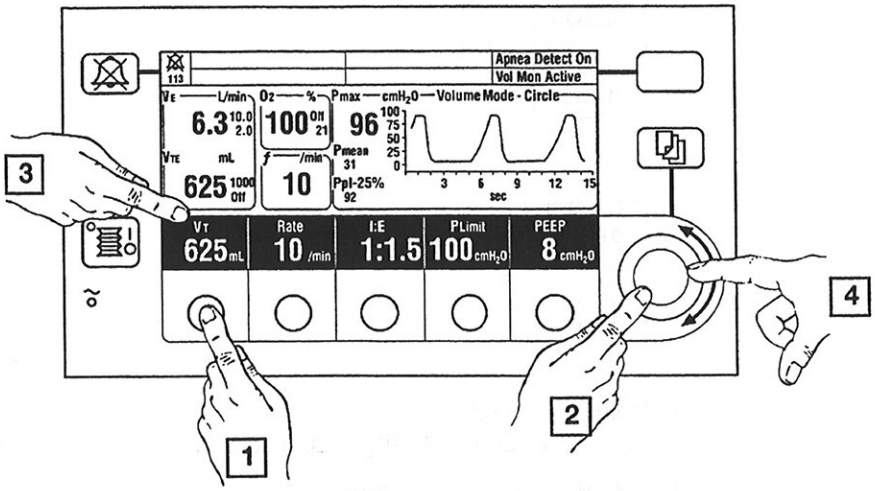


Figure 5-3
Tidal Volume - (V_T) Set (or Pressure Set)

See Figure 5-3 for the steps that follow

Push V_T selection switch, V_T display window (3) displays a box that flashes on and off around it.

Use knob to increase or decrease V_T. Adjustment increments change automatically as you move through ranges.

Read change of settings in window.

There can be a shown limit display of less than a stated range considering other settings and conditions. For example;

Ranges - breath rate (4 to 100 breaths per minute), V_T (20 to 1500 mL). If you were to try to set 1500 mL at 100 breaths per minute, built-in ventilator limits will not permit those settings. Pressure Mode: Setting the I:E Ratio at 1:2 will

allow you to set the full range of 100 breaths per minute. However, with an I:E Ratio of 1:1 the breath rate setting is limited to 75.

Volume Mode: With an I:E setting of 1:2 the tidal volume cannot be set over the full range. Setting the I:E Ratio at 1:2 and the Breath Rate at 100 breaths per minute, limits the tidal volume to 400 mL.

You'll get a display message that flashes on and off. The value that you were adjusting when the ventilator limit is reached continues to have a box that flashes on and off around it to show it was that value which moved the ventilator to the limit.

"Maximum Value has been reached"
"Check other settings"

"Minimum Value has been reached"
"Check other settings"

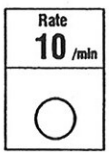
Changing other settings may permit a greater range for the particular parameter setting that moved you beyond the maximum value.

After settings are set and shown on V_T display, push in adjustment knob or push selection switch again to confirm. This locks the new adjustment in memory. A tone sounds and box goes to a normal display.

Adjustments for

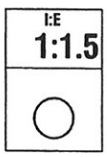
- Breathing Rate
- I:E Ratio
- High Airway Pressure limit
- PEEP
  follow the same procedure as for V_T.

Breathing Rate Set (frequency of breaths per minute)



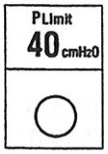
Can be adjusted continually from 4 to 100 breaths per minute in one breath steps.

I:E Ratio Set



Ratios from 2:1 through 1:8, in 0.5 steps (e.g.: 2:1, 1.5:1,... 1:7, 1:7.5, 1:8).

High Airway Pressure limit Set



Plimit - set range 12 to 100 cm H_2O, 1 cm H_2O steps.

- Selects the maximum (and sustained) airway pressures tolerated in the patient's breathing system.
- If the adjustable pressure limit is reached, inspiration stops and exhalation starts.
- Not the same as the inspiratory pressure control used for pressure ventilation.

Note: Pmax is the peak sensed airway pressure; Plimit is the airway pressure limit set with the front panel controls;

WARNING: ⚠ **Do not use a separate mechanical PEEP valve, incorrect operation and patient injury can result.**

PEEP Set

Mech. Vent ON

- Electronically controlled.
- Operator sets PEEP with the front panel control. Can be set to OFF, or between 4 and 30 cm H_2O in increments of 1 cm H_2O.
- PEEP is in effect during mechanical ventilation, but not if mechanical ventilation is turned OFF (in BAG mode). This reduces the work of breathing caused by uncompensated PEEP.
- High airway pressure alarm limit is an absolute value and does not use set PEEP as an offset.
- Peak inspiratory pressure is always Pinspired plus PEEP.
- PEEP is operational during all mechanical ventilation modes.
- Selected value is always clearly shown on the display during mechanical ventilation.
- During mechanical ventilation, monitoring airway pressure establishes and maintains PEEP.

Mech. Vent OFF

- Can be set when mechanical ventilation is OFF, but, it does not change operation until mechanical ventilation is started.

Selection and Adjustment with Menus

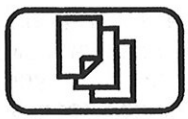
The power ON screen is shown when you turn ON the anesthesia system ON/OFF switch. Allow about five seconds for the ventilator to conduct its "Self Test".

When the "Self Test" is complete, the ventilator displays the waveform and other parameter settings for usual operation. Ventilation mode and parameter settings default to the last used settings.

Main Menu

See Figure 5-4

Push Menus Select switch. Main Menu displays unless:



- A control adjustment was changed but not kept in memory, then the unconfirmed message is displayed.
- A display window is being shown.

Selecting the Exit to Waveform Display erases the menu.

The menu select switch functions as an escape button if no menu selection is in progress.

All menus except O2 go back to the waveform display in 23 seconds from the last selection if the adjustment knob was not turned during the menu selection process. O2 menu will go back to waveform display after 20 minutes.

Figure 5-4
Main menu

To choose other menus from the Main Menu, turn knob in a CW or CCW direction.

Note: At times, if a sensor or internal component malfunctions, an "Unavailable" indication displays on the selection, but, selections without this display can be selected.

While menus are displayed:

- mechanical ventilation can be started or turned OFF,
- alarms are active.

The "Cursor bar" moves up or down on the main menu as the adjustment knob is turned. When the cursor bar (black with white letters) is on the menu to view, push the knob to choose that menu for display.

Alarm Limits Menu

See Figures 5-5 and 5-6

- From the Main Menu, choose "1. Alarm Limits" by turning the adjustment knob. Push to confirm.
- Low 21% selected by default on first display.
- Push adjustment knob to confirm selection or, turn knob to a different selection.

If you turn the knob clockwise, the cursor moves as shown in Figure 5-5.

When you stop moving the knob it puts the cursor around that value for selection and then you can change settings. You cannot make changes to a value unless you confirm the selection. After confirmation, you can make the change, but you must then confirm the change after it is made for it to stay in memory.

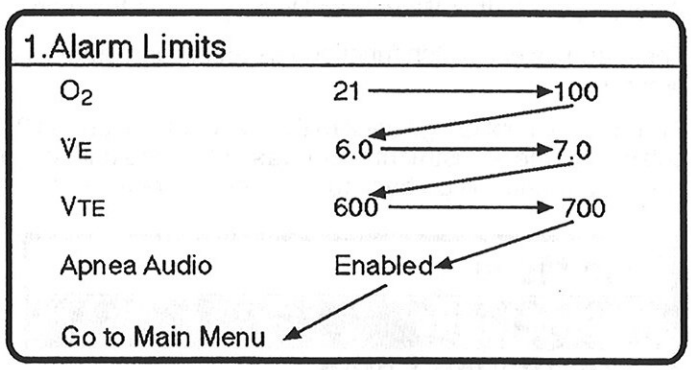


Figure 5-5
Choose Alarm Limits

Table 5-1 Alarms/Range Limits/Incremental Adjustments

Alarm	Range	Increment
low FiO_2	21-100%	1%
high FiO_2	21-100%, off	1%
low V_E	off, 0-10 L/min.	0.1 L/min.
high V_E	0-30, off L/min.	0.1 L/min.
low V_{TE}	off, 0-1500 mL	20 mL
high V_{TE}	20 - 1600 mL, off	20 mL
Apnea Audio	enabled/disabled	

- Rotate the knob until the cursor highlights the value you wish to change. Push the knob to choose the selected value.
- A turn of the knob changes the limit.
- Push the knob again to confirm change.
- The box becomes a cursor, black with white text.
- Use the same procedure to change the alarm limit.

Low and high V_E and V_T are selected and changed as was done for O_2 limits.

"Apnea Audio" can be used to disable the audio portion of the apnea alarm when ventilating in Pressure mode. This may be desirable when ventilating a circuit known to have a relatively large gas leak (e.g. leaky tracheal tube). Apnea Audio may only be disabled when

- In pressure mode
- Mechanical ventilation on
- Low $\dot{V}_E$ Alarm limits set

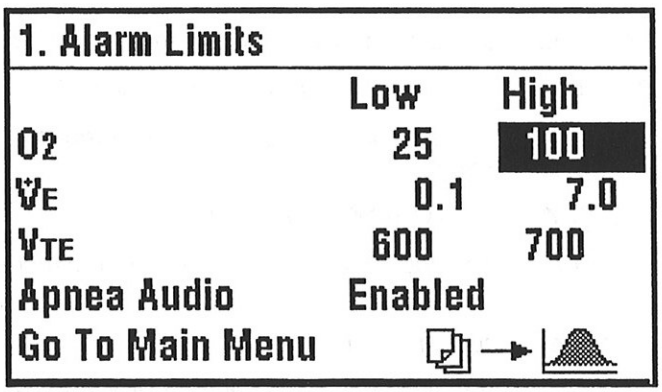


Figure 5-6
Adjust High O_2 Limit

Ventilation Setup Menu

See Figure 5-7 through 5-12

- From the Main Menu, choose "2. Ventilation Setup" by turning the adjustment knob, push to confirm.

Note: Heliox Mode pertains only to ANSI gas systems with Heliox flow tubes installed. Heliox mode is enabled through the Service Mode for those systems requiring this mode.

- To Select a new ventilation mode

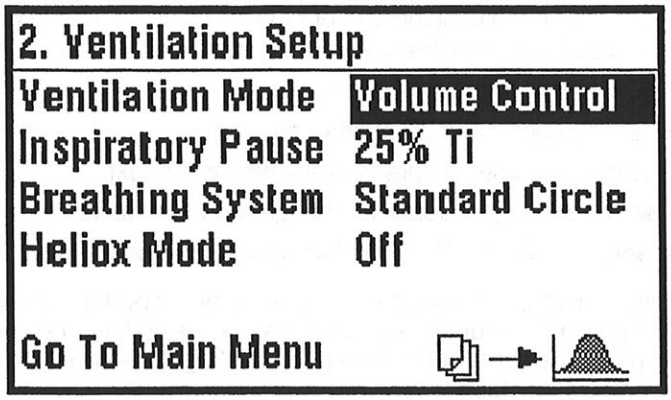


Figure 5-7
Choose Ventilation Mode

- Turn the adjustment knob until a box is placed around the current ventilation mode.
- Press the adjustment knob to pull down the Ventilation Mode menu.
- Select a new mode and press the adjustment knob to confirm.
- The ventilator will continue to operate in the current mode until the following prompt is satisfied:
- "TURN KNOB TO CHANGE SETTING"
- Once the new setting is made and confirmed, the mode change takes place.
- Go to next setup, or "Go To Main Menu."

The following illustration shows Volume and Pressure Control. V_T Comp Off displays only when there is an alarm condition possibly caused by an Inspiratory flow sensor malfunction.

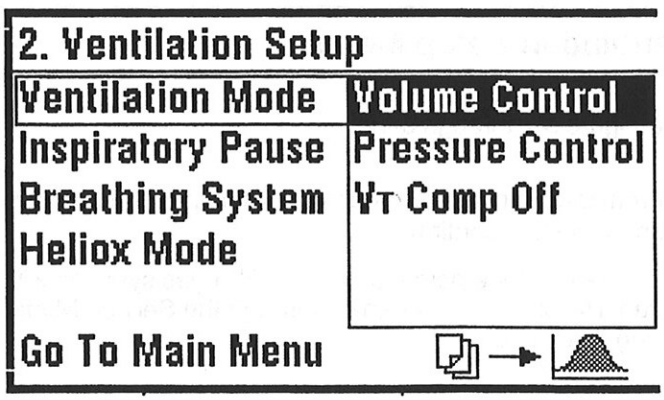


Figure 5-8
Choose Volume Control Mode

To Set Inspiratory Pause

Inspiratory pause is functional only in the volume mode. (In pressure mode Inspiratory Pause displays a message "No Pause ⚠". Changes cannot be made.) Pause may be set to OFF or a percentage of inspiratory time (5 to 60%) in increments of 5 percent. The minimum pause that can be selected is 400 ms.

- Turn the knob to select inspiratory pause. The last pause setting is shown in reverse (white on black background)
- Push knob to confirm selection. White on black changes to a box, see figure 5-10.
- Turn the adjustment knob to select the desired pause as a percentage of inspiratory time or turn pause off.
- Push the knob to confirm. After selection, display returns to white on black.
- Go to next setup or to Main Menu.

The next time the ventilator is turned on, inspiratory pause will be at the setting chosen when it was last used.

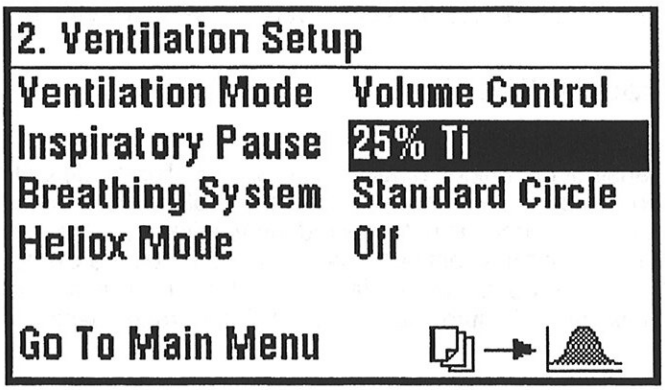


Figure 5-9
Selection of Inspiratory Pause

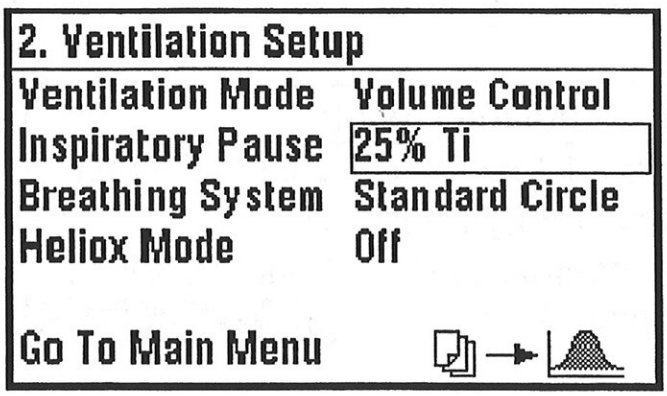


Figure 5-10
Inspiratory Pause selection confirmed, pause time adjustments 5 to 60% possible

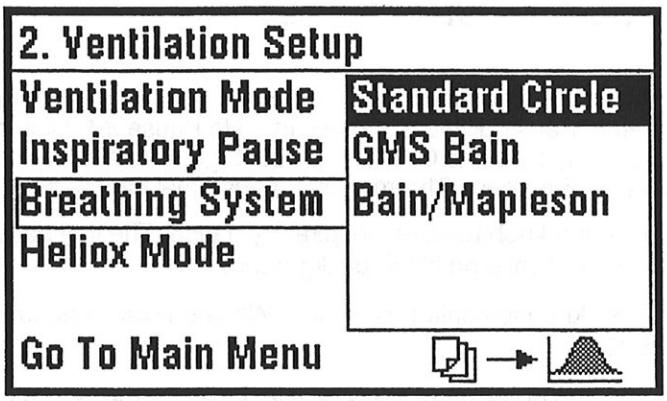


Figure 5-11
Choose Breathing System

Choosing a Breathing System

Choose a breathing system the same as you made other selections. The selected breathing system is displayed above the waveform.

Select Heliox Mode

Because of the unique qualities of Heliox, Heliox mode ON must be selected when Heliox is used. The ventilator makes allowances for the variance in Heliox gas. If Heliox mode is not selected the ventilator sensor and display values will be in error and the ventilator may go into the Volume Compensation Off mode. In the Heliox mode, the ventilator thinks that all gas in the breathing circuit other than oxygen is helium. See Appendix D for graphs depicting the precision.

WARNING ⚠ **Incorrect selection of Heliox/Normal mode will adversely impact tidal volume delivery and monitoring accuracy and may cause the ventilator to enter "V_T Comp Off". An appropriate adjustment of the Plimit setting should always be made to help ensure patient safety.**

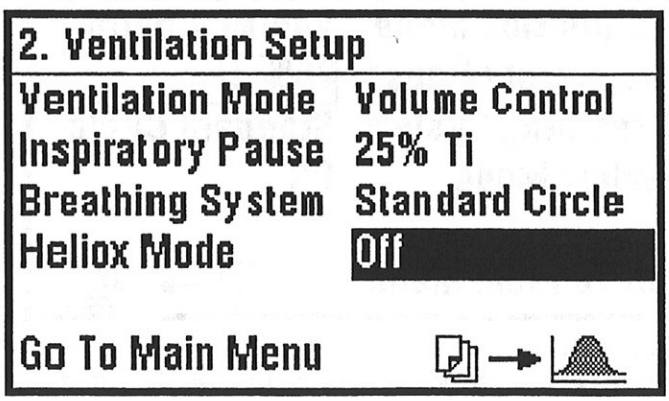


Figure 5-12
Heliox ON or OFF

Screen and Audio Setup Menus

See Figures 5-13 through 5-17

- From the Main Menu choose "3. Screen and Audio Setup"

Turn adjustment knob to select;

- Display Brightness (1 to 10), last setting retained in memory for start-up.
- Alarm Loudness (1 to 5), last setting retained in memory for startup.
- Alarm limits (Show or Hide), last setting retained in memory for startup.
- Units of Measure (Show or Hide), defaults to Show for startup.
- AudiTorr™ (off or 1 to 5), defaults to OFF on power up.

Confirm selection by pushing knob.

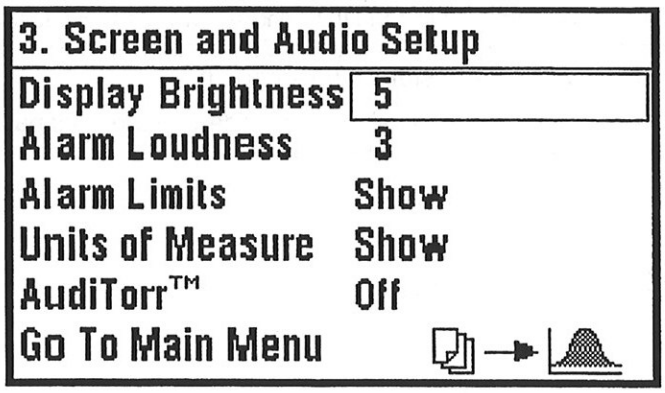


Figure 5-13
Choose Display Brightness (1 to 10)

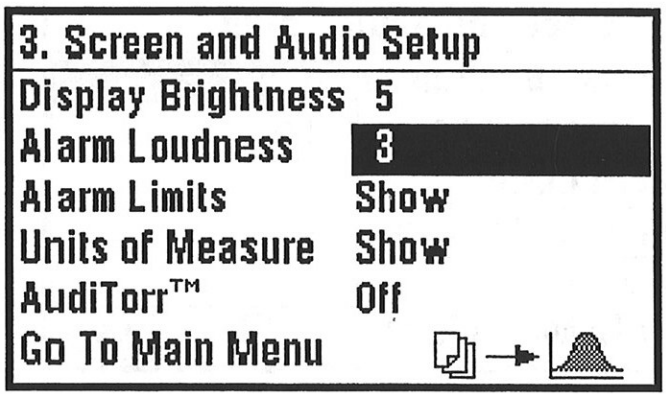


Figure 5-14
Choose Alarm Loudness (1 to 5)

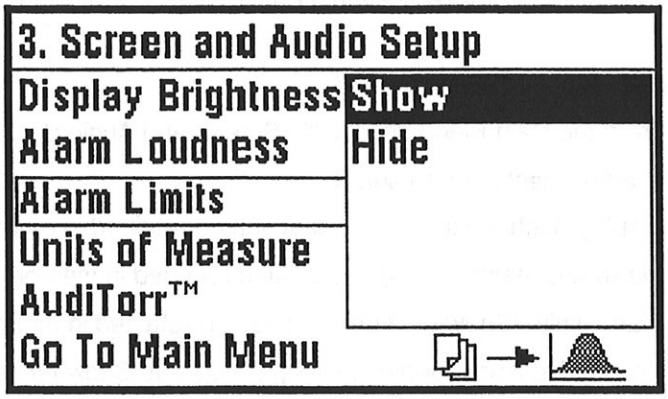


Figure 5-15
Choose Alarm Limits (Show/Hide)

When Alarm Limits is in the HIDE Mode, the high and low limit indicators are not displayed. The limits for the violated parameter default to Show if an alarm occurs or when the system is powered on.

Units of measure may be shown or hidden on the front panel display screens upon operator selection. They are:

L/min.	($\dot{V}_E$)
mL	(V_{TE})
/min.	(f)
%	(O_2)

Some users prefer to turn off these indicators to make the display screens less "cluttered."

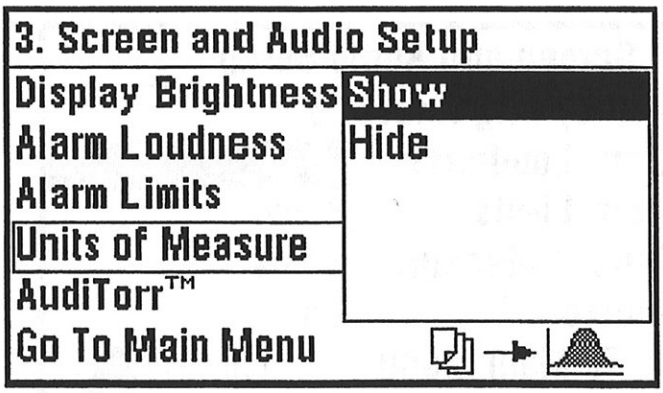


Figure 5-16
Choose Units of Measure (Show/Hide)

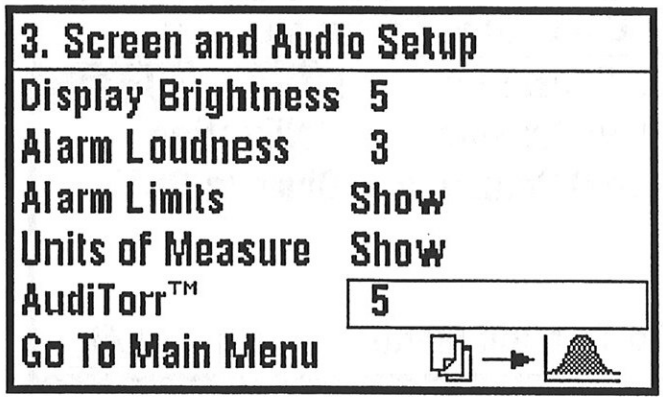


Figure 5-17
Choose AudiTorr Off or loudness 1 to 5

AudiTorr is a function of the 7900 ventilator producing an audible signal for the user. The audible signal indicates changes in the rise and fall of airway pressure. As airway pressure rises, during inspiration, AudiTorr will generate small bursts of tones. A flute-like tone is generated for every rise or fall of 2 cmH_2O. The frequency or pitch of the tone is proportional to the pressure level. The pitch increases with increasing airway pressure. If there is no change in airway pressure there is no tone generated. If pressures below baseline are created by a patient's spontaneous breathing or a disconnected tube, a more harsh, grating tone is generated clearly indicating a fall below the established baseline airway pressure.

AudiTorr is ON/OFF user selectable and has adjustable loudness or volume from 1 to 5 via the "Screen and Audio" menu. AudiTorr defaults to OFF during power up.

Calibration/Communication Menus

See Figures 5-18 through 5-20

- Choose "4. Calibration/Communication" menu by a turn of the adjustment knob.
- Push knob to confirm selection.

Oxygen Sensor Cal

- When the menu comes up, O_2 Sensor Cal - Instructions, displays.
- Choose Instructions.
- A cursor displays around the selection.
- Push knob to confirm selection.
- Instructions on how to proceed are displayed.
- See section 6 for detailed instructions.

Note: You have a choice of one or two point calibration. One point being the 21% O_2 calibration; two point being 21% followed by 100% O_2 calibration. 100% calibration cannot be initiated until after a successful 21% calibration.

If the 7900 Ventilator is unable to calibrate the O_2 Sensor, a "Calibration Failure" message displays on the Alarm Management Screen. Dashes appear in the% O_2 monitoring area of the front display screen.

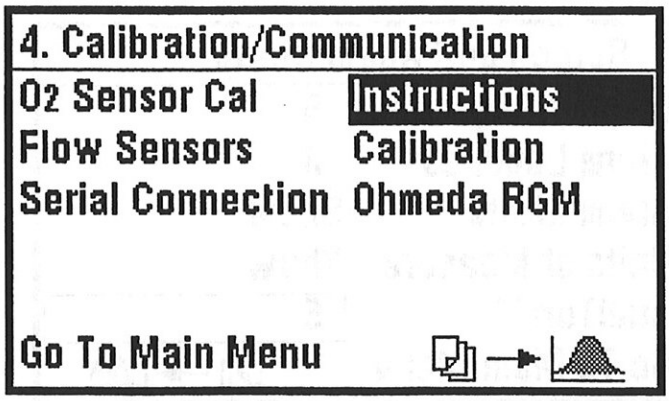


Figure 5-18
Choose O_2 Sensor Calibration

Flow Sensor Cal

- See section 6 for the flow sensor calibration instruction procedure.
- Turn knob to choose "Flow Sensor Cal", push to confirm.
- Menu displays a choice, Calibration or Operational Test.
- Turn the adjustment knob to highlight choice and press to confirm.
- Instructions on how to proceed are displayed.

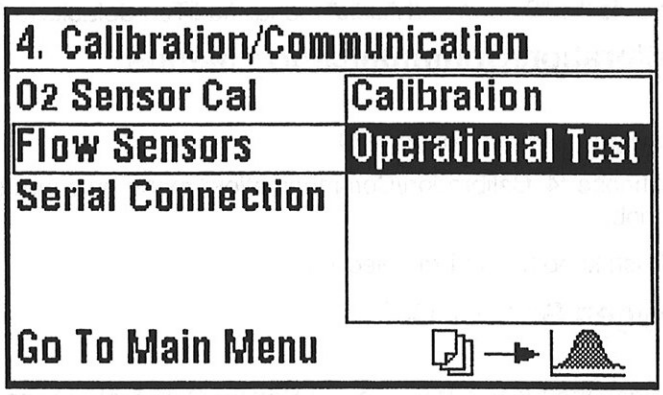


Figure 5-19
Choose Flow Sensor Calibration

Serial Connection

- Turn knob to choose the desired serial connection.
- push knob to confirm selection.

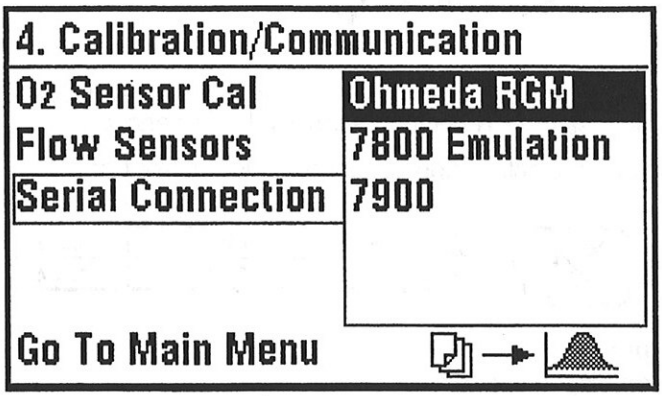


Figure 5-20
Choose Serial Connection, RGM indicated

SERIAL CONNECTION COMPATIBILITY TABLE

Protocol Selection	Application	Model/Version
Ohmeda RGM	Ohmeda RGM Respiratory Gas Monitor	Version 3.0 - 5.1 (w/o gas comp. data) Version 6.0 and later (includes gas comp. data)
7800 Emulation	HP CMS Other monitors programmed to communicate with Ohmeda 7800 Ventilator (Excludes wave-form data)	HP - CMS Release F or later Use Ohmeda cable part number 1503-3077-000
7900	HP CMS via VueLink Module (includes waveform data)	VueLink model M1032A with driver option A04 and cable option K09

Alarm Display Area Description

Note: There are occasions when technical alarms display. When these alarms display, see the Technical Alarm Table, Appendix "A.""

The alarm displays appear along the top of front panel.

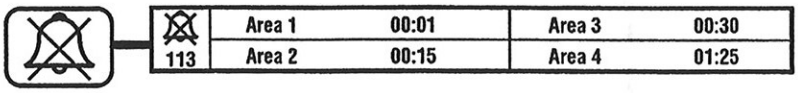


Figure 5-21
Alarm display windows

There are four alarm display areas;

- if not corrected and another high priority alarm occurs, first alarm moves to area 2, then to area 3 and sequences as new high priority alarms occur.

Note: The stepping sequence; area 1 to area 2, area 2 to area 3 etc. is true only if all the incoming alarms are of the same priority. The sequence is different when there is a mix of high, medium and low priority alarms. If there are more than four alarms, the fourth and fifth alarms (oldest alarms) will rotate in alarm area 4.

To the right of the alarm a count-up-timer displays the time a high priority alarm has been active,

- 00:01 through 99:59 minutes/seconds.
- Apnea alarms count up for only 2 minutes.

To the left of the alarm display area is the Alarm silence/Reset switch and a display of the silence time remaining. The silence time counts down from 120 seconds.

Alarms fit into two groups;

- patient alarms, see section 5 for adjustment and appendix "A" for listing,
- technical alarms, see appendix "A" for list.

Alarm priorities;

- high priority has a bright background,
- medium priority has a dark background,
- technical alarms, a dark background, refers to non-patient data (see Appendix "A" for list).

Each priority of alarm has a different audio tone for more accurate identification.

Alarm silence/reset

- Silences audio alarms that are on.
- Some alarms silence permanently, others do not. See Appendix "A."
- Starts a count down timer, 120 to 0 seconds to show remaining silence time.
- After 120 seconds the silenced alarm sounds again.
- New alarm conditions are shown immediately and sound their audio tone.

Monitoring Functions

Airway Pressure Monitoring

The Ohmeda 7900 Ventilator continuously monitors airway pressures in the patient breathing system and then uses this information to generate alarms and manage airway pressure. This data is also shown on the display as a waveform.

System Monitoring

Ventilator hardware, sensors and other components are constantly monitored for problems by ventilator software.

Low Airway pressure alarm

The low airway alarm is an important part of the ventilator's patient disconnection detection and alarm. A low airway pressure condition is detected if the airway pressure does not rise at least 4 cm H_2O above PEEP during any mechanical breath. The low airway pressure alarm will be activated if this low airway pressure condition exists for every mechanical breath during a 20 second period.

Airway Pressure Waveform (Paw)

Pressure Mode Waveform

See Figure 5-22

In PRESSURE MODE inspiratory pressure is controlled by the ventilator at a constant pressure. Flow adjusts to the patient's lung compliance and airway resistance.

PEEP plus Pinspired are equal to Inspiratory Pressure.

PEEP controls expiratory pressure in proportion to the PEEP setting. See Figures with waveform illustrated and note that baseline pressure is greater than zero.

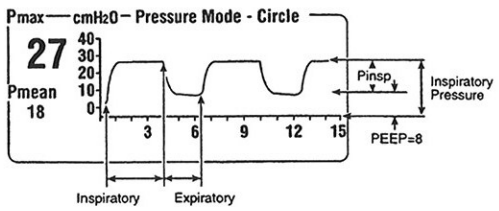


Figure 5-22
Paw waveform in the Pressure Mode, I:E Ratio is 1.5:1

Airway Pressure Waveform X-Axis or time scale

The time scale changes when a new breathing rate is set.

- 4 to 25 breaths per min., the time scale is 0 to 15 seconds,
- 26 to 75 breaths per min., the time scale is 0 to 5 seconds,
- 76 or greater breaths per min., the time scale is 0 to 3 seconds,
- On a change, the existing pressure data is erased and new waveform data starts at time = 0.

Airway Pressure Waveform Y-Axis or pressure scale

Scale changes automatically when Plimit is set (confirmed).

- 12 to 40 Plimit, the y-axis range is, 5 to 40,
- 41 to 60 Plimit, the y-axis range is, 5 to 60,
- 61 to 100 Plimit, the y-axis range is, 5 to 100.
- when the pressure scale changes, the existing pressure data is erased and the new waveform data starts at time = 0.

In VOLUME MODE and in PRESSURE MODE the waveform is noticeably different as can be seen in Figures 5-22 and 5-23.

Volume Mode Waveform

See Figure 5-23

- inspiratory time 3.0 sec.
- expiratory time 1.5 sec.
- pause time 0.4 sec.
- PEEP set at 8.
- maximum sensed inspiratory pressure (Pmax), 26.
- mean positive airway pressure (Pmean), 15.
- inspiratory pause pressure (Ppl), 24.

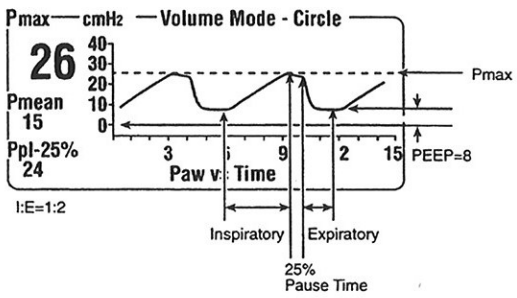


Figure 5-23
Paw waveform in the Volume Mode

Patient Monitoring

Volume (derived parameters, V_{TE}, *f*, V_E), airway pressure (Pmax, Ppl, and Pmean), and oxygen are continuously monitored by the ventilator after it is turned ON.

Related alarms include:

- apnea
- low/high V_E
- low/high V_{TE}
- low airway pressure
- high airway pressure
- sustained airway pressure
- sub-atmospheric airway pressure
- low/high oxygen

Sensor and Ventilator Monitoring Functions

Flow sensor, in the expiratory side of the breathing circuit, measures patient exhalation volume.

Flow sensor, in the inspiratory limb, supplies feedback for the volume ventilation mode.

Airway pressure is monitored on the patient side of the inspiratory flow sensor.

Pressure alarms (i.e. high, sustained, sub-atmospheric airway...) are monitored all the time.

Airway pressure higher than the Plimit set stops inspiration and cycles the ventilator into the exhalation cycle to decrease pressure in the patient circuit.

The oxygen sensor connects into the inspiratory limb of the patient circuit.

If the ventilator finds an O_2 sensor failure, an alarm occurs.

O_2 alarms occur for measured values above and below set high and low limits.

Monitoring Displays

Software gathers and prioritizes sensor data for display;

- displays patient breathing waveforms,
- displays sensed breathing circuit conditions.

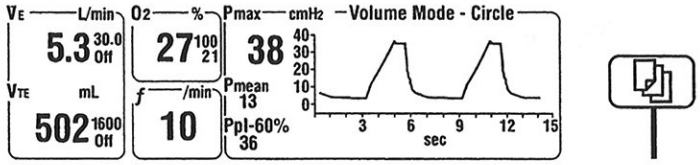
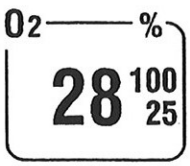


Figure 5-24
Monitoring Displays

- 1. V_E - display range 0 to 99.99 L/min.

- 2. V_{TE} - display range 5 to 9999 mL

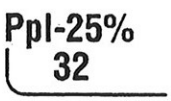


- 3. O_2 - display range 5 to 110%

- 4. Rate/min. - display range 0 to 105/min.

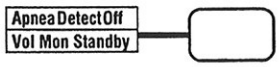
- 5. Pmax- display range 0 to 120 cm H_2O.

- 6. Pmean - display range -20 to 120 cm H_2O.



- 7. Ppl = Pplateau - display range 0 to 120 cm H_2O.
- Percent of pause - display range 5 to 60% of inspiratory time.
- 8. Waveform display, see Figures 5-22 and 5-23.

Volume monitor alarm switch Function



- Controls status of volume monitoring and apnea alarm during non-mechanical ventilation.
- Pushing switch causes four different states of volume monitoring.

1. Volume monitor Standby - Apnea Detect OFF
2. Volume monitor Active - Apnea Detect ON
3. Volume monitor Standby - Apnea Detect ON
4. Volume monitor Active - Apnea Detect OFF

The Volume monitor alarm function switch is designed to be flexible for the user and still offer as many safety features as possible.

Between cases the ventilator may be set in state 1. This will keep all volume and apnea alarms off until a breath is detected or mechanical ventilation is commenced.

The ventilator switches from state 1 to state 2 whenever it detects a breath (greater than 5 mL). Moving the patient tubing or brushing against the manual bag is often sufficient to create a detectable breath.

State (2) is used during mechanical ventilation. The user cannot change the state during mechanical ventilation.

During spontaneous breathing (mechanical ventilation off) the volume monitor alarm states can be changed by the user. During anesthesia wake up it is common for the patient to breathe smaller breaths than normal or smaller breaths than those created by the mechanical ventilator. The user may select "volume monitor STANDBY and apnea monitor ON" (State 3). In this case the ventilator monitors and displays exhaled tidal volumes; but, it will not alarm if the patient breaths are below the low tidal volume and minute volume monitor alarm limits. In state 3, even if the volume monitor is in STANDBY, the ventilator alarms if no breath is detected for 30 seconds (apnea). Small breaths will not cause an alarm but no detected breaths will cause an alarm.

State 4 is normally employed during situations where the volume monitor and apnea monitor are expected to be silent. One case is during a cardiopulmonary bypass case. A user may, during bypass time, select state 4 and then set the lower volume alarm limits to OFF (via the menu). When the ventilator is set in this way it will not alarm for small breaths, such as may happen when surgeons press on the thorax and lungs, and will not alarm when no breaths are being detected.

WARNING: ⚠ **Supporting a spontaneously breathing patient with the alarm system setup in this way will not offer any warning of insufficient breathing volumes or stoppage of breathing.**

Notes:

6/Maintaining the Ventilator

Maintenance schedule

This schedule is the recommended minimum standard with correct use and environmental conditions. Higher frequencies of use or unusual environments can dictate more frequent maintenance.

CAUTION: ⚠ Attempt no repair unless it is done by a person with correct qualifications and equipment.

Complete test and maintenance procedures by trained service persons	Minimum one time a year
Periodic Maintenance	30 days minimum and after disassembly and autoclaving
Check oxygen sensor calibration	21% Daily 100% Monthly
Replace oxygen sensor	As required
Replace each flow sensor	As necessary (recommend each month)
Flow Sensor Calibration	Once per week
Replace exhalation valve block elastomeric components (O-rings and gasket)	As required, yearly minimum. All components are expendable, user serviceable parts
Supply Gas Hose O-ring	As required, minimum one time a year
Clean exhalation valve block, autoclavable	Use cleaning and sterilization schedule compatible with your institution's infection control and risk management policies
Clean exhalation valve block gasket/diaphragm, autoclavable	Use cleaning and sterilization schedule compatible with your institution's infection control and risk management policies
Clean bellows assembly, autoclavable	Use cleaning and sterilization schedule compatible with your institution's infection control and risk management policies
Replace Autoclavable Bellows Assembly components	As required. All components are expendable, user serviceable parts
Supply gas inlet filter	Drain as necessary - replace element yearly, or when discolored

Calibrate the Oxygen Sensor

The user has the choice of a one point O_2 calibration (21%) or a 2 point calibration at 21% and 100% O2. Upon entrance into the Calibration/Communication menu, the user first performs a 21% calibration. The software does not allow the user to select a100% calibration until a successful 21% calibration has been completed. Until a successful 21% calibration is performed, the 100% selection is shaded to indicate that a 21% calibration is needed before a 100% calibration can occur. If the 21% calibration is successful, and the user remains within the Calibration/Communication menu, the user is allowed to perform the 100% calibration.

For 21% calibration (room air) the 15 mm adapter should be removed from the O_2 sensor. The O_2 cell may be laid on it's side or suspended with the sensing surface pointing down for calibration. The cell should not be held in your hand and the sensing surface must point down, not upwards, during calibration. Be certain to follow the displayed instructions and wait the entire three minutes before performing either the 21% or 100% calibration

- Check the O_2 sensor calibration at 21% before each use and at 100% monthly
- Check that the sensor is satisfactorily connected into the interface panel of the anesthesia machine.
- Use the menu switch to select "4. Calibration/Communication" menu

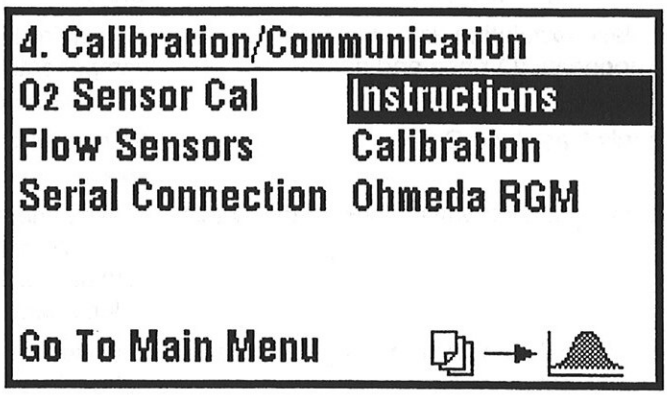


Figure 6-1
Choose O_2 Sensor Calibration

- When the menu comes up, push the knob to select Instructions
- The following display appears
- Push the adjust knob and confirm 21% calibration

Note that 100% calibration has a triangle icon following it. This indicates that 100% calibration cannot be initiated until a successful 21% calibration has been completed.

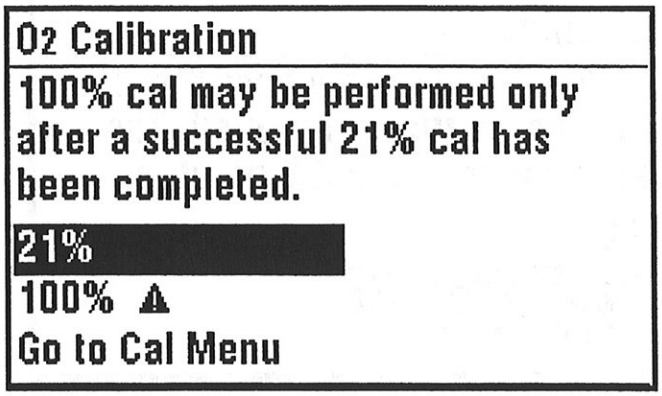


Figure 6-2
O_2 Sensor Cal Instructions

O_2 Cal Instruction Menu, 21%

- Check 21% Cal daily or each time the ventilator is put into use.
- Confirming 21% displays a menu with instructions on calibration.
- Remove the 15 mm adapter from the O_2 cell from before letting the cell stabilize in the room air for three minutes.
- Push knob to start calibration.
- Calibrating displays adjacent to Start Cal.

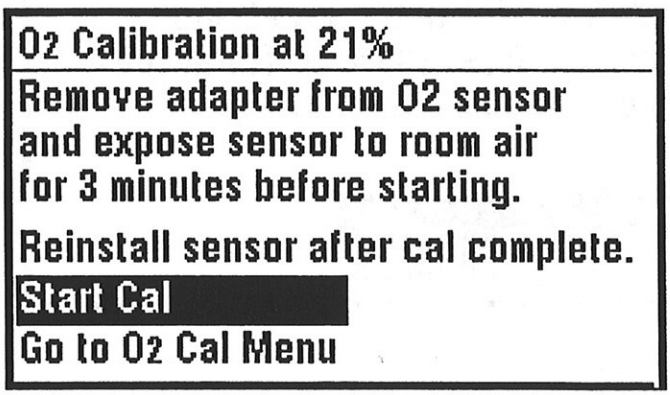


Figure 6-3
O_2 Sensor Cal 21% Instruction menu

- Complete or Failed displays adjacent to Start Cal on right.
- Failed - system defaults to Start Cal one more time.
- Rerun Cal check.
- If Fail displays again , replace O_2 sensor.
- When the O_2 calibration at 21% is successfully completed 100% calibration may be initiated

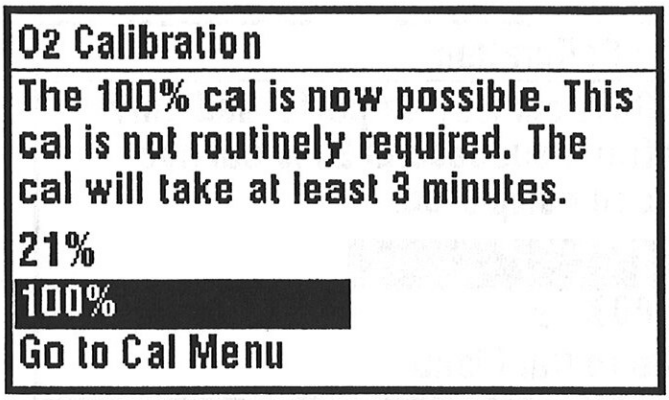


Figure 6-4
Select 100% Calibration

O_2 Cal Instruction Menu, 100%

- Check Cal at 100% monthly.
- Confirming 100% displays a menu with instructions on calibration.
- Push knob to start calibration.
- Calibrating displays adjacent to Start Cal.

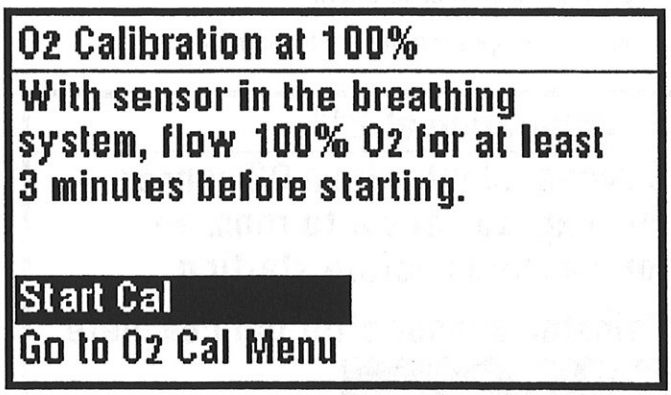


Figure 6-5
O_2 sensor calibration at 100%

Water condensation on the oxygen cell's sensor membrane will interfere with the proper operation of the oxygen monitor. The indicated oxygen concentration in the patient gases will be less than the actual patient gas oxygen concentration due to the increased partial pressure of water vapor at the sensing membrane.

Calibration Check is Complete

- Complete or Fail displays adjacent to Start Cal on right.
- Failed - system defaults to Start Cal one more time.
- Rerun Cal check.
- If Fail again displays, replace O_2 sensor.

Calibrating the Flow Sensors

Calibrate Flow Sensors weekly. Check that each sensor is satisfactorily connected into the interface panel of the anesthesia machine.

Note: When the flow sensors are mounted on the breathing circuit ports, the tubes leaving the flow sensors must be vertical (point straight up). This prevents water that may condense in the flow transducers from flowing into the sensor tubes leading to the anesthesia machine. Any water trapped inside the small sensor tubes will cause erroneous flow and airway pressure measurements. Make certain the flow sensor dual tubes are clear and are not kinked. Check the sensors for cracks and other unusual appearance – if suspect, replace.

Note: Low flow anesthesia techniques tend to cause increased accumulation of moisture in the breathing circuit. This often shows up as a more rapid increase in fogging of the check valve domes and flow transducers, sometimes to a point of water droplets collecting. To minimize this condition, drain the breathing circuit every day. (A good way to drain the GMS Absorber is to open the drain port and press the O_2 flush button for a few seconds after each case, or at least at the end of each day.

Flow Sensors Cal Menu select

- Turn the knob to choose Flow Sensors Cal
- Menu displays Calibration and Operational Test
- Turn the knob to select one or the other, push to confirm selection.
- Flow sensors flow calibration is chosen.

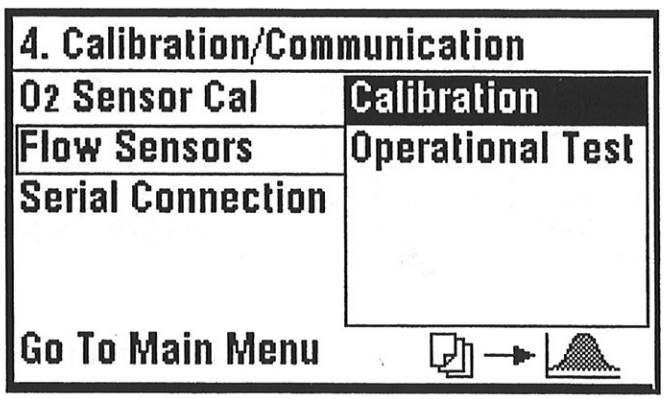


Figure 6-6
Choose Flow Sensors Calibration

Flow Sensor Calibration Instruction Menu

- Flow Sensors Calibration Instruction menu displays.
- Disconnect flow sensors from patient interface before starting
- Start Cal is selected when menu is selected.
- Push knob to start calibration.
- Calibrating displays adjacent to Start Cal on the right.

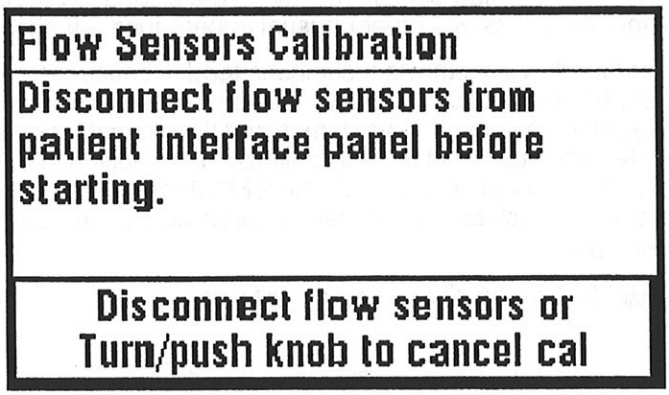


Figure 6-7
Before Calibration - disconnect flow sensors menu

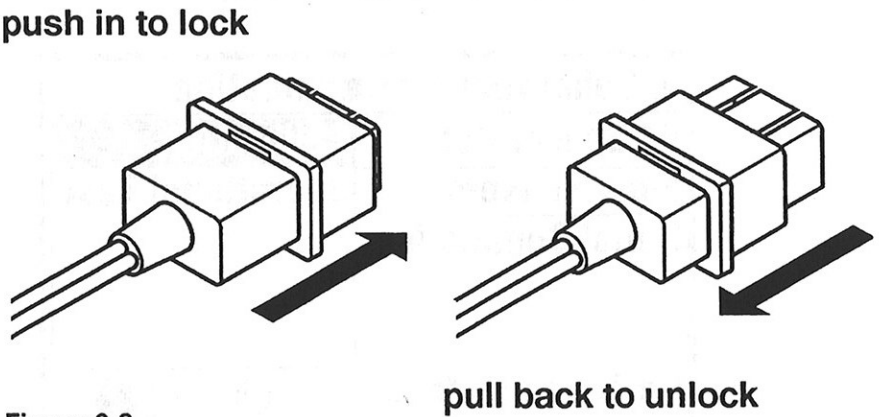


Figure 6-8
Disconnect Flow Sensors, Lock Release

Disconnect - Grip the lock collar around the sensor connector and slide it back toward the tubes. Continue to grip the collar and disconnect the sensor.

Connect - Make sure the lock collar is pushed back toward tubes as far as it will go. Insert the connector into the indexed interface panel socket. Slide the lock collar forward toward the panel as far as it will go and lock the connection securely.

Flow Sensor Calibration Check is Complete

- Complete or Fail displays adjacent to Start Cal.
- If the attempt to calibrate fails twice, the message indicates a pressure transducer zero is out of range and a service call is required.

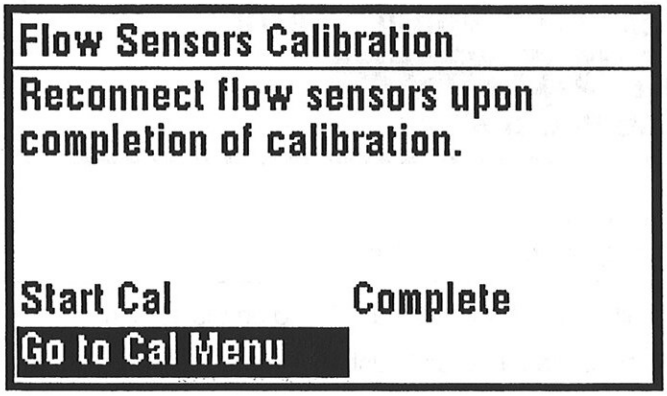


Figure 6-9
Calibration completed

Flow Sensor Operational Test

Choosing Flow Sensor Operational Test brings up the following display with instructions. The Operational Test ensures that the sensors are properly sensing the flow in the patient circuit.

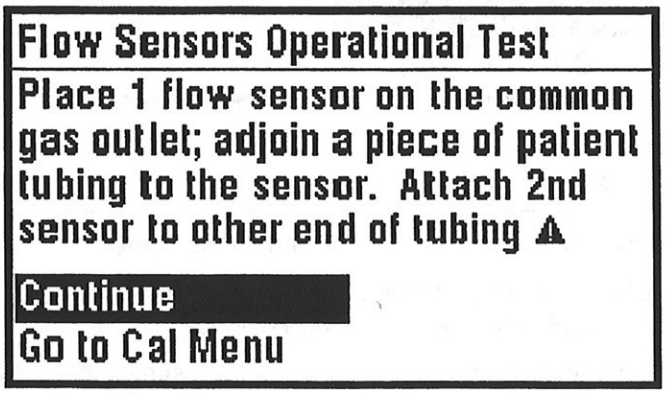


Figure 6-10
Begin Flow Sensor Operational Test

- Follow the instructions displayed on the screen
- Upon completing the instructions, select Continue and push the knob to confirm. The following display appears.

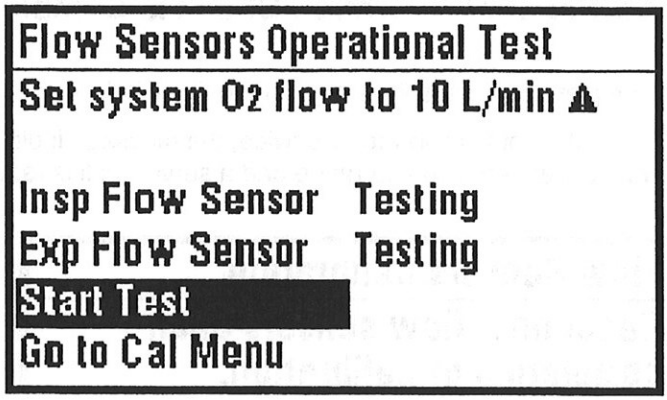


Figure 6-11
Start Operational Test, Phase 1

- Follow the instructions displayed on the screen
- Select Start Test and push knob to confirm
- The sensors are now undergoing a software operating test.

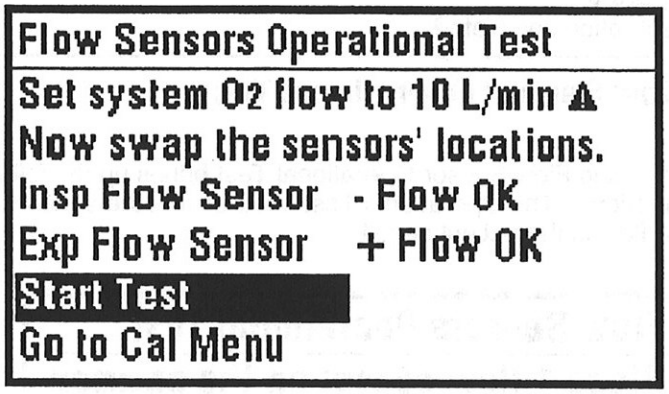


Figure 6-12
Start Operational Test, Phase 2

- Follow the instructions displayed on the screen
- Display will indicate the status of the inspiratory flow sensor as -Flow OK and Expiratory flow sensor as +Flow OK.

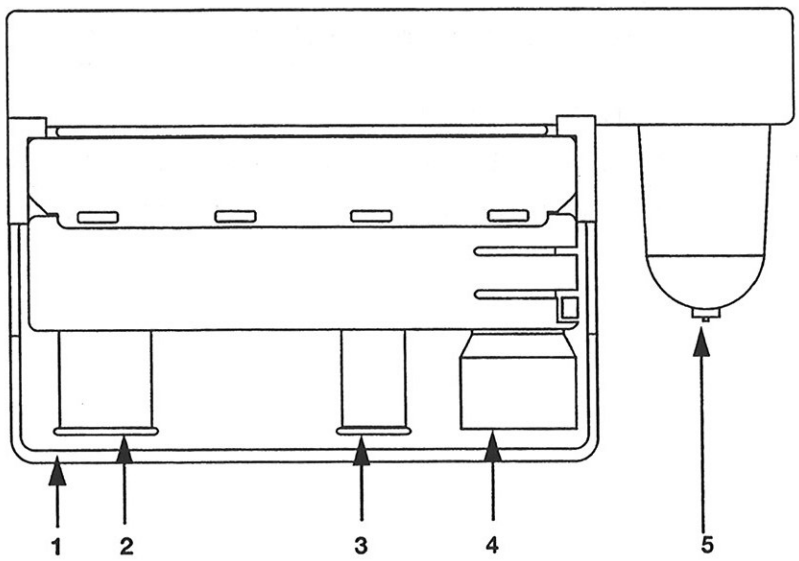
Note: The display shown in Figure 6-12 assumes that the expiratory flow sensor is connected to the common gas outlet and the inspiratory flow sensor is connected to the tubing outlet.

- Change the sensor locations and repeat Operational Test, Phase 1.

WARNING ⚠ **Always carry out the system preoperative checkout procedures before putting the system in use. Failure to make sure of correct assembly, setup and operation before use can result in injury to the patient.**

Exhalation Valve Block, Disassembly and Removal

WARNING: ⚠ **When removing the hose assembly from the exhalation valve block, grasp the cuff or end-caps at the end of the hose, not the hoses. Do not pull on the drive gas hoses, the retention force is large and the hoses will be damaged. Do not apply force directly downward as the hoses can release suddenly possibly causing damage to the valve block or injury to the operator. To remove the hoses, grasp the cuff and apply a careful, light twisting or rocking movement while applying light downward pressure.**



1. **Lock bar in locked position**
2. **25 mm port, dual tube drive gas**
3. **17 mm port, dual tube return gas**
4. **30 mm port, waste gas exhaust. U.S. domestic needs 30/19 mm adapter**
5. **Bowl drain valve, push stem to drain**

Figure 6-13
Valve block, lock bar locked

Valve Block Removal

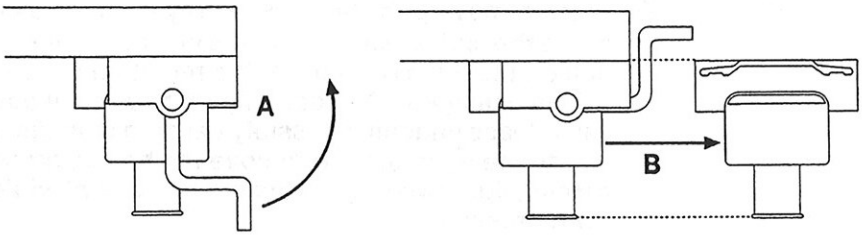


Figure 6-14
To remove the valve block for cleaning and/or replacement

1. Lift the lock bar A.
2. The valve block drops and tension is released.
3. Hold the valve block with both hands on either side and pull straight out B.

Disassembly for Cleaning

The exhalation valve block is autoclavable while assembled, but, to correctly clean and make sure all surfaces are sterilized you must disassemble the unit. See Cleaning and Sterilization.

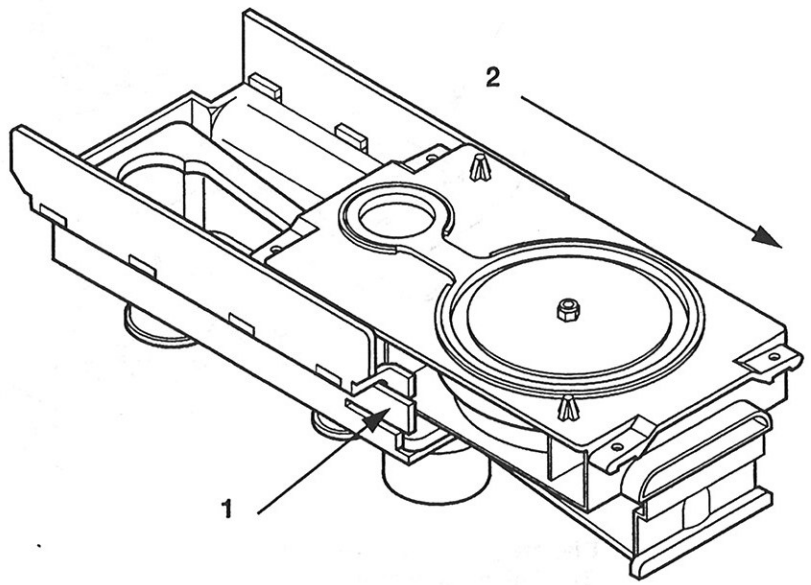
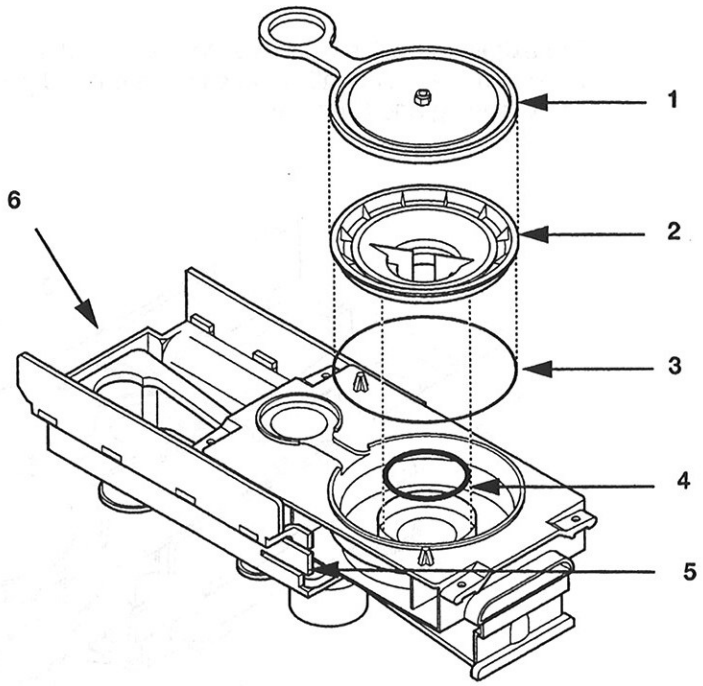


Figure 6-15
Valve block disassembly

See Figure 6-15

1. Remove the diaphragm/gasket assembly.
2. Hold the exhalation valve block in your hands, one on each side with tabs pointed away from you.
3. Use your index fingers to gently pry out the tabs (1) on each side.
4. Use your thumbs to slide the top portion of the valve body (2) away from you.



1. **Diaphragm/gasket assembly**
2. **Exhalation valve seat**
3. **O-ring, large. On reassembly, visually check that the O-ring does not show around the edges of the valve seat.**
4. **O-ring, small**
5. **Lock tabs, one on each side**
6. **Gasket**

Figure 6-16
To remove the valve block O-rings

Disassembly

1. Remove the diaphragm gasket assembly by simply lifting it off.
2. Grasp the inside cross piece of the valve seat and lift it out. There is a large O-ring captive on the seat, item 3.
3. Remove O-rings, items 3 and 4. Replace in accordance with maintenance schedule.
4. Remove the gasket, item 6, inspect and replace as necessary.
5. On reassembly, ensure that O-ring, item 3, is properly seated in its groove.

Supply Gas Inlet Filter

WARNING: ⚠ **Turn off the supply gas and make sure the system is relieved of pressure before draining the sediment bowl. Material in the bowl relieved with pressure applied could cause injury.**

This 5 micron filter has a manual drain like the valve stem of an automobile tire. Drain as liquid and sediment collect in the bowl. Use a blunt object, push up on the plunger.

See Appendix C for illustrated parts and maintenance kits.

Replace every year or more frequent as the white element discolors or if gas flow seems too slow.

Autoclavable Bellows Assembly (ABA)

WARNING: ⚠ **Only a person who has read this section of this manual and clearly understands the text should undertake disassembly, assembly, cleaning and sterilization of the ABA. Failure to be totally knowledgeable with the disassembly and assembly of the ABA can result in equipment malfunction and injury to the patient.**

⚠ **Always carry out the system preoperative checkout procedures before putting the system in use. Failure to make sure of correct assembly, setup and operation before use can result in injury to the patient.**

Disassembly

This unit is not sterile as it is shipped from the factory.

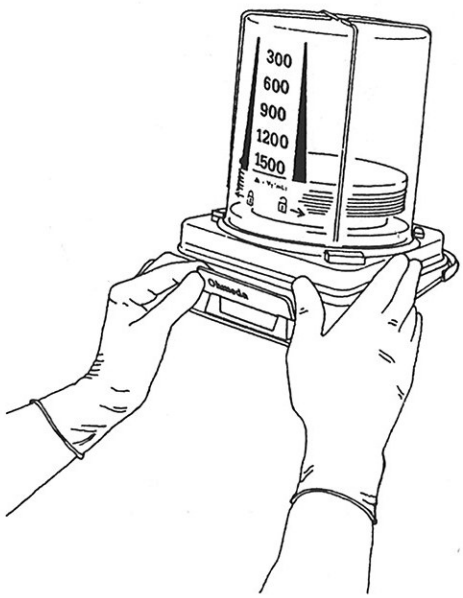


Figure 6-17
Push lever, remove ABA.

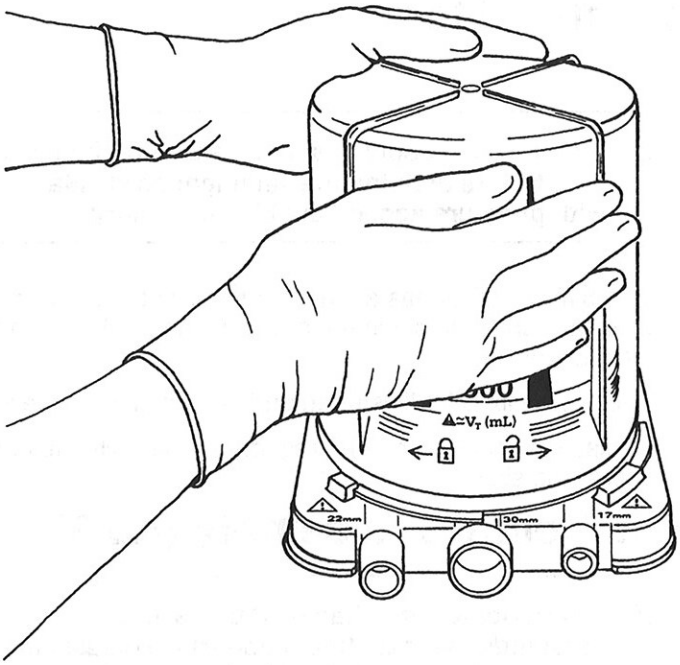


Figure 6-18

Turn housing counter-clockwise, lift to release, 🔓 , Unlock

On reassembly, make sure the housing tabs are locked on the bottom.

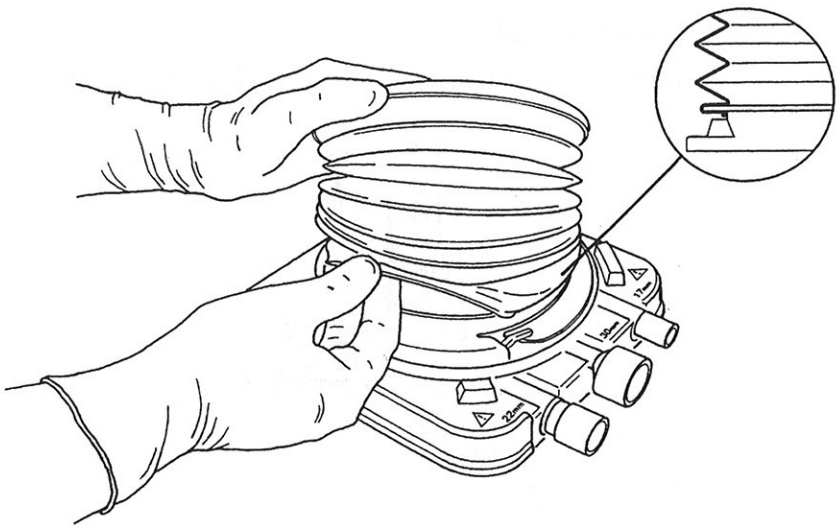


Figure 6-19
Remove bottom convolution of bellows from rim.

On reassembly,

- pull up on the bellows until only one convolution is beneath the rim
- make sure the inner ring is correctly installed in disk groove

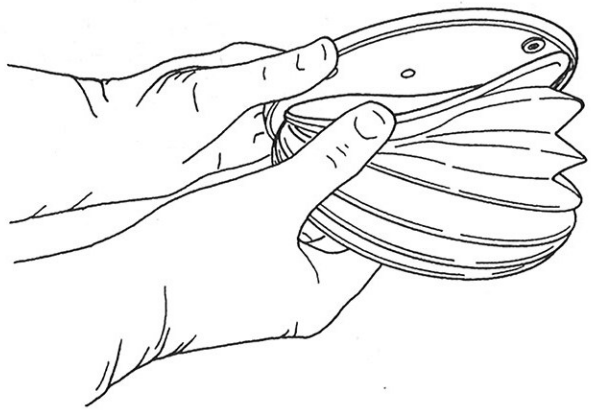


Figure 6-20
Remove disk from bellows.

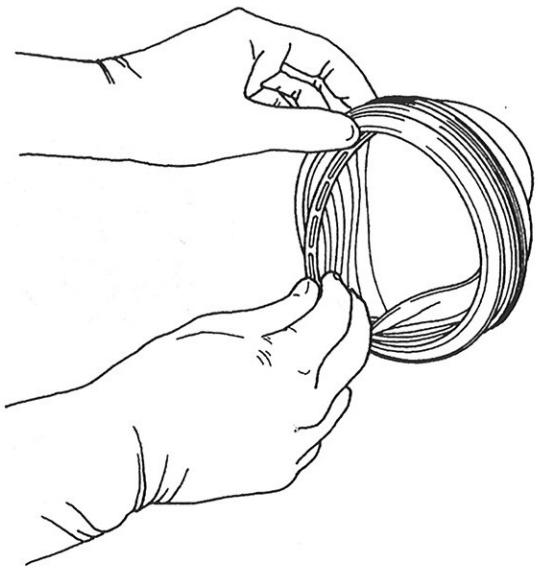


Figure 6-21
Remove inner ring from the top convolution.

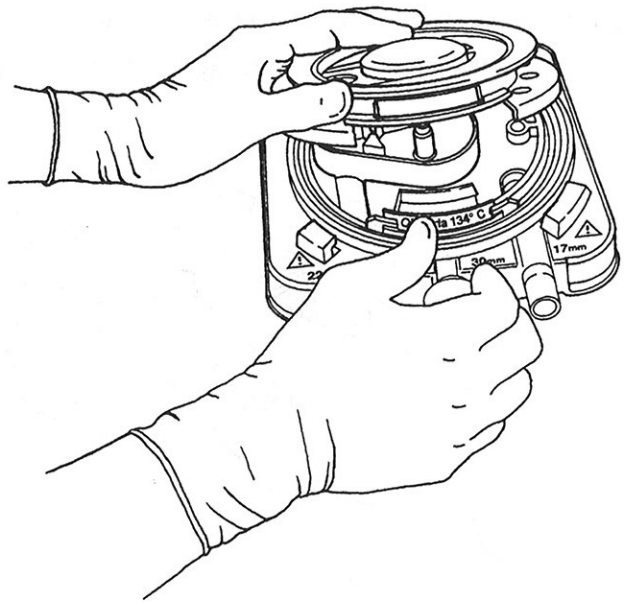


Figure 6-22
Push latch toward center, remove rim.

On reassembly a "click/click" sounds, pull up on edge to make sure of a correct lock.

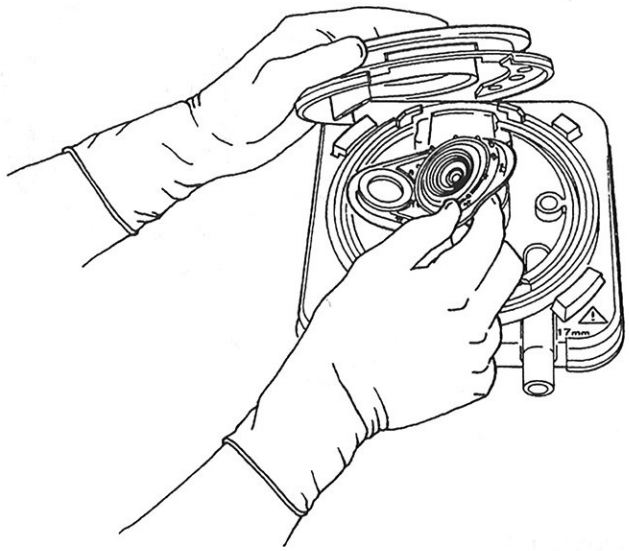


Figure 6-23
Remove pressure relief valve diaphragm and seat assembly. Be careful with the valve seats.

WARNING: ⚠ **Do not remove Autoclavable Bellows Assembly seat from diaphragm of the pressure relief valve. This can distort the seat or diaphragm and cause injury to the patient.**

Assemble diaphragm to bottom with arrows pointed up ⇑ .

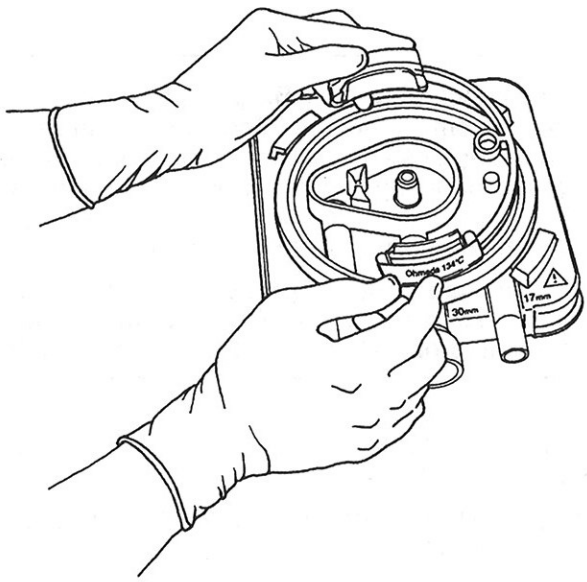


Figure 6-24
Push latch tabs toward center, lift off.

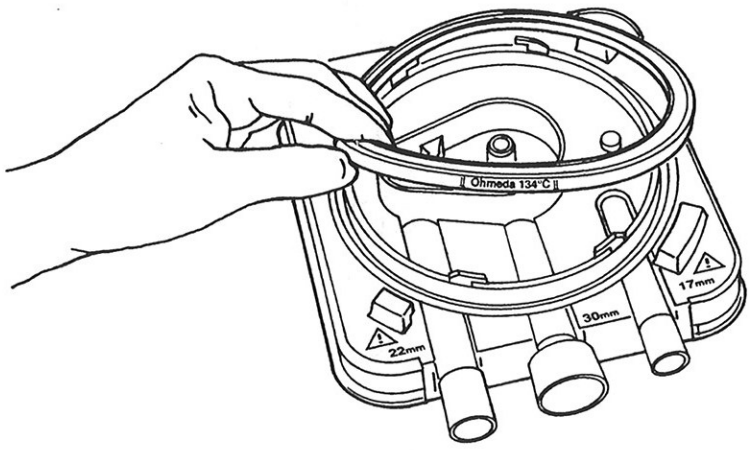


Figure 6-25
Remove seal.

Assemble to bottom with arrows pointed up ⇑ .

Assemble in opposite order

On reassembly, if the bellows shows signs of wear or touching the housing, apply a thin layer of KRYTOX lubricant to the ribs of the bellows housing. Wear or touching the housing is shown by a dust-like power on the housing and/or bellows.

Make sure the lubricant is applied smooth and there are no lumps.

Post Assembly Test

WARNINGS:

⚠ **When occluding the ABA ports for doing a test do not use objects that are small and can slide fully into the system. Objects in the breathing system can stop or disrupt the supply of breathing-system gases, possibly cause injury to the patient. Before putting the breathing system in use on a patient, always check the breathing system components for obstructions.**

⚠ **Always carry out the preoperative checkout procedures before putting the system in use. Failure to make sure of correct assembly, setup and operation before use can result in injury to the patient.**

This post assembly test is a quick check to make sure all components are correctly reassembled —

IT IS NOT AN ALTERNATIVE FOR A SYSTEM PREOPERATIVE CHECK-OUT PROCEDURE.

If the ABA successfully passes its post assembly test requirements, remount it in the system.

If it does not, disassemble it to make sure reassembly was correct, examine and replace any damaged parts.

See Appendix C for illustrated Parts List for part numbers.

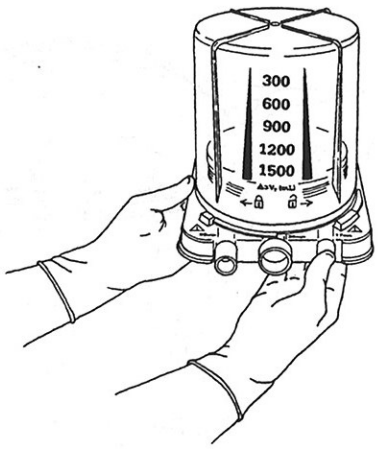


Figure 6-26
Hold ABA vertical — Occlude 17-mm port.

Figure 6-27
Invert the ABA. Bellows must not fall more than 100 mL/min.

If it does;

- 17-mm port is not satisfactorily occluded,
- bellows is incorrectly installed,
- seal is not correctly installed with the groove up,
- other parts can be damaged.

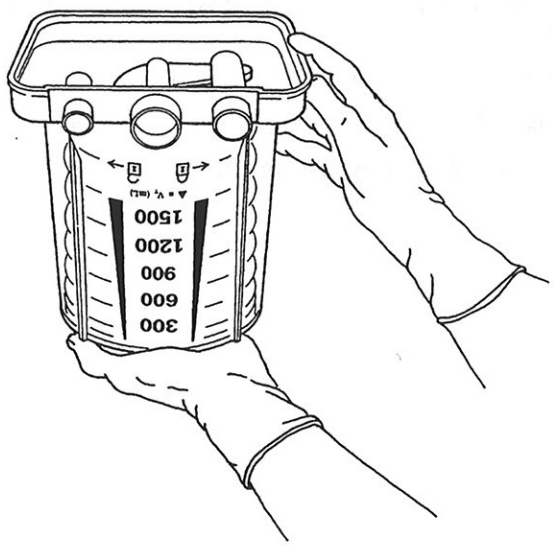


Figure 6-28
Remove occlusion from the 17-mm port

- permit bellows to fully extend
- occlude 22-mm port.

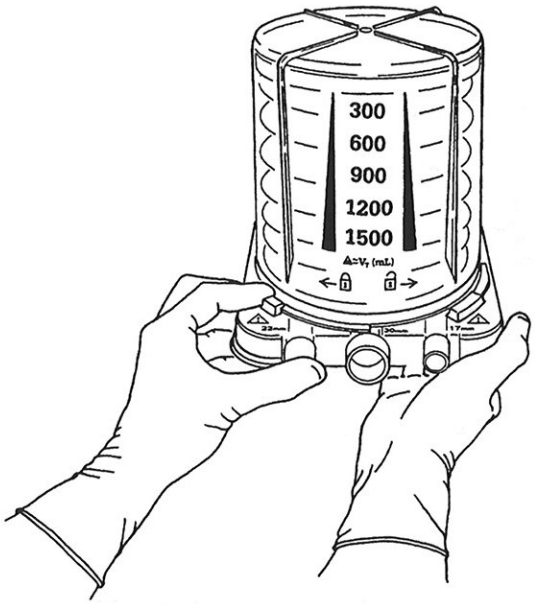


Figure 6-29
Put the ABA back to vertical

- bellows must not fall more than 100 mL/min.

If it does;

- bellows or pressure relief valve not correctly installed,
- other parts can be damaged.

If the ABA successfully passes its post assembly test requirements, remount it in the system.

See the gas machine Operation and Maintenance Manual.

- Make Ventilator/Bellows Assembly and breathing system connections.
- Before use, carry out preoperative checkout procedures.

Cleaning and sterilizing

Use the cleaning and sterilization schedule that is compatible with your institution's infection control and risk management policies.

Use procedures that are recommended and approved by the manufacturer of the washer and sterilizer.

Refer to this chart for cleaning and sterilization of the system. Use a cleaning and sterilization schedule that your institution's sterilization and risk-management policies suggest.

Item	To clean	To sterilize
Control module	rub with neutral detergent and rinse	n/a
Bellows assembly	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Flow sensors	n/a Disposable	n/a Disposable
Exhalation valve block	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Oxygen sensor	rub with neutral detergent (Ph 7 to 10.5) and rinse	n/a for cell
Oxygen sensor adapter	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Clear plastic areas	water dampened cloth	n/a
Dual hose and manifold	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
GMS interface manifold	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
MAS interface manifold	rub with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable

Replace damaged parts with components made or sold by Ohmeda.

Test the unit after disassembly and/or parts replacement;

- conduct a Post Assembly test on ABA,
- conduct a preoperative checkout in system.

Cleaning the control module

Clean the external surfaces of the control module with a soft, lint-free cloth made moist in a solution of neutral liquid detergent, Ph 7 to 10.5, and rub with a clean water dampened cloth.

CAUTIONS:

⚠ Use cleaning solution sparingly. Do not soak system components, too much solution can damage internal devices.

⚠ Do not put on covers of fabric or plastic to keep dust off the system. They can cause static charges that can damage the equipment.

Cleaning

1. Disassemble

WARNING: ⚠ **Do not remove Autoclavable Bellows Assembly seat from diaphragm of the pressure relief valve. This can distort the seat or diaphragm and cause injury to the patient.**

2. Gently hand clean or machine spray clean components in hot water.
- Use a neutral detergent recommended for rubber and plastic.
- Use of enzyme disinfectant/sterilants are not recommended.
3. Flush components with clean hot water - fully dry them.

CAUTIONS: ⚠ Do not submerse rubber goods for more than 15 minutes — swelling or faster aging could occur.

⚠ Do not permit the bellows to dry with the convolutions deflated, hang it up to dry with the convolutions extended by gravitational force. The bellows can not operate properly if the convolutions are bonded together.

4. After the parts are fully dry;
- examine them for damage,
- reassemble,
- perform the post assembly test on the ABA.
5. Connect the ABA to the ventilator and breathing system.
6. Perform the system preoperative checkout procedure.

Sterilization

Steam autoclaving is the only recommended procedure of sterilizing the Ohmeda Autoclavable Bellows Assembly, ventilator exhalation valve block, dual drive gas hose, and the absorber interface manifolds.

CAUTION: ⚠ Only parts identified with 134°C markings are autoclavable. Many parts that are not autoclavable are identified with the symbol  .

Autoclaving

The ABA and the ventilator exhalation valve may be autoclaved assembled or disassembled. However, the recommended procedure is to disassemble.

Assembled

- use a pre-vacuum cycle for 3 minutes at 132°C (238°F)

Disassembled

- use a pre-vacuum cycle for 3 minutes at 132°C (238°F)
- also may use a gravity displacement cycle 3 minutes at 132°C (238°F)

After the parts are sterilized

- examine them for damage,
- reassemble.
- It is usual for the bellows and other rubber goods to change color from steam autoclaving.
- Perform the post assembly test.

See applicable Gas Machine O&M Manual

- Connect the bellows assembly to the ventilator and breathing system,
- perform the system preoperative checkout procedure.

Periodic Maintenance

WARNING: ⚠ **Do not carry out a test procedure or maintenance on medical devices while they are being used on a patient. Possible injury could result.**

Frequent disassembly, cleaning and sterilization will decrease the useful life of components. All components in the ABA, ventilator exhalation valve, dual drive gas hose and absorber manifolds are user serviceable and expendable parts. Carry out visual examinations and leak checks after disassembly and reassembly or each 30 days. See appendix C for descriptions and part numbers.

Visual examination

- Disconnect the ABA from the anesthesia machine.
- Disassemble the ABA per Disassembly section.

WARNING: ⚠ **Do not remove Autoclavable Bellows Assembly seat from diaphragm of the pressure relief valve. This can distort the seat or diaphragm and cause injury to the patient.**

- carefully examine each component for deterioration or damage;
  - cracks
  - warping
  - tackiness
  - swelling or other physical changes
  - replace parts as required
- assemble and carry out the Post Assembly Leak Test.

Leak Test the Ventilator Drive Circuit

After ventilator manifold disassembly or removal from the ventilator , carry out this leak test.

Make sure that;

- anesthesia system is setup,
- system preoperative checkout is complete and the system is ready for use,
- system patient circuit leak check has been completed as explained in the Anesthesia System Operation and Maintenance Manual, section 4,
- O_2 cylinder is connected and the cylinder valve is open,
- anesthesia machine power is applied.

1. Turn all flow control valves off or to minimum flow.
2. Turn the breathing system's Bag/APL-ventilator switch to the ventilator position.
3. Occlude the patient circuit—at the WYE connector.

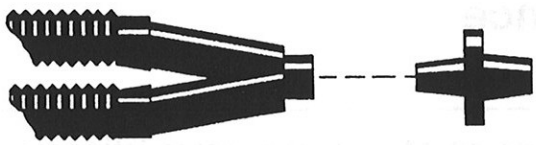


Figure 6-30
Occluding the breathing system at the "Y" connector with test plug
Stk. No. 2900-0001-000

WARNING: ⚠ **When occluding the breathing system for a test function, do not use objects that are small and can slide fully into the system. Objects in the breathing system can stop or disrupt the supply of breathing-system gases possibly causing injury to the patient. Before putting the breathing system in use on a patient, always check the breathing system components for unwanted objects.**

4. Remove the AGSR (Anesthesia Gas Scavenging Receiver) hose at the AGSR valve inlet port from the ventilator.
5. Turn off other devices in the circuit that can leak in this mode at a pressure of greater than 15 cm H_2O. Consult your breathing system operator's manual.
6. Set the O_2 flow control valve to a flow of 10 L/min.
7. Occlude the scavenging hose removed in step 4.
8. Observe the pressure rise on the circuit manometer located on the GMS Absorber. Ensure that the pressure levels off at a pressure level below 45 cm H_2O as the relief valve opens. You should be able to hear an audible hiss.
9. Reduce the fresh gas flow to 300 mL/min. and observe the pressure fall on the patient circuit manometer. Ensure that the pressure levels off at a level above 15 cm H_2O.

10. If the system does not successfully complete the leak test and leak(s) cannot be corrected, do not use the ventilator. Have a trained service person make repairs.
11. Remove occlusions added to the circuit.

WARNING: ⚠ **Make sure all hoses, tubing and other circuit connections are made correctly before putting the anesthesia system in use. Failure to comply can result in patient injury. Refer to the operation manuals for these devices.**

Notes

Appendix A - Ventilator Alarms

Description of Breathing Circuit Integrity Checks

The 7900 ventilator's volume apnea alarm uses the inspiratory and expiratory flow sensors to determine if breathing circuit gas is being lost from the patient circuit. The gas volume loss threshold varies depending on circuit and flow sensor configurations. When using a standard circle system with the inspiratory and expiratory flow sensors located at the absorber, at least 50% of the inspired gas volume delivered during a mechanical breath must exhaust through the expiratory flow sensor or the Volume Apnea Alarm conditions will be met. When an (optional) proximal expiratory volume sensor is used, at least 65% of inspired volume must pass through the sensor during exhalation to prevent the alarm condition. In any configuration, if a breath exceeding 10 mL tidal volume is not sensed, the Volume Apnea Alarm conditions will be met. Volume apnea conditions exceeding the alarm threshold must be continuously present for 30 seconds in order for the alarm to sound. The alarm condition will be cleared if an acceptable breath is detected.

The 7900 ventilator's Low Airway Pressure Alarm is complementary to the Tidal Volume Apnea Alarm. A Low Airway Pressure Alarm occurs if the peak airway pressure, associated with a mechanical breath, is not greater than 4 cm H_2O above the minimum airway pressure observed for the breath. Conditions that exceed the alarm threshold must be continuously present for 20 seconds in order for the alarm to sound. Once activated, a single mechanical breath observed to exceed the 4 cm H_2O threshold will clear the alarm.

In addition to the Volume Apnea and Low Airway Pressure Alarms, other ventilator alarms are included to indicate potential hazard conditions. All alarms that occur should be investigated to ensure adequate patient safety.

Ventilation Patient/Operator Alarms

(See Table notes following the table)

These alarms are those that will most frequently be displayed during a clinical case. Operator action must be taken to ensure the patient is not in distress and to clear the cause of the alarm.

*** Alarms indicated thus can usually be corrected without calling a service person**

Message	Alarm	Condition	Operator action	Priority
High Paw	High airway pressure	Airway pressure greater than Plimit	Check patient E.T. location	High
High O_2	High O_2	O_2 greater than high limit	Check fresh gas flow Check Alarm limit settings	High

Appendix A - Ventilator Alarms

Message	Alarm	Condition	Operator action	Priority
High V_E	High exhaled minute volume	V_E greater than high limit	Check patient for spontaneous breathing. Check ventilator and alarm settings	Medium
High V_{TE}	High exhaled tidal volume	V_{TE} greater than high limit	Check patient for spontaneous breathing. Check ventilator and alarm settings	Medium
Low O_2	Low O_2	O_2 less than low limit	Check fresh gas flow Check Alarm limit settings	High
Low Paw	Low airway pressure	Peak airway pressure less than threshold for greater than 20 seconds	Check tubing connections Check patient connection	High
Low V_E	Low exhaled minute volume	V_E less than low limit	Check patient condition Check tubing connections Check alarm settings	High
Low V_{TE}	Low exhaled tidal volume	V_{TE} less than low limit	Check patient condition Check tubing connections Check ventilator and alarm settings	Medium
* No O_2 pressure	Anesthesia system O2 supply pressure	Status line indicates no pressure on start up	Check the system for O_2 supply failure	Tech/High
Sub-Atmos Paw	Sub-atmospheric airway pressure	Airway pressure less than -10 cm H_2O	Check fresh gas flow Check patient condition Check gas evacuator	High
Sustained Paw Minimum System Shutdown[3]	Sustained airway pressure	Airway pressure-greater than or equal to sustained limit for 15 seconds Airway pressure >100 cm H_2O for 10 seconds	Check tubing for kinks, blockage or disconnects	High High[1]

Message	Alarm	Condition	Operator action	Priority
Volume Apnea	Tidal volume apnea	No measured breaths in the last 30 seconds	Check patient. Bag as needed. Check for disconnects	High
Volume Apnea >2 min[2]	Tidal volume apnea	No breaths detected in the last 2 min. or more	Check patient. Bag as needed. Check for disconnects	High

Table Notes:

† Alarm Tones

High priority alarms have two distinctive 5 pulse bursts to indicate the alarm is a high priority. The burst/pulses are three with a pause followed by two more pulses, repeating until silenced or condition is corrected.

Medium priority alarms have a distinctive 3 pulse burst to indicate the alarm is a medium priority. The pulses repeat until silenced or condition is corrected.

1. These alarms are **PERMANENTLY** silenced after the user acknowledges the alarm by pressing the alarm silence switch.
2. This alarm message does not have an elapse time indication.
3. Ventilator internal software will attempt to reset the processor after a "shutdown", message has been displayed for 10 seconds.

Technical System Alarms

The following listed alarms may occasionally be seen by the operator. These alarms may be transient in nature due to conditions during normal operation and can clear after several breaths without operator intervention.

(See Table notes following the tables)

TABLE 1

* Alarms indicated thus can usually be corrected without calling a service person

Message †	Alarm	Condition	Operator Action	Priority
Insp Overshoot[1]	Pinspired overshoot	PAW is greater than Pinspired threshold		Tech
Inspiratory Overshoot - This alarm is active only in the pressure control mode during mechanical ventilation. If PAW is greater than Pinspired by 3 cm H_2O or 10% (which ever is greater) the alarm sounds. The associated window message is "Possible Cause of Pressure Overshoot is High Gas Flow".				
* Pinspired not achieved	Set Pressure Not Achieved	Pmax does not reach a Pinspired threshold	User may still have control of actual Pinspired (Conditions or combination of settings may prevent ventilator from achieving desired settings)	Tech
Pinspired Not Achieved - In the Pressure Ventilation Mode, under some circumstances, the ventilator may not get to the preset pressure in the inspiratory time allotted. This results in an alarm. It is still possible to ventilate the patient but the operator must rely on the monitored pressure, as displayed on the airway pressure waveform, to adjust the inspiratory pressure.				
* PEEP Not Achieved	PEEP not achieved	Pmin - PEEP is not within a specific window	Check tubing connections. Rate and/or I:E Ratio may prevent ventilator from reaching desired PEEP level	Tech
PEEP Not Achieved - When a set PEEP (PEEP) level is not attainable during the expiratory time allotted, the operator is alerted by this alarm. A new PEEP may be selected to correct for these conditions. Breathing circuit or Endotracheal tube leakage or fast breath rates and short expiratory times may cause this alarm. It is possible to ventilate the patient, but the operator must use the monitored pressure, displayed on the airway pressure waveform, to adjust PEEP.				

Message †	Alarm	Condition	Operator Action	Priority
* V_T Not Achieved	Undershoot of tidal volume	V_{TI} less than V_T threshold	Preset tidal volume not achieved Operator may still influence tidal volume with settings	Tech
Undershoot of Tidal Volume - An alarm occurs when the preset tidal volume has not been delivered. This is typically caused by the ventilator reaching its maximum flow delivery state. The operator should rely on exhaled tidal volume measurements, end tidal CO_2 and/or clinical signs to determine if ventilation is o. k. This alarm is not triggered until 6 mechanical breaths in a row satisfy the alarm condition.				

Table Notes:

† Alarm Tones

Technical alarms have a distinctive 1 pulse burst to indicate the alarm is technical priority, repeating until silenced or condition is corrected.

TABLE 2

* Alarms indicated thus can usually be corrected without calling a service person

Message †	Alarm	Condition	Operator Action	Priority
Apnea Alarm Silenced	Apnea audio disabled	User selected disabled from menu	Operator must be aware that apnea alarms will not sound	Tech
Bag Mode Detected Verify the Bag/ventilation switch position	Bag/Vent switch set to Bag Mode during mechanical ventilation	Airway press. is in excess of manifold press. during a period of inspiration	Bag/Vent switch in proper position	Tech
* Check O_2 sensor	O_2 sensor	O_2 less than threshold	Try calibrating O_2 sensor	Tech
* Circuit Auxiliary	Auxiliary circuit	Use of auxiliary circuit in DCGO	Check dual common gas outlet Check that auxiliary circuit is in use	Tech
Heliox Mode is ON	Heliox Mode selected	Heliox Mode selected	Select only if using Heliox gas	Tech
* Insp flow sensor Failure Exp flow sensor Failure	Flow sensor EEPROM failure	EEPROM cal data read failure (using default cal data	Replace bad flow sensor	Tech
* Insp. V_T/V_{TE} Mismatch System Leak Heliox	Flow sensors output	V_{TE} greater than V_{TI} Threshold Vdelivered V greater than V_{TI} threshold	Check patient condition Check tubing for leakage Check the flow sensor Try replacing the flow sensor	Tech
No Insp Flow Sensor No Exp Flow Sensor Inspiratory Reverse Flow Expiratory Reverse Flow Check Flow Sensors	Flow sensors configuration	No inspiratory flow sensor connected No expiratory flow sensor connected Negative flow on inspiratory flow sensor during inspiration Negative flow on expiratory flow sensor Incorrect connection, 0 flow on Insp sensor during inspiration, or 0 flow on Exp	Examine check valves Check transducer locations and tubing connections Check breathing circuit configuration	Tech

Appendix A - Ventilator Alarms

Message †	Alarm	Condition	Operator Action	Priority
Maximum (Minimum) value has been reached	Control setting error	Ventilation controls out-of-range	Change other parameters to expand the range	n/a
O_2 calibration error	O_2 calibration	Offset, slope or cell voltage not in range O_2 greater than 110%	Try calibrating O_2 sensor	Tech
* On Battery	Main electrical power	Status line indicates "on battery", or battery current test greater than 300 mA	Check system power cord Be aware of a 30 min. max. of batt. operation	Tech
Press knob to confirm change	Unconfirmed control settings	No confirmation of changed setting	Press adjustment wheel to confirm settings or change settings and then confirm	Medium
*12 hour test	12 hour test	12 continuous hours since last OFF state test	Cycle system power ON and OFF	Tech
An alarm message shall be displayed after 12 continuous hours of operation to tell the clinician that a power cycle is needed to test (both on AND off states of) the gas inlet valve.				
* Sans Gas Frais	No fresh gas flow	Patient breathing in DCGO	Operator has attempted to turn on the ventilator with the dual common gas outlet in the auxiliary position	Medium
Sensor(s) Cal Due	Cal data failure in EEPROM	Default cal data is being used	Operator must recalibrate the flow sensors	Tech
* Unable to drive Bellows	Collapsed bellows or bag/ vent switch in bag position	Manifold pressure greater than airway pressure plus threshold	Check fresh gas flow Check and restore breathing circuit volume, breath cannot be delivered until bellows volume is restored. Check position of bag/vent switch on breathing circuit	Tech

Message †	Alarm	Condition	Operator Action	Priority
Verify Low V_E Limit	Verify low V_E Alarm Limit	apnea audio disabled and low V_E limit <50% of measured V_E	Reset low V_E Alarm Limit	Tech
Volume Compensation Off	V_T Compensation Off	Insp V_T/V_{TE} mismatch alarm	Correct Insp V_TV_{TE} mismatch alarm (see above). Reselect Volume Pressure Mode	Medium

Table Notes:

† Alarm Tones

Technical alarms have a distinctive 1 pulse burst to indicate the alarm is technical priority. The pulse is a single burst, repeating until silenced or condition is corrected.

TABLE 3

Message †	Alarm	Condition	Operator Action	Priority
A/D Converter Failure Minimum System Shutdown	ADC	ADC time out	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Bootup Memory Failure Minimum System Shutdown	Bootup memory [1]	Bootup memory CRC failure	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Control setting input has failed Minimum system monitoring[1]	Control settings change failure	Internal software error has occurred in a control setting change initiated by the user	Monitoring still available, but bag the patient	Tech
CPU Failure Minimum System Shutdown	CPU	ALU, register,. . . test failure	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
CPU Internal Error Minimum System Shutdown	Microcontroller[1]	Internal bus error	Manually bag the patient Monitoring is not functioning or unreliable Service the ventilator	Shutdown
Display Voltage Out-of-Range Minimum System Shutdown	Display supply voltage	Voltage out-of-range	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Flow Valve Failure Minimum System Monitoring	Flow valve	Incorrect feedback	Monitoring is still available, but bag the patient Service the ventilator	Tech
Gas Inlet Valve Circuit Failure Minimum System Monitoring	Gas inlet valve	Incorrect feedback	Monitoring still available, but bag the patient Service the ventilator	Tech

Message †	Alarm	Condition	Operator Action	Priority
Inspiration Stopped	Drive pressure limit switch	Drive gas safety switch engaged	Operating at the edge of control settings envelope may cause this alarm	Tech
High Pressure Limit reached Minimum System Monitoring	Drive pressure limit switch	Switch is engaged and pressure sensors not reading high pressure	Operating at the edge of control settings envelope may cause this alarm Service the ventilator	Tech
Internal Ventilator Clock Too Fast Minimum System Shutdown	System clock too fast[1]	Clock frequency greater than 110% of expected value	Manually bag the patient Monitoring is not functioning or unreliable Service the ventilator	Shutdown
Internal Ventilator Clock Too Slow Minimum System Shutdown	System clock too slow[1]	Clock frequency less than 90% of expected value	Manually bag the patient Monitoring is not functioning or unreliable Service the ventilator	Shutdown
Software Watchdog Failure Minimum System Shutdown	Logical watchdog[1]	Time-out or incorrect code executed	Manually bag the patient Monitoring is not functioning or unreliable Service the ventilator	Shutdown
Memory (EEPROM) Failure	EEPROM	Read/write failure, CRC failure	Default values will be used at power up Can still ventilate the patient, but ventilator needs service	Tech
Memory (flash) Failure Minimum System Shutdown	Flash EPROM[1]	CRC failure	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Memory (RAM) Failure Minimum System Shutdown	External RAM[1]	Walking pattern test failure	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Memory (video) Failure Minimum System Shutdown	Display RAM	Redundant storage test failure	Manually bag patient Monitoring is not functioning or it is unreliable Service the ventilator	Shutdown
Memory (redundant storage) Fail Minimum System Monitoring[1]	System Parameter Fail	Memory failure of system parameters	Ventilator needs service. Switch to Bag Mode, manually bag (ventilate) the patient	Tech

Appendix A - Ventilator Alarms

Message †	Alarm	Condition	Operator Action	Priority
Auxiliary gas outlet	DCGO without French	DCGO switch is in auxiliary position and language is not French	Check switch and language settings	Tech
No Battery	Battery	Battery voltage less than 7 V while running on machine elect power	The battery system is not ready for backup Service ventilator System is unable to run on backup battery	Tech
Low Battery Charge		Voltage less than 12.5V while running on machine elect power	This message should disappear after charging for 12 hours. If not the battery may be defective and need replacement	Tech
Low Battery Minimum System Monitoring[1]		Battery voltage less than 11.35V while running on battery	In the event of mains power failure, operator must switch to BAG on the GMS and manually bag (ventilate) the patient	Tech
System Shutdown Minimum System Shutdown		Battery voltage less than 10.9V while running on battery	Battery must be changed or serviced	Shutdown
V Battery Failure V Battery Failure	Battery Voltage > 16V Battery current > 4 amps	Battery Voltage > 16V Battery current > 4 amps	Service Ventilator. System is unable to run on backup batt.	Tech
+15V manifold Out-of-Range Minimum System Shutdown	+15 V 10 VA test	+ 15V out of range	Service the ventilator. Switch to BAG mode, manually bag (ventilate) patient.	Shutdown
Positive SIB Vref Out-of-Range Minimum System Shutdown	+15 V Sensor interface board test	+15V out of range	Service the ventilator. Switch to BAG mode, manually bag (ventilate) patient.	Shutdown
Manifold pressure sensor failure Minimum system monitoring[1]	Manifold pressure sensor	Drive pressure limit switch engages and manifold pressure is not greater than 80 cm H_2O	Ventilator needs service. Switch to BAG mode, manually bag (ventilate) patient.	Tech

Message †	Alarm	Condition	Operator Action	Priority
Hardware Watchdog Failure Minimum System Shutdown	Sequential watchdog	Time-out or state failure	Manually bag the patient. Monitoring is not functioning or unreliable	Shutdown
Vaux_ref out-of range Minimum system shutdown	V_AUX 5.5V test	+5.5 V out of range	Service the ventilator. Switch to BAG mode, manually bag (ventilate) patient.	Shutdown
Vext_ref out- of-range Minimum system shutdown	V_EXT_REF test	+1.225 V out of range	Service the ventilator. Switch to BAG mode, manually bag (ventilate) patient.	Shutdown
+15V Analog Out-Of-Range -15V Analog Out-Of-Range Minimum System Shutdown	analog supply voltage	status bit turned on by hardware circuitry	Service the ventilator. Switch to BAG mode, manually bag (ventilate) patient	Shutdown

Table Notes:

† Alarm Tones

Technical alarms have a distinctive 1 pulse burst to indicate the alarm is technical priority. The pulse is a single burst, repeating until silenced or condition is corrected.

1. Ventilator internal software will attempt to reset the processor after a "shutdown" message has been displayed for 10 seconds.

Appendix B - Specifications

Environmental Requirements

Temperature

Operation	5 to 40°C, (Oxygen cell operates to specifications at 10 to 40 deg C)
Storage	-40 to 70°C Oxygen cell storage is -(minus) 15 to 50°C, 10 to 95% Rh, 500 to 800 mm Hg

Humidity

Operation	15 to 95 %Rh, non-condensing
Storage	10 to 100% Rh, include condensing

Altitude

Operation	500 to 800 mm Hg (3565 to -440 meters)
Storage	375 to 800 mm Hg (5860 to -440 meters)
Compensation range	-100 to 3,000 meters (525 to 795 mmHg)

Size and Weight (Control Module)

Height	15 cm max.
Width	25 cm max.
Depth	38 cm max.
Weight	15 Kg max.

Electromagnetic Compatibility

Environment

Suitable for use in the EM environment described in EN 60601-1-2

Immunity Levels

The SE 7900 Product Line complies with the requirements of EN 60601-1-2 (Electromagnetic Compatibility - Requirements and tests). The following basic EMC standards were applied to verify conformance.

Emissions

CISPR 11 Group 1 (EN 55011)

Immunity

IEC 801-2, 8 kV air, 3 kV contact
IEC 801-3, 3 V/m
IEC 801-4, 2 kV power line
IEC 801-5, 2 kV line to earth, 1 kV line to line

Appendix B - Specifications

Inputs

Electrical

Power Input	110/120 Va-c ± 10%, 50/60 Hz 220/240 Va-c ± 10%, 50/60 Hz 54.5 Watts
Backup Battery	Internal rechargeable battery capable of supporting 30 minutes of operation
Serial Interface	Isolated RS-232 compatible port
Switch to battery	Unit functions to specifications through the transition to battery power

Pneumatics

Gas Source	Anesthesia System
Gas Composition	Medical Air or O_2
Nominal Supply Pressure	350 kPa (50 psi)
Pressure Range at Inlet	240 to 700 kPa (35 to 100 psi)
Peak Gas Flow	120 L/m @ 240 kPa (35 psi), 0.75 seconds
Continuous Gas Flow	80 L/m @ 240 kPa (35 psi)
Flow valve range	1 to 120 L/min at 35 psig.

Fresh Gas

Flow Compensation Range	200 mL/min. to 15 L/min.
Gas Composition	O_2 , N_2O, N_2 Air, Heliox, CO_2 Anesthetic Agents

Appendix B - Specifications

User Control

User interface software will provide the following input information to the ventilator.

- Ventilation Mode/Standby
- Breathing Rate
- I:E Ratio
- Tidal Volume (if applicable)
- Pressure Level (if applicable)
- Inspiratory Pause (Off - adjustable 5 to 60%)
- PEEP Level
- Alarm Limits
- Alarm Silence

Power cord

Length	1475 ± 50 mm
Voltage rating	125 to 264V a-c at 10A, by country and/or translation
Wattage rating	1250 Watts
Current Carrying Capacity	10A
Leakage current	<10 uA @135V a-c, 60 Hz, by country and/or translation
Type	Three conductor medical grade power supply cord by country and/or translation

Operating Specifications

Pressure

Patient airway pressure range	-20 to +120 cm H_2O +/-2 cm H_2O
High pressure alarm set range	12 to 100 cm H_2O, 1 cm increment
Sustained pressure alarm range	6 to 30 cm H_2O, 1 cm increment
Display range	-20 to 120 cm H_2O

Volume

Tidal volume display range	0 to 9999 mL, 1 mL resolution
Setting range	5 to 1500 mL
Minute volume	0.0 to 99.9 liters, 0.1 liter resolution

Breath rate	0 to 105 bpm (breaths per minute), 1 bpm resolution
Volume sensor type	Variable flow orifice

Oxygen

Display range	0 to 110% O_2
Display resolution	1% increments
Sensor type	Galvanic fuel cel
Measurement range	0 to 100% O_2.
Measurement accuracy	Better than ± 3% of full scale
Cell response time	35 seconds *
Low O_2 alarm range	21% to 100%
High O_2 alarm setting	21% to 100% **Note:** Low O_2 limit may not be set above the high O_2 limit, nor may the high O_2 limit be set below the low O_2 limit.
Expected cell life	Four months of shelf life (23°C room air) and one year of normal operation .

* Response time of cell and adapter as measured using the test method described in ISO 7767 (1988-12-15), clause 50.9.

Breathing Connections

Gas scavenging port 30 mm ISO taper

Breathing circuit connections 17 mm and 25 mm taper

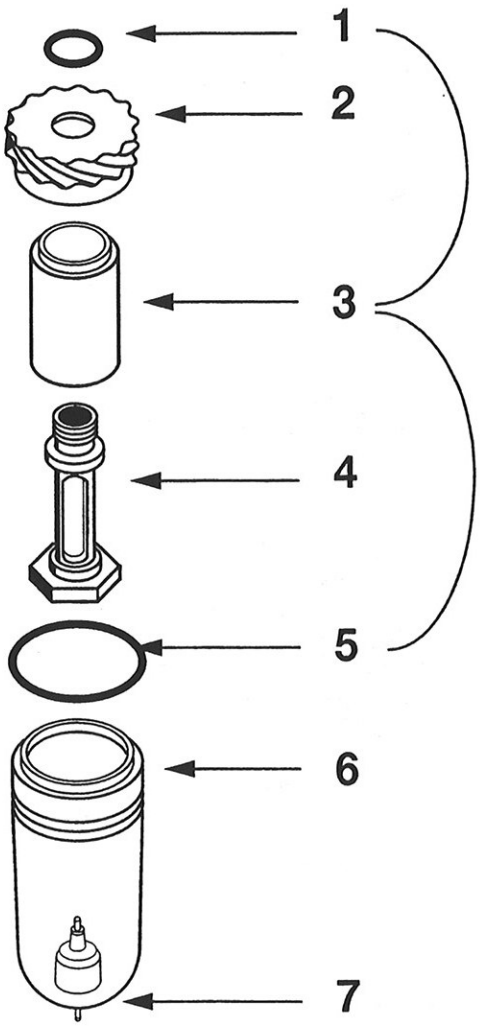
Interface with the gas machine and breathing system

The 7900 Ventilator is always mounted as an integral part of the Excel or Modulus SE Anesthesia Gas System. Signals from the gas machine are sent to the ventilator through an interface circuit board. These include:

- Power ON/OFF control from the gas machine
- Oxygen sensor signal
- Inspiratory flow signal
- Expiratory flow signal
- Airway pressure signal
- Dual common gas outlet interface (French models only)

Appendix C - Illustrated Maintenance Parts

7900 Supply Gas Inlet Filter Illustrated Parts



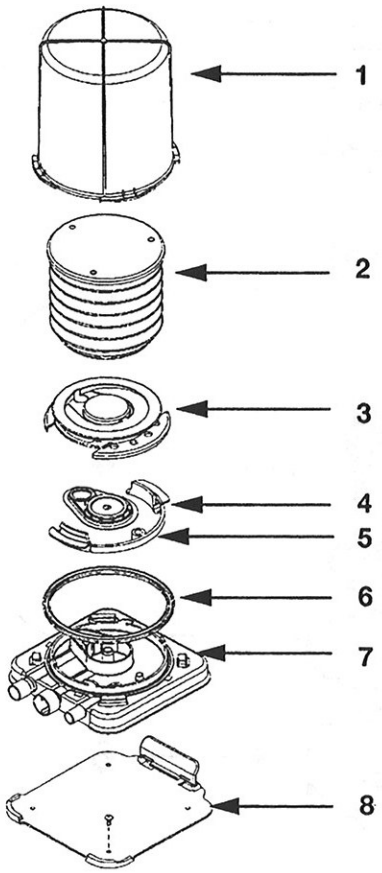
1.Gasket
2.Louver
3.Filter element
4.Mounting stud
5.O-ring
6.Bowl
7.Drain valve

Items 1, 3, and 5 are available as Supply Gas Filter Maintenance Kit 1500-3320-000.

Items 1 through 6 are available as a Supply Gas Filter and Bowl Replacement Kit 1500-3319-000.

Figure C-1
Supply gas filter assembly.

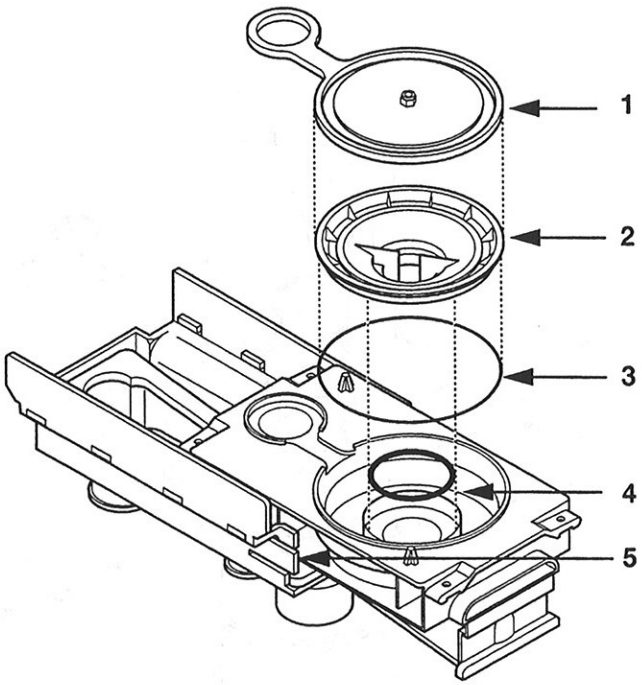
ABA Illustrated Parts List



1.Housing 1500-3117-000
2.Bellows 1500-3378-000
3.Rim 1500-3351-000
4.Pressure relief valve (Diaphragm and seat assembly)1500-3377-000
5.Latch 1500-3352-000
6.Seal 1500-3359-000
7.Base 1500-3350-000
8.Mounting plate 1500-3379-000
Not Shown
Mounting screws , 10-32 x 1/2 sst, 4 required, 9211-1050-106
Disc /ring/bumper ass'y for bellows 1500-3381-000

Figure C-2
Exploded view of ABA assembly.

Exhalation Valve assembly



1.	Diaphragm/gasket assembly	1503-3000-000
2.	Exhalation valve seat	(in repair kit)
3.	O-ring, large	1503-3059-000
4.	O-ring, small	1503-3058-000
5.	Locking tabs, one on each side	----------
6.	Gasket	1503-3048-000
7.	Exhalation manifold body, bottom.	(in repair kit)
8.	Exhalation manifold body, top	(in repair kit)

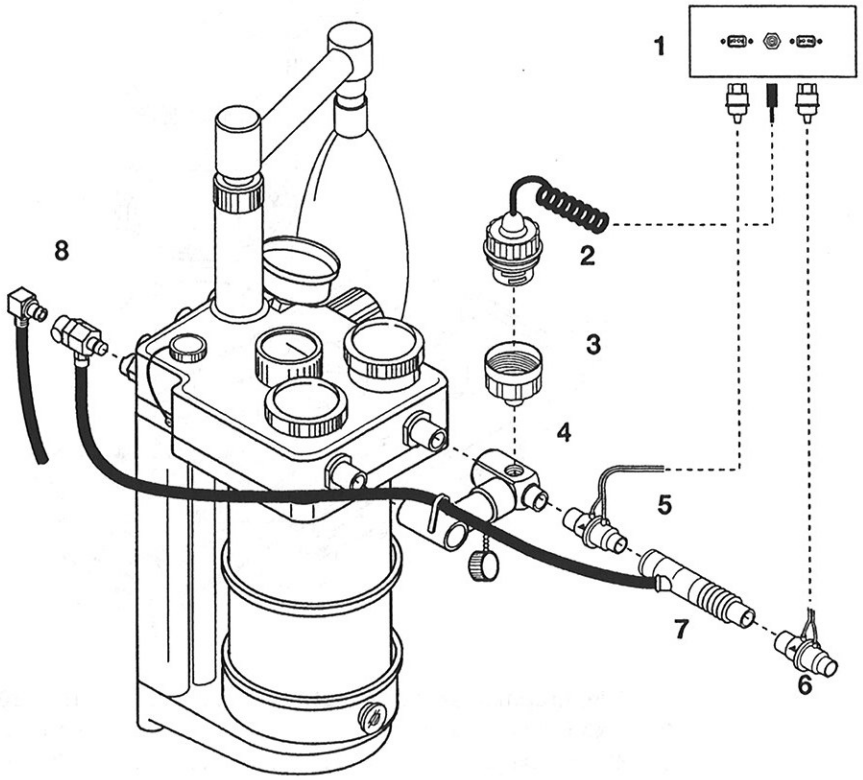
Not shown: Repair Kit for exhalation valve1503-8004-000

(Kit contains -

1, 1503-3001-000;
2, 1503-3000-000;
1, 1503-3048-000;
1, 1503-3058-000; and
1, 1503-3059-000.)

Figure C-3
Exploded View of the Combined Exhalation Valve manifold (1500-3001-000)and Exhalation Diaphragm /Gasket assemblies (1500-3000-000).

Bain circuit, sensor connections



1.Interface Panel on Gas Machine
2.Inspiratory Oxygen Sensor 6050-0004-110
Cable 1503-3087-000
3.Adapter 1503-3084-000
4.Manifold Assembly 0236-0482-700**
5.Inspiratory Flow Sensor (22 mm) 1503-3067-000
6.Expiratory Flow Sensor (15 mm) 1503-3066-000
7.Bain Circuit not supplied
8.Common Gas Inlet Tee 0236-0481-700**

**included in the GMS Bain Circuit Adapter Kit 0236-0483-800

Other Available Parts

Stand Alone Bain Circuit Adapter 0216-6498-802

Figure C-4
Bain Circuit Connections (GMS Bain Illustrated)

Appendix D - Ventilator Accuracy

7900 Ventilator Accuracy Data

The following accuracy data are based on patient conditions and settings described in ASTM F1101. The ventilator is assumed to be operating in volume mode (Heliox OFF). For the following to be true, the ventilator is operating with 100 percent oxygen in the breathing system; or, it is connected to an anesthesia gas analyzer. If the ventilator is operating without being connected to an anesthesia gas analyzer, additional errors are described in the gas composition charts that follow.

Volume Mode (100% O_2)

Volume delivery accuracy:	> 210 mL tidal volume - accuracy better than 7%
	< 210 mL tidal volume - accuracy better than 15 mL
	< 60 mL tidal volume - accuracy better than 10 mL

Pressure Mode (100% O_2)

Inspiratory pressure delivery accuracy	greater of ± 10% or ± 3 cm H_2O
PEEP delivery accuracy	± 1.5 cm H_2O
Pressure monitoring accuracy	greater of± 5% or ± 2 cm H_2O
Volume monitoring accuracy	> 210 mL tidal volume - accuracy better than 9%
	< 210 mL tidal volume - accuracy better than 18 mL
	< 60 mL tidal volume - accuracy better than 10 mL

Note: Gas composition errors may be in addition to the above normalized accuracy. When adding errors, positive errors can have the effect of nulling out negative errors.

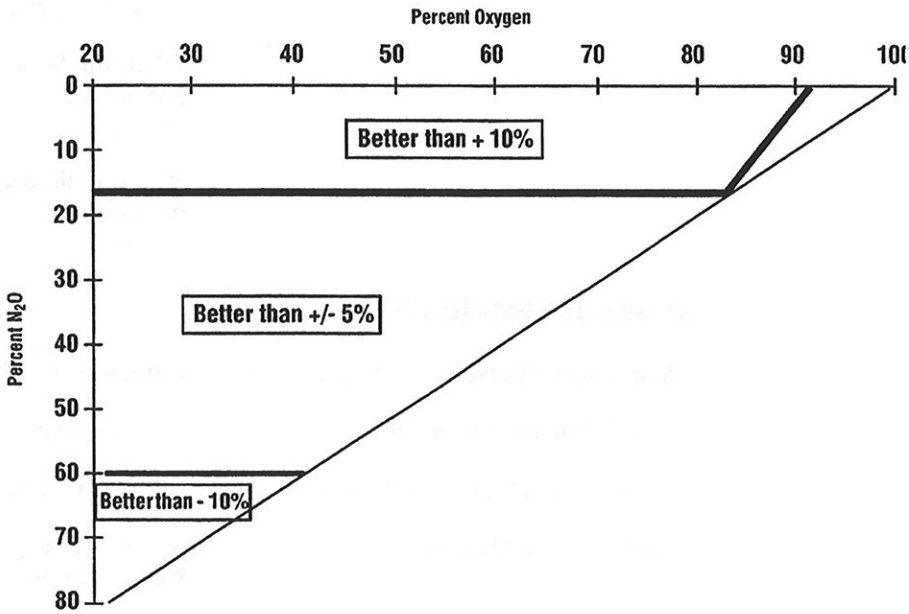
Note: Use of anesthetic agent could affect the errors by approximately -0.95%/% volume agent in normal mode and roughly -2.5%/% volume agent in Heliox mode. If the 7900 Ventilator is connected to an Ohmeda RGM (Respiratory Gas Monitor), the affect of gas composition on volume data is corrected for automatically.

Volume Compensation Off

Delivered volume accuracy: greater of ± 10% or ± 20 mL

(Open loop volume mode is not a normal user selectable ventilation mode. It is an uncompensated ventilation mode used when a possible inspiratory flow sensor problem has been detected. The delivery accuracy is evaluated at the ventilator drive gas outlet in this mode of operation.)

Gas Composition Related Errors (Both Modes)



Heliox Mode

The effect on volume delivery and monitoring accuracies of Heliox mixtures is within +8% to -15% when operating the 7900 Ventilator in the Heliox Mode.

Open loop mode volume delivery accuracy: +/- 10% of the set value under the following conditions:

13. Accuracy evaluated at the ventilator outlet.

14. This is not a normal operating mode. The ventilator is operating in an irregular condition.

Appendix E - 7900 External Communications Protocol

This protocol is designed for communications via the ventilator's public serial connection. It is intended for use with an HP-CMS equipped with a VueLink Module or other monitor programmed to support this 7900 protocol.

Protocol Overview

Output Data

The following output data (sent from the ventilator to an external device, referenced in this Protocol description as "Monitor X) will be supported by this protocol :

waveform data (12 bit data, 125 Hz sample rate)

- raw pressure waveform
- flow waveform
- volume waveform

measured numeric data (sent every breath, or at minimum every 10 seconds)

Note: Question mark (?) displayed, means uncertain data Dash (-) displayed, means data not used.

• tidal volume	(5-9999 mL), (?), (-)
• breath rate	(0-105 breaths/min), (?), (-)
• minute volume	(0.0-99.9 L/min), (L/min x 100), (?), (-)
• oxygen concentration	(0-110 %), (?)
• Pmax	(0-120 cm H_2O), (?)
• Pmin	(-20 to 120 cm H_2O), (?)
• Pplateau	(0-120 cm H_2O), (?), (-)
• Pmean	(-20 to 120 cm H2O), (?), (-)

status data (sent once per second if a change occurs in the status data; or a minimum of once every ten seconds if no change occurs)

• set tidal volume	20-1500 mL
• set breath rate	4-100 breaths/min
• set I:E	2:1 - 1:8 (1:000.5, 1:000.67, 1:001.0, 1:001.5, 1:002.0.....1:008.0)
• set PEEP	off, 4-30 cm H_2O
• set inspired pressure	5-60 cm H_2O
• set maximum pressure	2-100 cm H_2O

- high oxygen limit 21-100 %, off
- low oxygen limit 21-100 %
- high tidal volume limit 20-1600 mL, off
- low tidal volume limit off, 0-1500 mL
- high minute volume limit 0-30 L/min, off (LX10)
- low minute volume limit off, 0-10 L/min (LX10)
- sustained pressure limit 6-30 cm H_2O
- operational modes/states mechanical ventilation, inspiratory pause, volume monitor standby, alarms are silenced
- alarm information on/off

setup data (sent once per request)

- software version # 0.1 to 99.9
- language 0=English, 1=Spanish, 2=German, 3=Kanji, 4=Dutch, 5=Swedish, 6=French, 7=Italian, 8=Danish
- display contrast setting 1 - 10
- alarm volume setting 1 - 5
- altitude minus (-) 400 to 3600 meters (sent in 100's of meters)
- drive gas Air or O2
- ventilator model # 6 = 7900

Input Data

The following input data (sent from an external device to the ventilator) will be supported:

- send setup data
- send all data
- send waveform data
- set auto/slave mode
- disable/enable checksum
- enable compressed mode

Appendix E - 7900 External Communications Protocol

Protocol Description

Electrical Interface

- RS-232C signal standards
- 9 pin female D connector - Data Communications Equipment configuration (DCE)

pin 2 - receive data

pin 3 - transmit data

pin 5 - signal ground

Serial Communication Parameters

- Baud: 19.2K

  Byte format: Start bit + 7 data bits + parity bit + stop bit

  Parity: ODD

Software Interface

Ohmeda 7900 Waveform Communication Protocol

Command Headers:

<ESC>VTD	DISABLE CHECKSUM
<ESC>VTE	ENABLE CHECKSUM
<ESC>VTQ	ENABLE COMPRESSED MODE
<ESC>VTS	SLAVE MODE (RESETS AUTO MODE)
<ESC>VTX	AUTO MODE
<ESC>VT$	SEND SETUP DATA
<ESC>VT?	SEND ALL DATA
<ESC>VTW	ENABLE WAVEFORM DATA

Response Headers:

:VTD	MEASURED DATA RESPONSE
:VTM	SETUP DATA RESPONSE
:VTN	NACK (negative acknowledge)
:VTQ	STATUS DATA RESPONSE
:VTW	WAVEFORM DATA RESPONSE
:VTR	ALARM SILENCE SWITCH PRESSED RESPONSE
:VTY	ACK (positive acknowledge)

DEVICE COMMANDS Sent By External Device

Data Transmit Mode Select Commands

<ESC>VTXc<CR> Auto Mode

<ESC>VTSc<CR> Slave Mode

Data Format Mode Select Commands

<ESC>VTQc<CR> Compressed Format

Data Request Command

<ESC>VT?c<CR> Send All Data (Valid in Slave Mode only)

<ESC>VT$c<CR> Send Setup Data

Enable Waveform Data Mode

<ESC>VTWabc<CR> Send Waveform Data

<ESC>VTW = header

a & b = any one of the following:

(note 1: order determines order of data in response packet)

(note 2: b valid only if a != 0)

0	turn waveform data OFF
P	include Pressure Data
F	include Flow Data
V	include Volume
c =	checksum
<CR> =	terminator

Checksum Control Commands

<ESC>VTEc<CR> Enable Checksum Mode

<ESC>VTDc<CR> Disable Checksum Mode (checksum byte ignored in this command, but cannot be <CR>)

DEVICE RESPONSES Sent Back By Ventilator

ACK Response

:VTYc<CR>	Positive Acknowledge Response

NAK Response

:VTNc<CR>	Negative Acknowledge Response

Alarm Silence Switch Pressed Response

:VTRc<CR>	Alarm Silence Switch Press Response (if no alarms are on or all displayed alarms are silenced)

Compressed-Data Measured Data Response

In auto mode, the Measured Data Response will be transmitted at the end of a breath or 10 seconds from the last transmission, whichever occurs first.

:VTDaaaabbbbddddeeefffggghhhiiijc<CR>	Compressed Data Measured Data Response (each entry is zero filled and right justified--i.e. aaaa = 0095) "?" means bad data due to any technical problem(s); "-" means data not available due to system state

aaaa	measured tidal volume	mL, ?, -
bbbb	measured minute volume	L*100, ?, -
ddd	measured respiratory rate	/min, ?, -
eee	measured oxygen level	% O_2, ?, -
fff	measured max positive pressure	cm H_2O, ?
ggg	measured inspiratory plateau pres	cm H_2O, ?
hhh	measured mean pressure	cm H_2O, ?
iii	minimum pressure	cm H_2O, ?
j	measured data status	0100000x (bit 0=1=new breath data; bit 0=0=10 second data)
c	checksum	

Compressed-Data Status Data Response

The Status Data Response will be transmitted every 1 second (if a change occurs in the status data) or a minimum of once every 10 seconds. Note that the status byte bit is set=1 for an active condition and 0 for an inactive condition.

:VTQaaaabbbddddeeffgggghhiijjjkkkllllmmmnnnooqrrrrrrrrrrrrc<CR>
Compressed Data Status Data Response

aaaa	set tidal volume	mL
bbb	set tidal volume	/min
dddd	set I:E ratio	1:eee.e
ee	inspiratory pause	% Pause
ff	set PEEP	cm H_2O
ggg	set peak pressure limit	cm H_2O
hh	set inspired pressure	cm H_2O
ii	set sustained pressure alarm limit	cm H_2O
jjj	high minute volume alarm limit	L*10
kkk	low minute volume alarm limit	L*10
lll	high Vte limit	mL/10
mmm	low Vte limit	mL/10
nnn	high oxygen alarm limit	% O_2
ooo	low oxygen alarm limit	% O_2
q	ventilation mode	
	('v'=volume mode, 'p'=pressure mode, 'b'=Vt compensation off, '-'=bag mode only)	
rrrrrrrrrrrr	status bytes (see bitmaps below)	
c	checksum	

Status Bytes Bitmaps

FROM BYTE 1 THRU BYTE 11 "Alarm ID" and "Category " colums deleted

bit **byte 1**

7900 Message
D0 - High O2
D1 - Low O2
D2 - 1
D3 - 1
D4 - 1
D5 - Check O2 Sensor
D6 - O2 Calibration Error

bit **byte 2**

7900 Message
D0 - -High Paw
D1 - Low Paw
D2 - Sustained Paw (shutdown)
D3 - Sustained Paw
D4 - Sub-Atmos Paw
D5 - 1
D6 - 1

bit **byte 3**

7900 Message
D0 - Pinspired Not Achieved
D1 - PEEP Not Achieved
D2 - No Pressure Mode/PEEP
D3 - Manifold Pressure Sensor Fa ilure
D4 - Inspiratory Overshoot
D5 - Inspiration Stopped
D6 - High Pressure Limit Reached (min sys)

bit **byte 4**

7900 Message
D0 - Low VE
D1 - High VE
D2 - Low Vte
D3 - High Vte
D4 - Vt Not Achieved
D5 - Volume Apnea
D6 - Volume Apnea > 2 min

bit **byte 5**bit **byte 6**

7900 Message
D0 - No Insp Flow Sensor
D1 - No Exp Flow Sensor
D2 - Insp Reverse Flow
D3 - Exp Reverse Flow
D4 - Check Flow Sensors
D5 - Insp Vt/Vte Mismatch
D6 - Vdel Mismatch

7900 Message
D0 - Bellows Empty
D1 - Flow Valve Failure
D2 - Gas Inlet Valve Failure
D3 - 12 Hour Test
D4 - "Bootup GIV Failure"
D5 - No O2 Pressure
D6 - No Fresh Gas Flow

bit **byte 7**

7900 Message
D0 - +Vanalog Failure
D1 - -Vanalog Failure
D2 - +15V SIB Out-of_Range
D3 - +15V Manifold Out-of-Range
D4 - Display Voltage Out-of_Range
D5 - Vaux_ref Out-of-Range
D6 - Vext_ref Out-of-Range

bit **byte 8**

7900 Message
D0 - A/D Converter Failure
D1 - CPU Failure
D2 - Memory (EEPROM) Failure
D3 - Memory (flash) Failure
D4 - Memory (RAM) Failure
D5 - Memory (video) Failure
D6 - Bootup Memory Failure

bit **byte 9**

7900 Message
D0 - Software Watchdog Failure
D1 - Hardware Watchdog Failure
D2 - Internal Vent. Clock Too Fast
D3 - Internal Vent. Clock Too Slow
D4 - CPU Internal Error
D5 - Memory (redundant storage) Fail
D6 - Flow Sensor Cal Data Corrupt

bit **byte 10**

7900 Message
D0 - On Battery
D1 - No Battery
D2 - Low Battery Charge
D3 - Low Battery
D4 - Low Battery (shutdown)
D5 - Fail Batt. Volt. Out Of Range
D6 - Batt. Curr. Out Of Range

bit **byte 11**

7900 Message
D0 - Circuit Auxiliary
D1 - Auxiliary Breathing Circuit
D2 - "no confirmation of changed setting"
D3 - Control Settings Input Has Failed
D4 - Heliox Mode is ON
D5 - Volume Compensation Off
D6 - Mechanical Ventilation On

bit **byte 12**

7900 Message
D - 0 Volume Mode Active
D - 1 Apnea Detect ON
D - 2 Apnea Alarm Silenced
D - 3 Very Low VE Limit
D - 4 Alarms Silenced
D - 5 1
D - 6 Sensor(s) Cal Due

Setup Data Response

:VTMaaaabddeffghc<CR>Setup Data Response

aaaa	software revision number	0001-9999 = 0.01-99.99
b	language (see note)	0-8
dd	display contrast setting	1-10
e	alarm volume setting	1-5
ff	altitude setting	-4 to 36, in 100's of meters
g	drive gas	O = oxygen, A = air
h	ventilator model number	0 = 7800, 1 = 7810, 5 = 7850, 6 = 7900
c	checksum	

note: language: 0=English; 1=Spanish; 2=German; 3=Kanji; 4=Dutch; 5=Swedish; 6=French; 7=Italian, 8=Danish

Waveform Data Response

If Waveform Data Mode is enabled, a Waveform Data Response will be transmitted every 240 ms. Up to 2 blocks of fifteen (15) data samples taken every 16 ms. will be sent with each message. Each data value is a 3-digit, zero filled, right justified ASCII Hex representation of a 12 bit binary value

:VTW[aaabbb...nnnooo][aaabbb...nnnooo]c<CR>
Waveform Data Response for each [max. of 2] waveform signal selected

aaa	1st 16 ms waveform sample (0 -> "000", 512 -> "200", 4095 -> "FFF")
bbb	2nd 16 ms waveform sample
...	
nnn	14th 16 ms waveform sample
ooo	15th 16 ms waveform sample

Waveform Data shall be scaled as follows:

Pressure
range: -20 - 120 cm H2O
scale:

raw	scaled	xmit.
-20	0	"000"
0	512	"200"
120	3584	"E00"

Flow
range: -100 - +100 L/M
scale:

-100	512	"200"
0	2048	"800"
+100	3584	"E00"

Volume
range: 0 - 2 L
scale:

0	512	"200"
2	3584	"E00"

The Waveform Data will be sampled as follows:

Pressure
Samples will be every taken from the airway pressure sensor every 16 ms.

Flow
For each breathing system the samples will be every 16 ms. The flow may be sampled from the inspiratory flow sensor and/or the expiratory flow sensor, depending on the circuit type and the phase of the breath. The inspiratory flow sample will always be positive and the expiratory flow sample will always be negative.

Standard Circle Breathing System

If inspiratory flow > threshold (start of inspiration)
    If inspiratory flow is increasing
        Use inspiratory flow 16 ms sample

    Else if inspiratory flow is decreasing and expiratory flow > threshold
        Use expiratory flow 16 ms sample

    Else
        Use inspiratory flow 16 ms sample

Else If expiratory flow > threshold (start of expiration)
        Use expiratory flow 16 ms sample
Else
        Use the 16 ms flow sample from the previously used flow sensor

GMS Bain or Bain/Mapleson Breathing Systems

Always use the expiratory flow 16 ms sample (if no expiratory flow sensor is used, the 16 ms sample will always be 000).

Volume

Standard Circle Breathing System

Samples will be every 16 ms and will be based on integration of flow values. Inspiratory flow will increase volume, expiratory flow will reduce the volume. The volume will be reset to 0 at the start of a inspiration.

GMS Bain or Bain/Mapleson Breathing Systems

Samples will be every 16 ms and will be based only on the expiratory flow sensor (if no expiratory flow sensor is used, the 16 ms sample will always be 000).

Notes