Datex·Ohmeda

7900 SmartVent

Supplement to the Excel SE and Modulus SE manuals

Software Version 3.X
Operation Manual
Part 2

Setup
Cleaning and Sterilization
Maintence and Troubleshooting

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, Datex-Ohmeda recommends that a telephonic or written request for service advice be made to the nearest Datex-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 Datex-Ohmeda and by Datex-Ohmeda trained personnel. The Product must not be altered without the prior written approval of Datex-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 Datex-Ohmeda.

⚠ **Caution** U.S. Federal and Canadian law restrict this device to sale by or on the order of a licensed medical practitioner. Outside the U.S.A. and Canada, check local laws for any restriction that may apply

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

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.

Table of contents

8/Specifications and Theory of Operation (Continued)

Introduction

In this section

How to use this manual

The 7900 Ventilator has several user manuals. This manual (part 1 of the set) provides maintenance, troubleshooting, and technical information. The first five sections tell you how to maintain the ventilator:

•Complete maintains schedule (Section 1).

- How to remove and clean parts (Section 2).
- How to identify and replace worn or damaged parts (Section 4).
- How to calibrate the sensors (Section 4).
- What causes each alarm and what you can do about it (Section 5).

The next three sections supply technical information:

- Stock numbers for repair parts (Section 6).
- Communication protocols for data collection (Section 7).
- Theory of operation and specifications (Section 8).

Use this manual together with the other manuals. These include the operating instructions, and the Excel SE or Modulus SE operation manual, which tells you how to setup and connect the ventilator.

⚠ **WARNING** If an alarm occurs, safeguard the patient first, before troubleshooting or repair procedures.

Symbols used in the manual or on the equipment

⚠ Warnings and ⚠ Cautions tell you about dangerous conditions that can occur if you do not follow all instructions in this manual.

Warnings tell about a condition that can cause injury to the operator or the patient.

Cautions tell about a condition that can cause damage to the equipment. Read and follow all warnings and cautions.

Other symbols replace words on the equipment or in Datex-Ohmeda manuals. No one device or manual uses all of the symbols. These symbols include:

I	On (power)
O	Off (power)
⏻	Standby
	Standby or preparatory state for 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
134°C	Not autoclavable
	Type B equipment
	Type BF equipment
	Type CF equipment
⚠	Caution, ISO 7000-0434
⚠	Attention, refer to product instructions, IEC 601-1
	This way up
ϟ	Dangerous Voltage
	Input
	Output
REF	Stock Number
SN	Serial Number

Equipotential

Systems with this mark agree with the 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 Datex-Ohmeda's Quality Systems.

Variability

Read top of float.

Variability in steps

Vacuum inlet

Plus, positive polarity

Suction bottle outlet

Minus, negative polarity

O_2 Flush button

Lamp, lighting, illumination

Cylinder

Movement in one direction

Isolation transformer

Movement in two directions

Linkage system

Lock

Risk of Explosion.

Unlock

Low pressure leak test

Autoclavable

Mechanical ventilation

Bag position/ manual ventilation

Open drain (remove liquid)

Close drain

Inspiratory flow

Expiratory flow

O_2 sensor connection.

Maintenance summary and schedule

These schedules show the minimum frequency. You will have to service the equipment more frequently if you use it:

- In unusual conditions (dirty gas supplies, high temperature, high humidity, etc.).
- More frequently than normal.

Operator maintenance

Examine all components and do the maintenance procedures more frequently if necessary.

Minimum Frequency	Maintenance
Daily	• Clean the external surfaces. • 21% O_2 calibration (circuit O_2 sensor). • Flow sensor calibration
Weekly	• Disconnect flow sensors (automatic calibration)
Monthly	• 100% O_2 calibration (circuit O_2 sensor).
During cleaning and setup	• Inspect the parts for damage. Replace or repair as necessary
Annually	• Replace the o-rings and gaskets in the expiratory valve. • Replace the o-ring on the supply gas hose. • Replace the supply gas filter (some models).
As necessary	• Drain the water trap (some models) • Replace the circuit O_2 sensor. • Replace the disposable flow sensors (plastic) [1]

1. Under typical use the sensor meets specifications for 3 months

Datex-Ohmeda approved service

Minimum Frequency	Maintenance
Annually	Have an qualified service person do the service tests and scheduled service maintenance.

Cleaning and sterilization

⚠ **WARNING** Obey applicable safety precautions:

- Read the material data sheet for each cleaning agent.
- Read the operation and maintenance manual for all sterilization equipment.
- Wear gloves and safety glasses. A damaged O_2 sensor can leak and cause burns (contains potassium hydroxide).
- Do not breathe the fumes.

⚠ **CAUTION** To prevent damage:

- Refer to the manufacturer's data if you have questions about a cleaning agent.
- Do not use organic, halogenated, or petroleum based solvents, anesthetic agents, glass cleaners, acetone, or other harsh cleaning agents.
- Do not use abrasive cleaning agents (such as steel wool, silver polish or cleanser).
- Keep all electronic parts away from liquids.
- Do not permit liquid to go into the equipment housings.
- Do not soak synthetic rubber parts for more than 15 minutes. Swelling or faster aging can occur.
- Only autoclave parts that are marked 134°C.

In this section

Summary

Refer to your hospital's infection control policy.

Replace damaged parts with components made or sold by Datex-Ohmeda.

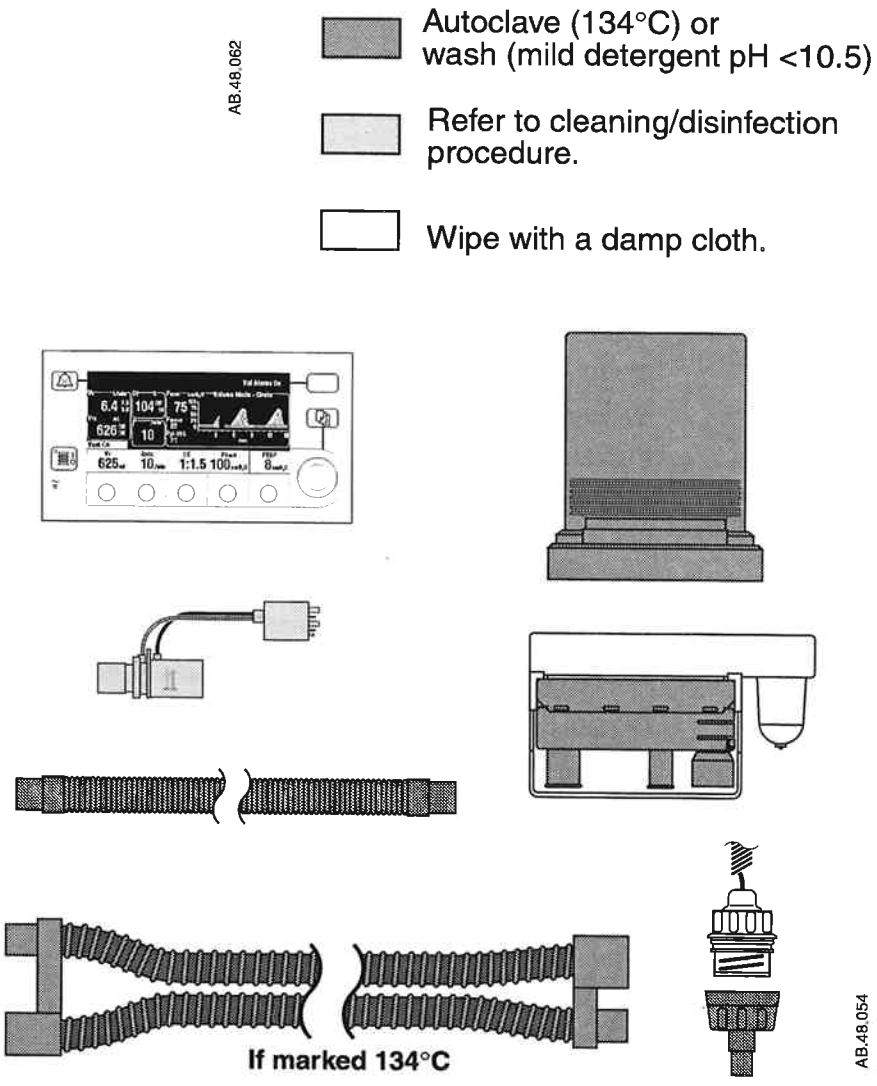


Figure 2-1 • Summary

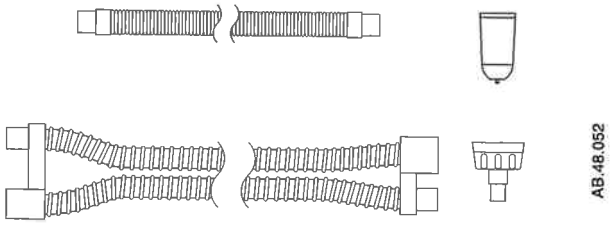
Item	To clean	Autoclavable
Control module	wipe with neutral detergent and rinse	No
Bellows assembly	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Flow sensors (plastic)	refer to cleaning procedure	No
Exhalation valve block	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Oxygen sensor	wipe with neutral detergent (Ph 7 to 10.5) and rinse	No
Oxygen sensor adapter	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
Clear plastic areas	water dampened cloth	No
Dual hose and manifold	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
GMS interface manifold	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable
MAS interface manifold	wipe with neutral detergent (Ph 7 to 10.5) and rinse	Autoclavable

Clean and sterilize

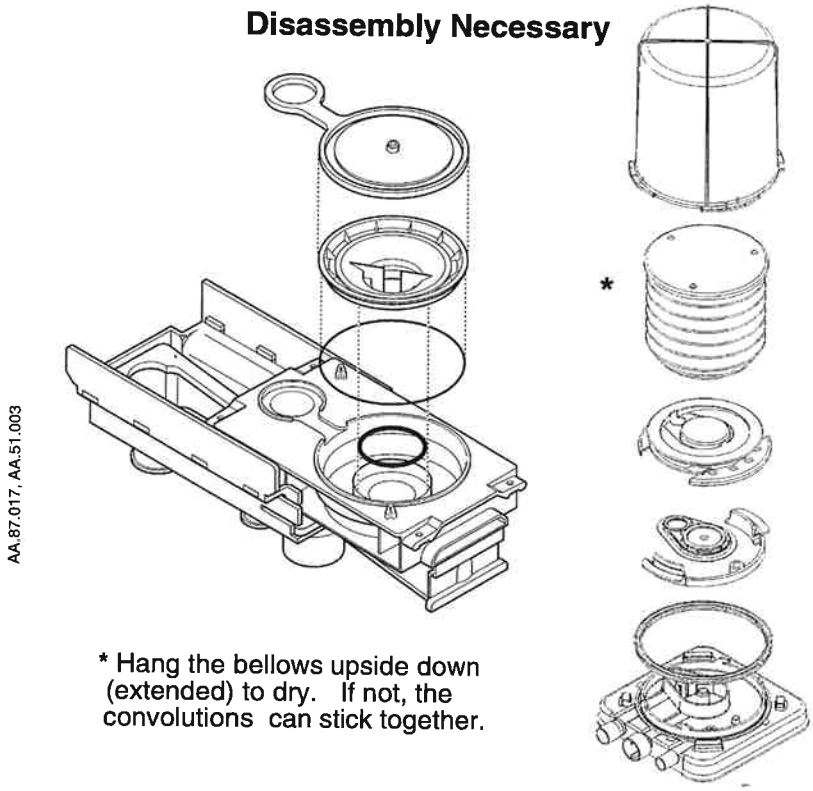
The Maintenance part of this section tells you how to remove and disassemble parts for cleaning.

To wash (by hand or machine)

No Disassembly



Disassembly Necessary



* Hang the bellows upside down (extended) to dry. If not, the convolutions can stick together.

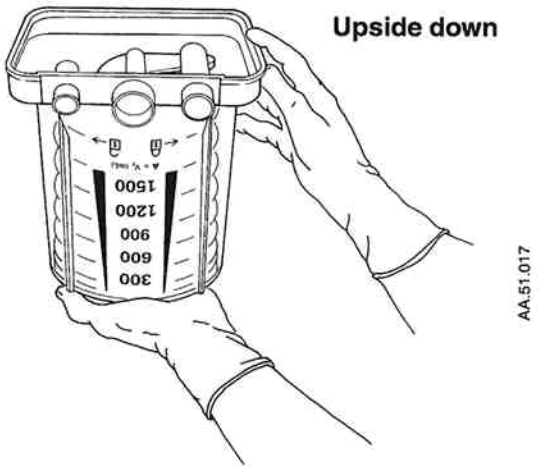
Use a mild detergent (pH <10.5). Then, rinse and dry completely. All parts except the O_2 sensor and flow sensors can be washed.

User maintenance tells you how to disassemble parts and clean inside them if necessary.

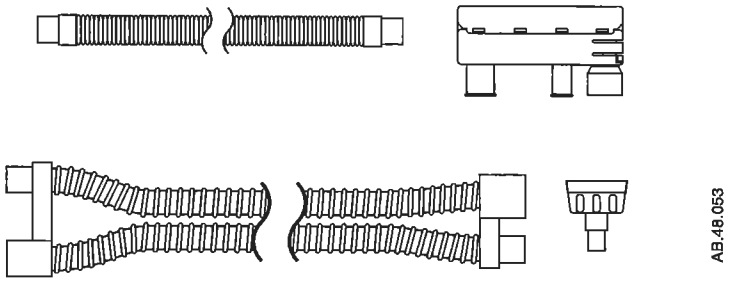
Autoclave

Autoclave at 134°C. Inspect the parts for deterioration. The user maintenance section tells you how to do this.

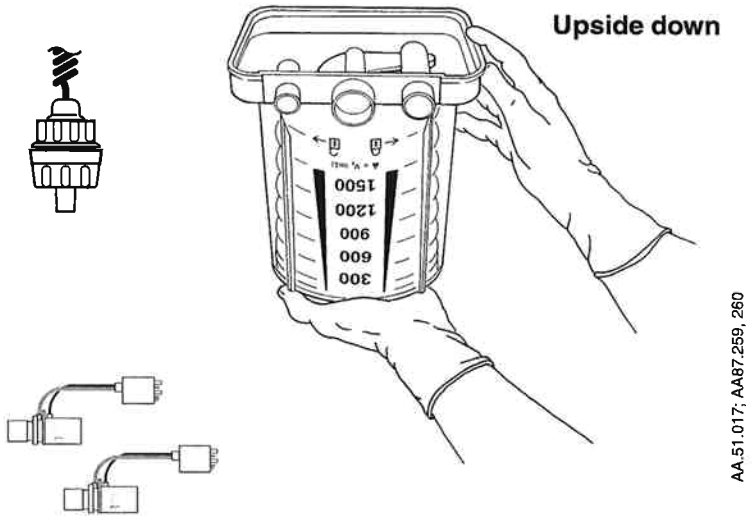
Special Procedures



Normal



Special requirements



- To clean the circuit O_2 sensor, wipe it with a damp cloth. Do not put the sensor in liquid.
- To clean/disinfect plastic flow sensors, use the flow sensor cleaning procedure. Do not get the connectors wet
- Disassemble the bellows before you wash it. If not, it will take a very long time to dry. Hang the bellows upside down to dry.
- Assemble the bellows before you autoclave. Autoclave the bellows upside down.

⚠ **WARNING** Do not use talc, zinc stearate, calcium carbonate, corn starch or equivalent materials to prevent tackiness. These materials can go into the patient's lungs and airways and cause irritation or injury.

⚠ **CAUTION** Do not put the circuit O_2 sensor or flow sensor connector in liquid.

⚠ Do not autoclave the Circuit O_2 sensor or the plastic flow sensors.

⚠ Do not clean the interior surfaces of the flow sensors. Use a damp cloth on external surfaces only.

How to clean and disinfect the flow sensors

⚠CAUTION Do not autoclave plastic flow sensors.

⚠ Do not use high pressure gas, or brushes to clean the flow sensors.

⚠ Do not use cleaning solvents that are not approved for use with Polycarbonates (e.g. CIDEX Plus).

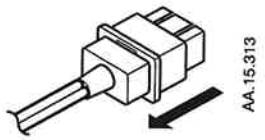
CIDEX sterilization

Both Datex-Ohmeda and the manufacturer of CIDEX (Johnson & Johnson) have tested this procedure.

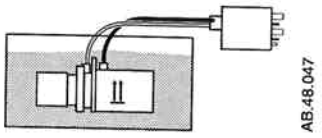
- CIDEX must be 14 day mixture, with activator vial REF REORDER # 2245
- One liter of this solution cleans four (4) flow sensors

Procedure

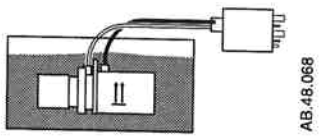
1. Disconnect the flow sensors.



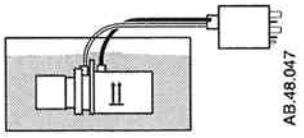
2. Submerge the flow sensor and tubes in activated CIDEX solution. Keep the connector dry.



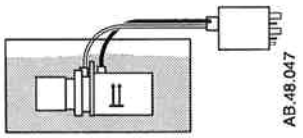
3. Keep the solution in the tubes for the sterilization period.



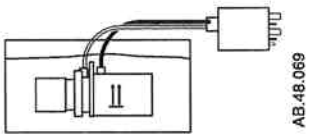
4. Submerge the flow sensor and tubes in distilled water. Again, do not get the connector wet.



5. Rinse as indicated in CIDEX instructions.



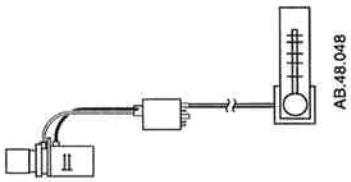
6. Do steps 4 and 5 again to remove all CIDEX.



7. COMPLETLY dry the flow sensor and the tubes before you use the sensor.

   Use a dry syringe, or connect vacuum or pressure to remove all liquid from the sensor (sensor, tubes, and connector):

   - Minimum time: 1 min
   - Maximum vac.: 76.2 cm Hg
   - Maximum flow: 10 l/min flow
   - Maximum pressure: 345 kPa.



Setup and Connections

The SmartVent is part of an Excel SE or Modulus SE configuration. For connection diagrams and set-up instructions, refer to the correct anesthesia machine manual.

Important Datex-Ohmeda strongly recommends that you use O_2 monitoring with this equipment. Refer to local standards for mandatory monitoring.

Important European Standard EN 740 requires CO_2 monitoring during ventilation.

⚠ WARNINGS Always make sure that the pipeline supply hoses and the breathing circuit components are not toxic and will not:

- Cause an allergic reaction in the patient.
- React with the anesthetic gases or agent to produce dangerous by-products.

⚠ To prevent incorrect values or equipment malfunction, use only Datex-Ohmeda cables, hoses and tubing.

⚠ This system operates correctly at the electrical interference levels of IEC 601-1-2. Higher levels can cause nuisance alarms that may stop mechanical ventilation.

⚠ To help prevent false alarms from devices with high-intensity electrical fields:

- Keep the electrosurgical leads away from the breathing system and the flow and oxygen sensors.
- Do not put the electrosurgical leads on any part of the anesthesia system.

⚠ To protect the patient when electrosurgical equipment is used:

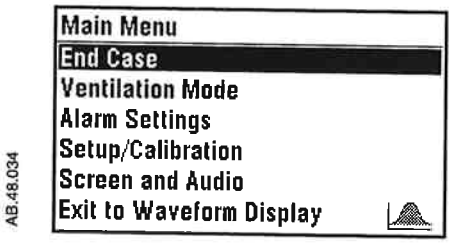
- Monitor the correct operation of all life support and monitoring equipment.
- Keep backup manual ventilation available in case the electrosurgical equipment prevents safe use of the ventilator.
- Do not use conductive masks or hoses.

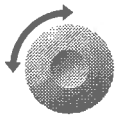
In this section

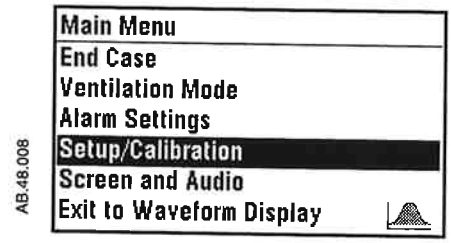
Circuit configurations

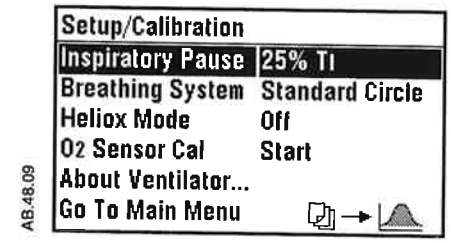
The 7900 SmartVent works with three basic circuits. Use the figures in this section to help select the correct circuit from the **Setup/Calibration** page. For connection diagrams and set-up instructions, refer to the correct Anesthesia machine manual.

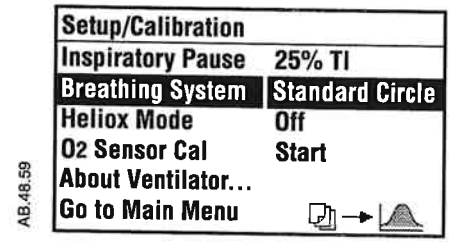
⚠ WARNING The breathing system must be set correctly for accurate monitoring.

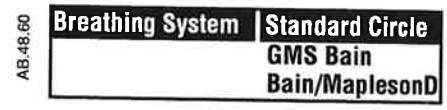




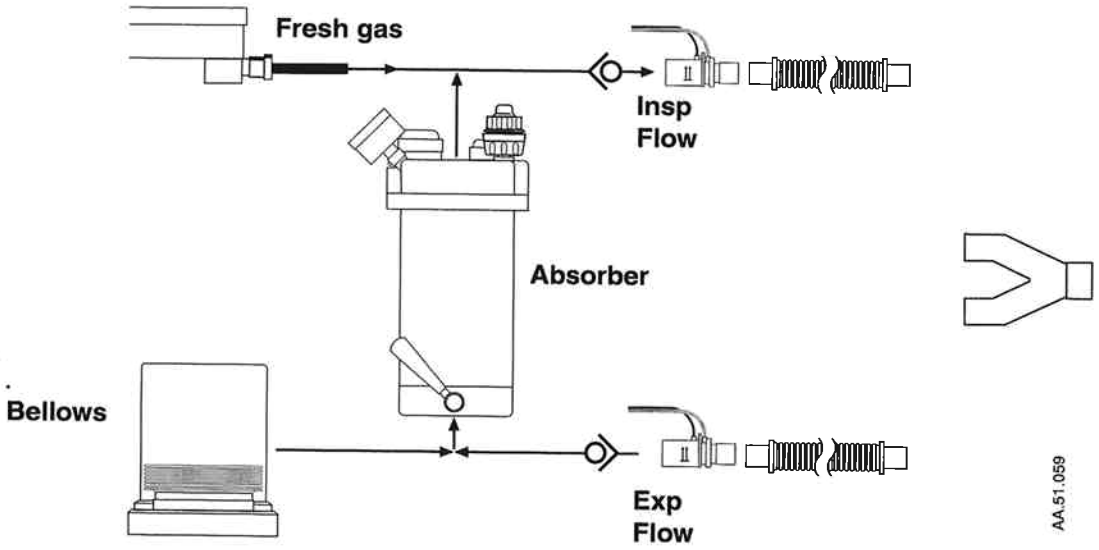




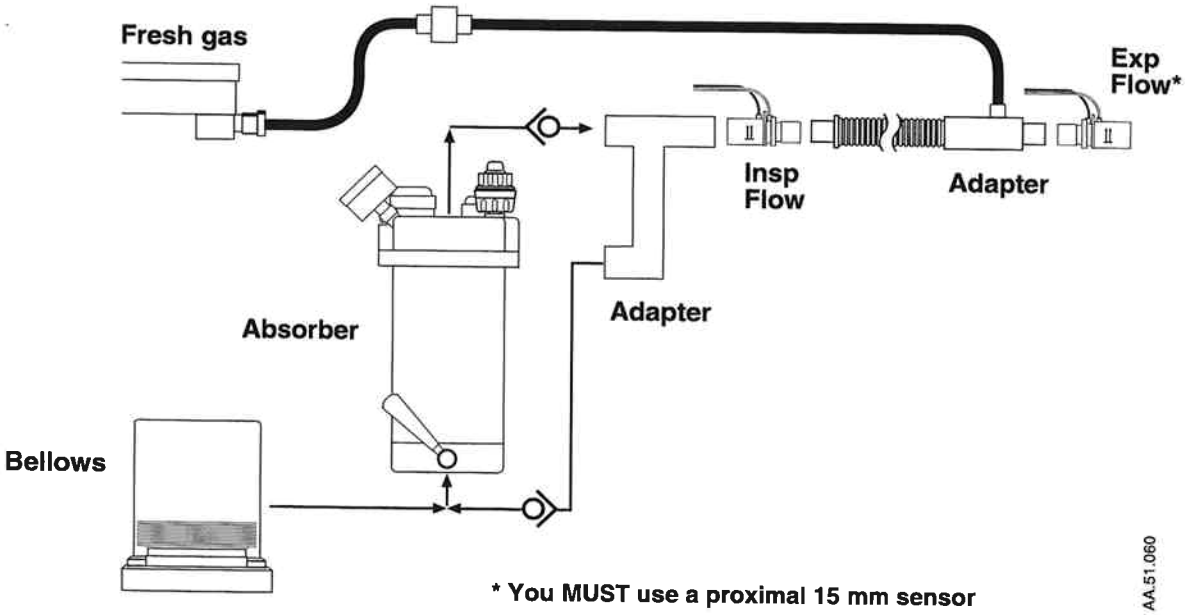




Standard circle

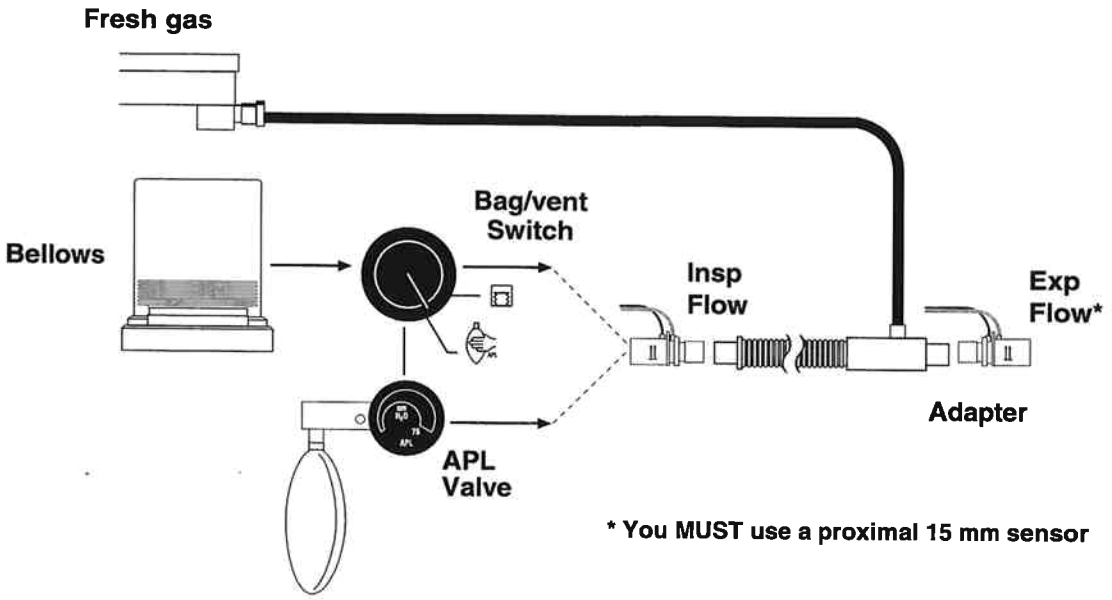


GMS Bain



*** You MUST use a proximal 15 mm sensor**

Bain/ Mapleson D



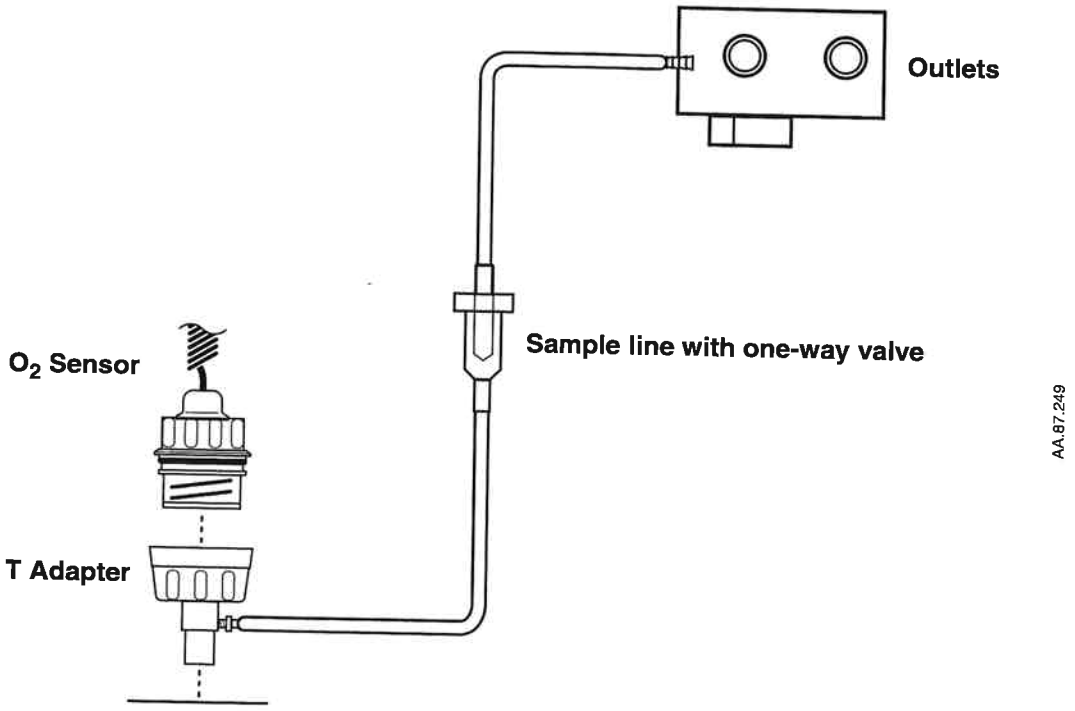
*** You MUST use a proximal 15 mm sensor**

Direct connection to auxiliary common gas outlet[1]:

Ventilator operation changes to O2 monitoring ONLY when you use the auxiliary common gas outlet (French systems).

- Mechanical ventilation is not available.
- The pressure gauge, Bag/Vent switch, APL valve, and bag arm are not part of the circuit.
- Volume and pressure monitoring are not available.

⚠WARNING You must connect a sample line and use the T adapter to measure O_2 at the auxiliary common gas outlet.



1. Found on Excel SE Systems sold in France.

Installation notes

When the system is installed, the service representative will check these settings and change them if necessary.

⚠WARNING These settings can only be changed by qualified service personnel.

- Language
- Power up defaults: When you turn the system off should it save the current settings or go back to facility default settings.
- Automatic calculation of V_E alarm limits during mechanical ventilation
- Altitude
- Ventilator drive gas
- Heliox mode availability

User Maintenance

⚠ WARNING TO PREVENT FIRES:

- Use lubricants approved for anesthesia or O_2 equipment, such as Krytox®[1].
- Do not use lubricants that contain oil or grease. They burn or explode in high O_2 concentrations.
- All covers used on the system must be made from antistatic (conductive) materials. Static electricity can cause fires.

⚠ WARNING Obey infection control and safety procedures. Used equipment may contain blood and body fluids.

In this section

1. ® Krytox is a registered trademark of Dupont de Nemours E.I. & Company Inc

Repair policy

Do not use malfunctioning equipment. Make all necessary repairs or have the equipment serviced by an authorized Datex-Ohmeda service representative. After repair, test the equipment to ensure that it is functioning properly, in accordance with the manufacturer's published specifications.

To ensure full reliability, have all repairs and service done by an authorized Datex-Ohmeda service representative. If this cannot be done, replacement and maintenance of those parts listed in this manual may be undertaken by a competent, trained individual having experience in the repair of devices of this nature.

⚠ **CAUTION** No repair should ever be attempted by anyone not having experience in the repair of devices of this nature.

Replace damaged parts with components manufactured or sold by Datex-Ohmeda. Then test the unit to ascertain that it complies with the manufacturer's published specifications.

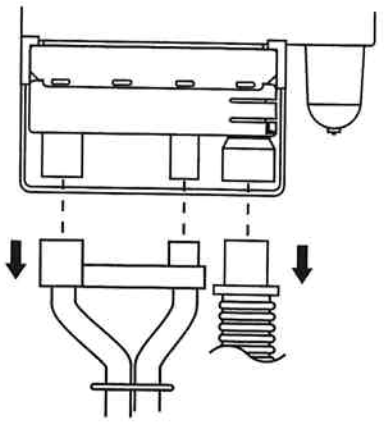
Contact the Datex-Ohmeda Field Service Support Center for service assistance. In all cases, other than where Datex-Ohmeda's warranty is applicable, repairs will be made at Datex-Ohmeda's current list price for the replacement part(s) plus a reasonable labor charge.

Expiratory valve service

⚠WARNING Do not pull too hard on the hoses. They can stretch and then snap back with sufficient force to hurt you or the equipment.

Step 1

Disconnect the hoses. Pull and twist gently.



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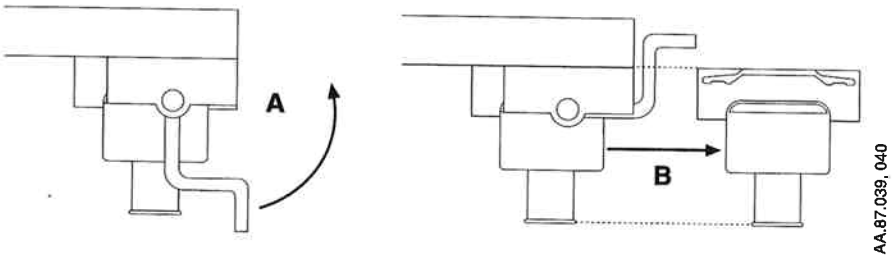
Step 2

Remove the assembly:
- Lift the bar (A).
- Pull out the block (B).



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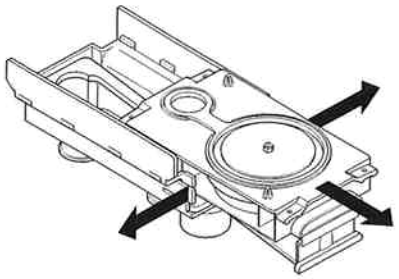
Step 3

Remove the valve assembly:

- Gently pull back the tabs on both sides.
- Slide out the assembly.



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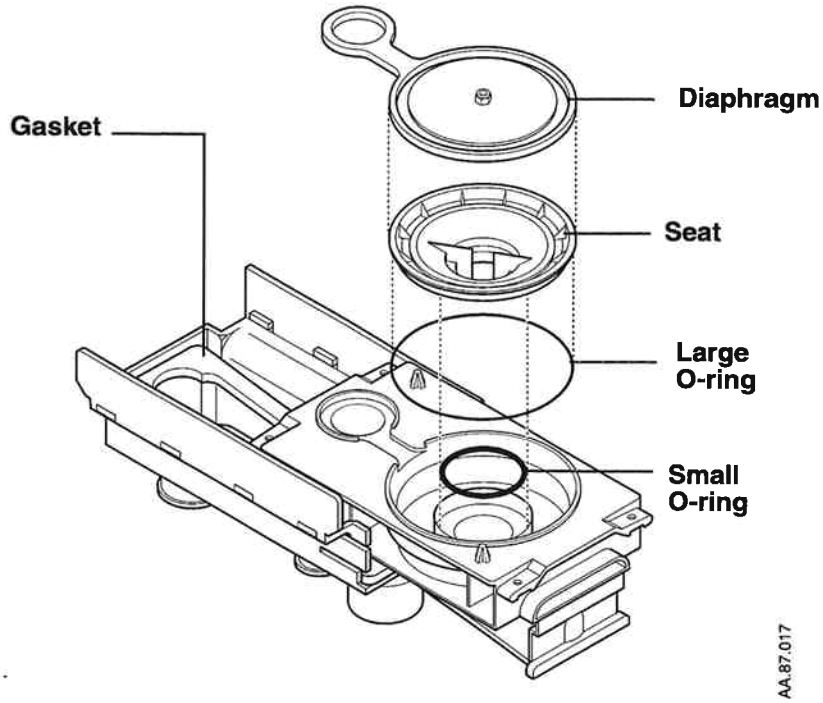
Step 4

Disassemble the valve:

- Lift out the parts.
- During reassembly, make sure the large o-ring fits into the groove.



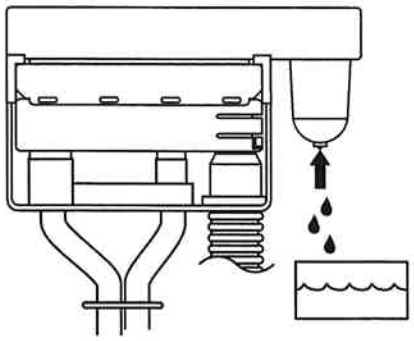
Before you use the system, complete the preoperative test procedure in the operation and maintenance manual for the anesthesia machine.

Filter service

Drain the trap as necessary. Replace the filter if it is discolored.

Step 1

Push up on the valve stem to open the drain.



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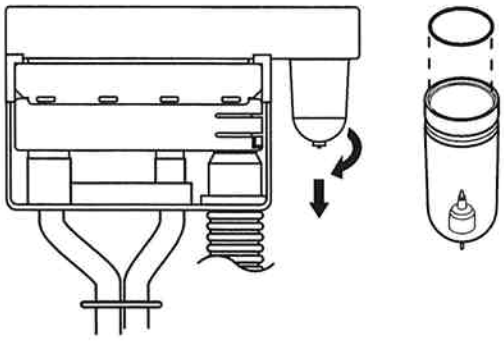
Step 2

Remove the container.



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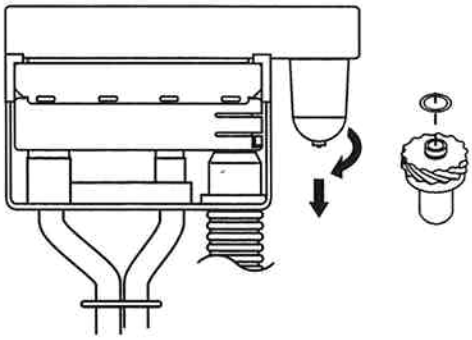
Step 3

Unscrew the stud and remove the filter.



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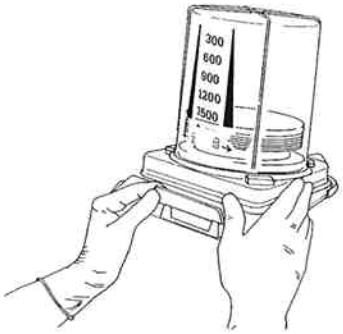
Before you use the system, complete the preoperative test procedure. Refer to the operation and maintenance manual for the anesthesia machine.

Bellows maintenance

Step 1

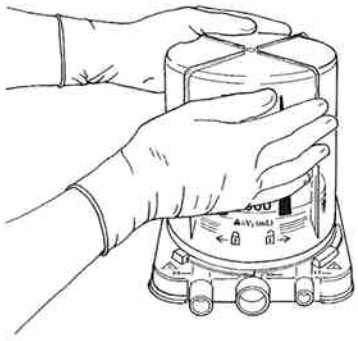
Push the lever and remove the bellows.



AA.51.062

Step 2

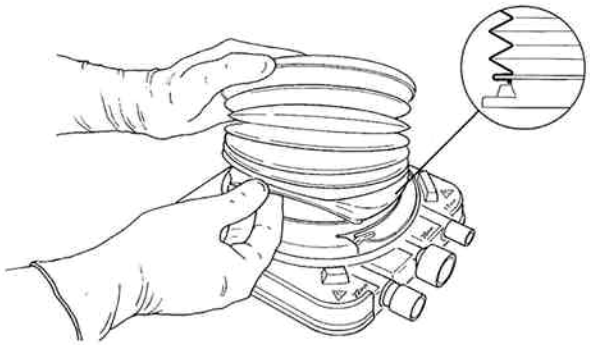
Turn the housing counter-clockwise and lift.



AA.51.007

Step 3

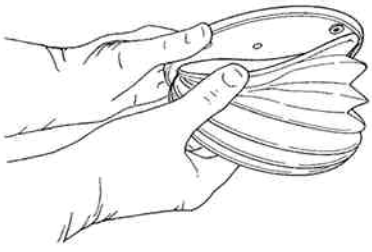
Remove the bottom edge of the bellows from the rim.



AA.51.008

Step 4

Remove the disk from the bellows.



AA.51.009

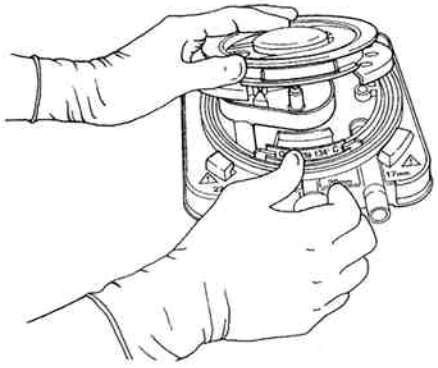
Step 5

Remove the ring from inside the top of the bellows.

AA.51.010

Step 6

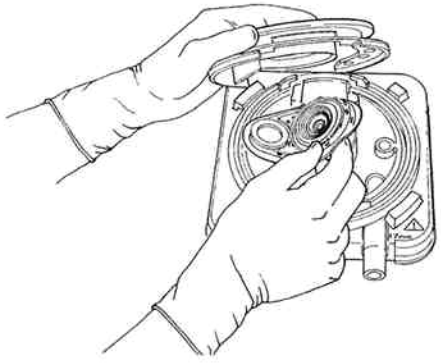
Push the latch toward the center and remove the rim.



AA.51.011

Step 7

Remove the pressure-relief assembly.

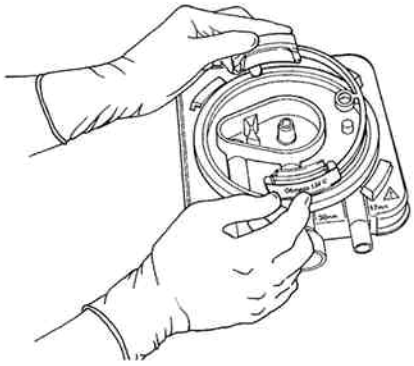


AA.51.012

⚠ **WARNING** Do not disassemble the pressure relief valve. This can damage the seat or diaphragm and cause injury to the patient.

Step 8

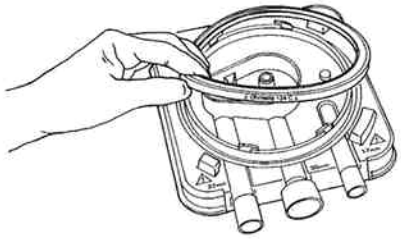
Push the latch towards the center and remove the locking tabs.



AA.51.013

Step 9

Remove the seal.



AA.51.014

Do these steps in the opposite order to assemble the bellows. If you see a dust like powder on the housing or the bellows, apply a thin layer of KRYTOX lubricant to the ribs of the bellows housing. Make sure the lubricant is applied smoothly and there are no lumps.

Make sure that:

- The arrow on the seal points up.
- You hear a double click when you install the rim.
- The rim is locked in position.
- The inner ring is correctly installed inside the top of the bellows.
- Only the bottom ring of the bellows fits over the rim.
- The housing is locked in position. You cannot lift it off.
- The bellows passes the bellows tests

Bellows tests

⚠ WARNING Objects in the breathing system can stop gas flow to the patient. This can cause injury or death:

- Do not use a test plug that is small enough to fall into the breathing system.
- Make sure that there are no test plugs or other objects caught in the breathing system.

⚠ WARNING The bellows assembly test does not replace the preoperative tests. Always complete the tests in the section Preoperative tests before you use the system with a patient.

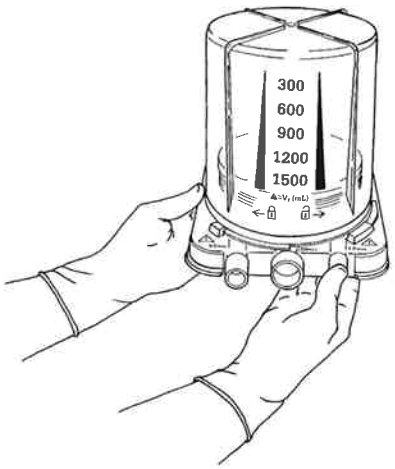
This test makes sure that all components are correctly assembled. It is not an alternative to a complete system checkout.

If the bellows operates correctly, install it in the system.

If there is a problem, disassemble the bellows. Look for and replace damaged parts.

Step 1

Hold the bellows assembly vertical and close the 17 mm port.



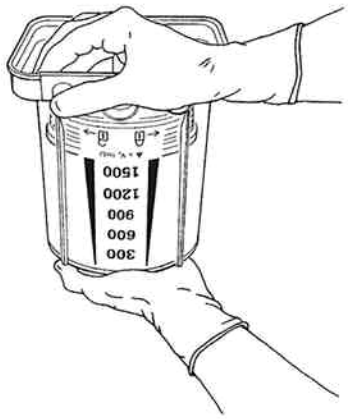
AA.51.015

Step 2

Invert the bellows. They must not fall more than 100 ml/min.

If it does:

- The ports is not tightly sealed.
- The bellows is incorrectly installed.
- The seal inside the bellows is not correctly installed (with its groove pointed up).
- Parts are damaged.



AA.51.016

Step 3

Remove the plug from the port. Permit the bellows to fully extend.

AA.51.017

Step 4

Close the 22 mm port. Then, turn the bellows right side up.

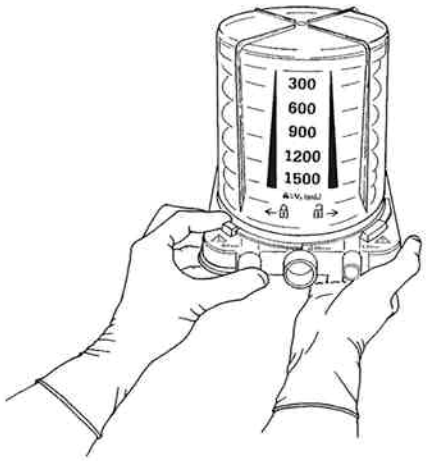
AA.51.018

Step 5

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

If it does:

- The port is not tightly sealed.
- The bellows or the pressure relief valve is not correctly installed.
- Parts are damaged.



AA.51.018

If the result for all the bellows tests was "passed," install it in the system.

Before you use the system, complete the preoperative test procedure. Refer to the Appendix of the System controls, operation, and checkout manual.

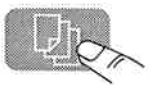
O_2 sensor calibration - 21% O_2

This procedure takes three minutes or less.

You must do the 21% O_2 calibration before the 100% O_2 calibration. During O_2 calibration the screen replaces O_2 data with - -.

Step 1

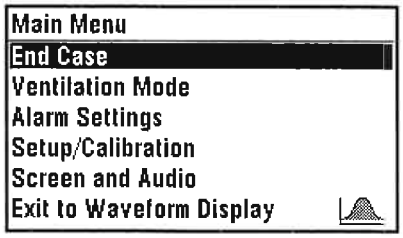
Push the menu key.



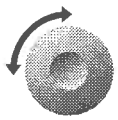
AB.29.013

Step 2

Turn the knob to select **Setup/Calibration** (highlight).



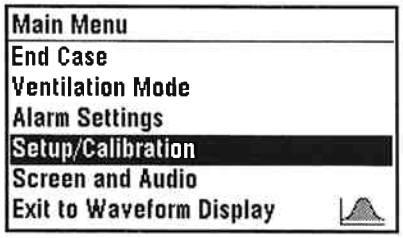
AB48.034



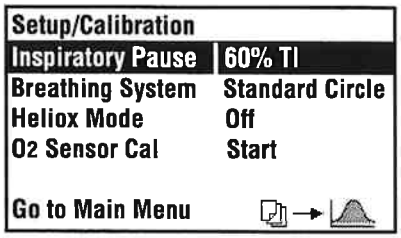
AB29.002

Step 3

Push the knob to show the next screen.



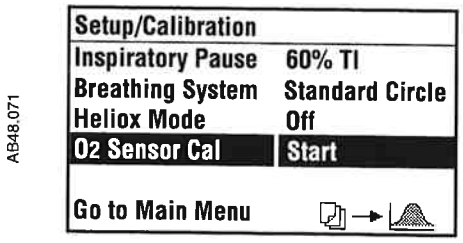
AB48.023

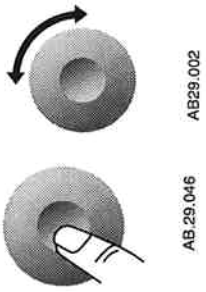


AB48.070

Step 4

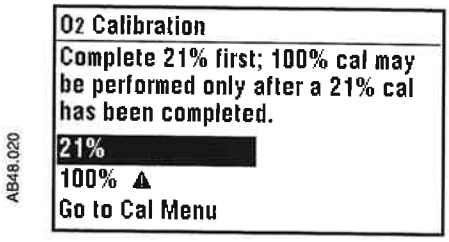
Turn then push the knob to select **O2 Sensor Cal**.





Step 5

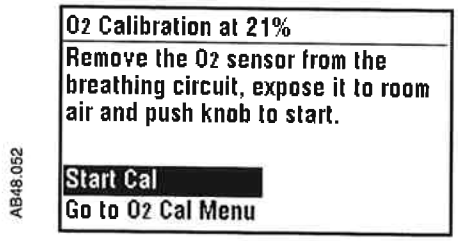
Select 21%. Then, push the knob.

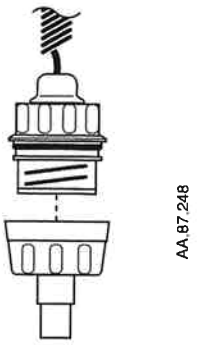


Step 6

Complete the steps shown on the screen.

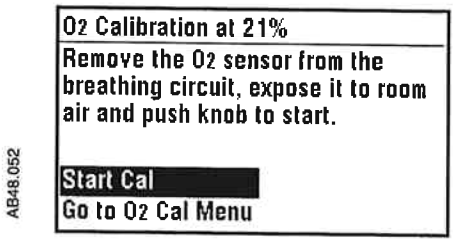
- Do not twist or stress the cable.
- Make sure the cable is connected.





Step 7

Select **Start Cal**.
Then, push the knob.



The screen shows "**Calibrating**", followed by the result (**"Complete"** or **"Failure"**).

After a successful calibration, the screen prompts you to put the O2 sensor back in the circuit.

If the calibration fails:

- Do the calibration again.
- If it still fails do a 100% O2 sensor calibration. If this passes, calibrate at 21% again.

After repeated failures, make sure that the altitude is correct (About Ventilator screen). Then, replace the O_2 sensor.

If the calibration passes, install the O_2 sensor. If necessary, do the 100% O_2 calibration.

Before you use the system, complete the preoperative test procedure. Refer to the operation and maintenance manual for the anesthesia machine.

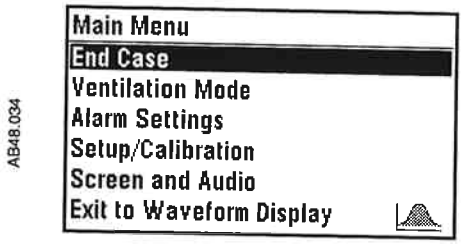
O_2 sensor calibration - 100% O_2

Step 1

Push the menu key.

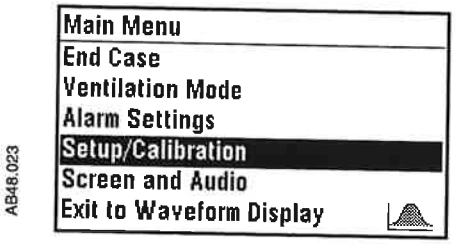
Step 2

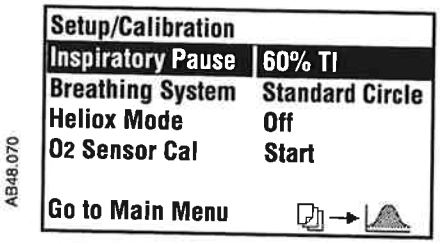
Turn the knob to select **Setup/Calibration** (highlight).



Step 3

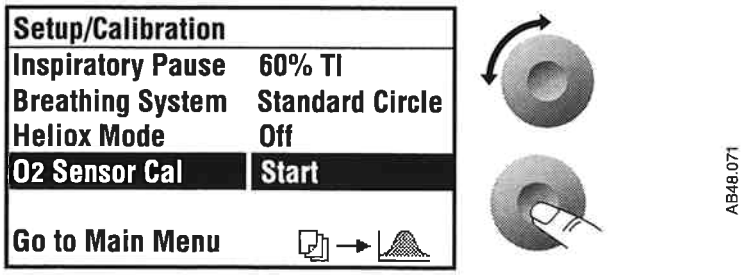
Push the knob to show the next screen.





Step 4

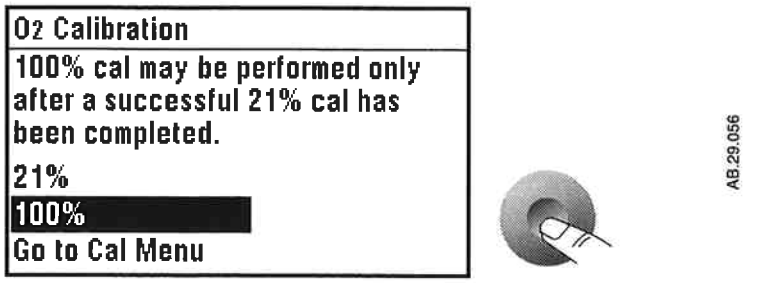
Turn the knob to select **O2 Sensor Cal "Start"** (highlight). Then, push the knob.



Step 5

Select 100%. Then, push the knob.

If ⚠ appears on the screen, you must complete the 21% calibration before you can select the 100% calibration.



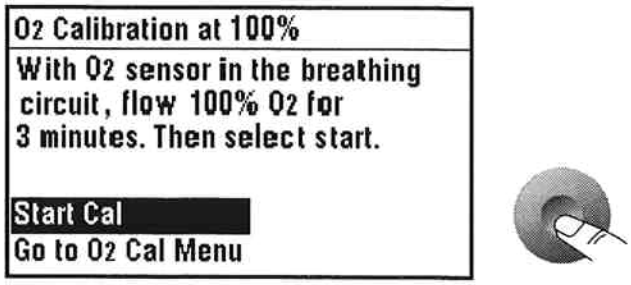
Step 6

With the O_2 sensor in the circuit, fill the circuit with 100% O_2:

- Push the flush button.
- Then flow 100% O_2 at 5 L/min.

Step 7

Select **Start Cal**.
Then, push the knob.



The screen shows "**Calibrating,**" followed by the result ("**Complete**" or "**Failure**").

If the calibration fails:

- Do it again.
- Decrease the airway pressure

After repeated failures, make sure the altitude is correct (About vent...). Then replace the O_2 sensor.

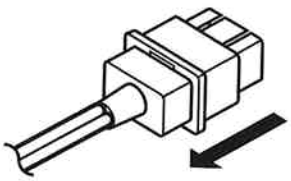
Before you use the system, complete the preoperative test procedure. Refer to the operation and maintenance manual for the anesthesia machine.

Flow sensor calibration

The system automatically corrects for zero offset when you unplug the flow sensor connectors with power on.

Step 1

Disconnect one or both flow sensors.



AA.15.313

Pull back to unlock

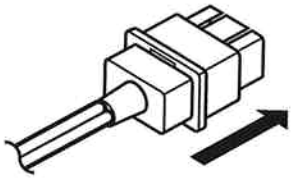
Step 2

When calibration is complete, the screen shows, "No Insp flow sensor" and "No Exp flow sensor"

No Insp Flow Sensor
No Exp Flow Sensor

Step 3

Install the flow sensors.



AA.15.314

Push in to lock

How to prevent water build-up

Why is water build-up a problem?

Pooled water in the sensor or water in the sensing lines causes false alarms and inaccurate measurements. Water in the drive gas hose can increase the baseline pressure between breaths (unintended PEEP).

How much water is too much?

A thin layer of water or a foggy look in the flow sensors is OK. Drops of liquid water is too much.

Where does the water come from?

Water comes from exhaled gas and a chemical reaction between CO_2 and the soda lime in the absorber.

At lower fresh gas flows more water builds up because less gas is scavenged and:

- More CO_2 stays in the absorber to react and produce water.
- More moist, exhaled gas stays in the absorber

Solutions:

- Drain the absorber each morning.
- Drain all hoses as necessary.
- Flow sensor tubes must point up so that they do not collect water.
- If check flow sensor alarms occur during a VERY LONG case, replace the flow sensors. Allow the original flow sensors to dry before you use them again.
- Install a water trap between the flow sensor and the expiratory port of the absorber (Kit stock number 1503-3147-000).

Alarms and Troubleshooting

⚠CAUTION No repair should ever be attempted by anyone not having experience in the repair of devices of this nature.

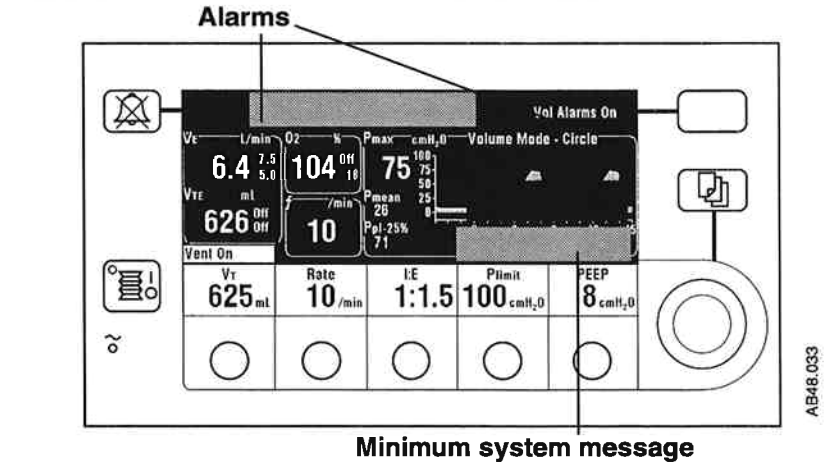
In this section

About alarms

⚠ WARNING If an alarm occurs, safeguard the patient first, before troubleshooting or repair procedures.

Two areas on the screen show alarms. The area at the top of the display shows most alarms. If there are more than 4 alarms at the same time, the lower priority alarms cycle every two seconds.

During severe malfunctions that prevent mechanical ventilation and/or monitoring, the area under the waveform shows minimum system messages. During normal operation, this area shows instructions (push the knob, etc.)



Alarm priority depends on the level of danger to the patient. High priority alarms require immediate attention. If an alarm is related to control settings, the limits flash and a box appears around the parameter.

Priority	Alarm tone	Alarm silence	Note
High	10 tones, 10 sec pause, repeat	120 Seconds or cannot be silenced	Reverse video. Screen shows elapsed time
Medium	3 tones, 25 sec pause, repeat	120 Seconds	----
Low	Single tone	Tone does not repeat	---

Alarm messages have three general causes:

- Malfunctions. Some malfunctions cause reduced function (for example no PEEP). Others prevent mechanical ventilation (Minimum shutdown).
- Patient monitoring. These are high and low limit settings that you adjust.
- Informational. Control settings or system conditions can change operation. For example, if the audible circuit leak alarm is Off, the screen shows "Circuit leak audio Off" as a low priority alarm.

Alphabetical list

The instructions in this section tell you what you can do:

- During a case to protect the patient
- After the case to repair a problem

This table does not include operator instructions.

There are two special types of alarms:

- Minimum monitoring alarms stop mechanical ventilation.
- Minimum shutdown alarms stop mechanical ventilation and monitoring.

Message	Priority	Cause	Action/Concerns	Repair
+15V Analog Out-of- Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
-15V Analog Out-of-Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
12 Hour Test	Low	System in use for more than 12 hours without a power-up self test.	To do the test, move the system switch from Standby to On.	Not necessary. Informational.
A/D Converter Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
All Vent modes Available	Low	A condition that prevented one of the ventilation modes has cleared.	None. Indicates a return to normal operation. Select pressure control of volume control ventilation.	- - -
Apnea Alarm in Standby	Low	Normal condition after End Case, power-up, or ACGO change from On to Off.	Monitoring resumes after first breath (mechanical) or 2 breaths within 30 sec (non-mechanical).	- - -
Apnea Alarm Off	Low	The cardiac bypass option is selected (alarm limit menu).	Apnea alarms are normally turned off when this option is selected.	- - -

Message	Priority	Cause	Action/Concerns	Repair
Aux Comm Gas Outlet On	Medium (low after acknow-ledged)	The outlet selection switch is set to the auxiliary common gas outlet.	Connect the patient circuit to the auxiliary outlet. For mechanical ventilation or manual ventilation with monitoring, select the common gas outlet.	- - -
Battery Charging	Low	The battery is not fully charged. If power fails, the total backup time will be less than 30 minutes.	Leave the system plugged in to charge the battery.	- - -
Battery Current High	Low	Battery current > 4 amps for 10 seconds.	The system continues to operate but may fail.	Contact a qualified service representative.
Battery Failure High	Low	Battery voltage > 16 V for 10 seconds.	The system continues to operate but may fail.	Contact a qualified service representative.
Battery Failure Low	Low	The battery voltage is too low (<7 V) to supply the system if power fails.	The battery does not have enough charge to power the equipment if power fails. Leave the system plugged in to charge the battery.	If the battery does not charge in 24 hours, contact a service representative.
Calibrate Flow Sensors	Low	The last flow sensor calibration failed.	Calibrate the flow sensors. Look for water in the flow sensor tubes. Dry if necessary.	Contact a qualified service representative.
Calibrate O_2 Sensor	Low	O_2% measured by sensor is >110%	Does the sensor measure 21% O_2 in room air?	Calibrate O_2 sensor.
Cardiac Bypass	Low	The alarm limit settings are set for a patient on cardiac bypass. Apnea alarms are off.	Use the alarm limits menu to change this setting.	- - -

Message	Priority	Cause	Action/Concerns	Repair
Check Flow Sensors	Medium (low after acknow-ledged)	No flow or negative flow on inspiratory sensor during inspiration in a circle system or negative flow on expiratory sensor in expiration (for 6 breaths in a row).	Is the correct type of circuit selected (Ventilation setup menu)? Are the flow sensors correctly installed? Are the flow sensor connectors reversed?	Inspect one way valves Replace flow sensors. Check the condition of the flow sensor and its tubing.
Circuit Leak Audio Off	Low	Control setting on the Alarm limit menu.	This message tells you that the audio alarm for circuit leaks was turned off.	- - -
Connect O_2 Sensor	Low	The O_2 sensor is not connected to the cable.	Connect the sensor.	Contact a qualified service representative to replace the cable.
Control Settings Input has Failed	Min. monitoring (Medium)	Ventilator malfunction.	Ventilate manually. Monitoring is still available.	Contact a qualified service representative.
CPU Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
CPU Internal Error	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Display Voltage Out Of Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Exp Flow Sensor Fail	Low	The system cannot read the calibration data stored in the sensor.	Operation continues with default values. Replace the flow sensor.	- - -

Message	Priority	Cause	Action/Concerns	Repair
Exp reverse flow	Medium (low after acknow-ledged)	Flow through the expiratory sensor during inspiration (for 6 breaths in a row).	Look at the check valves Water build up in the flow sensor tubes? Is a flow sensor tube cracked or broken?	Replace the expiratory check valve. Check the condition of the flow sensor.
Flow Valve Failure (DAC) Flow Valve Failure (current)	Min. monitoring (Medium)	Ventilator malfunction.	Ventilate manually. Monitoring is still available.	Contact a qualified service representative.
Gas Inlet Valve Failure	Min. monitoring (Medium) or Min. shutdown (High)[1]	Ventilator malfunction.	Ventilate manually. Monitoring is still available.	Contact a qualified service representative.
Hardware Watchdog Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Heliox Mode is On	Low	Control setting on ventilation setup menu.	When heliox is used, the ventilator must adjust volume calculations.	- - -
High O_2	Medium	O_2% > alarm high limit setting.	Is the limit set correctly? What is the O_2 flow? Did you just push Flush? Does the sensor see 21% O_2 in room air?	Calibrate O_2 sensor. Replace O_2 sensor.
High Paw	High	Paw is greater than Plimit. The ventilator cycles to expiration.	Are Plimit and other controls set correctly? Look for blockages. Check the patient connection.	Calibrate the flow sensors.

Message	Priority	Cause	Action/Concerns	Repair
Pressure Limit Switch Failure	Min. monitoring (Medium)	A pressure safety switch activated at a Paw <90 cm H_2O.	Ventilate manually. Monitoring is still available. Extreme control combinations may cause this alarm. Check control settings.	Contact a qualified service representative.
High Ve	Medium	The minute volume is greater than the set high limit. This alarm is suspended for 9 breaths after you change the ventilator settings.	Check patient for spontaneous breathing. Adjust control settings	- - -
High Vte	Medium	VTE is greater than high alarm limit. This alarm is suspended for 9 breaths after you change the ventilator settings.	Check patient for spontaneous breathing. Check ventilator and alarm settings.	- - -
Insp Flow Sensor Fail	Low	The system cannot read the calibration data stored in the sensor.	Operation continues with default values. Replace the flow sensor.	- - -
Insp Reverse Flow	Medium (low after acknow-ledged)	Flow through the inspiratory sensor during expiration (for 6 breaths in a row).	Look at the check valves Water build up in the flow sensor tubes? Is a flow sensor tube cracked or broken?	Replace the inspiratory check valve. Check the condition of the flow sensor.
Inspiration Stopped	High	Drive gas safety switch activated (high pressure).	Adjust control settings. Check systems for blockages.	- - -
Internal Ventilator Clock Too Fast	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Internal Ventilator Clock Too Slow	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.

Message	Priority	Cause	Action/Concerns	Repair
Low Battery Voltage	Medium	Voltage is <11.65V while using battery power.	Manually ventilate the patient to save power.	Make sure power is connected and circuit breakers are closed. Check ventilator fuse.
Low Drive Gas Pressure	Medium	The ventilator did not detect a rise in internal pressure when the flow valve opened.	Manually ventilate the patient.	Make sure that the appropriate gas supplies (O2 or air) are connected and pressurized.
Low O_2	High	O_2% < alarm low limit setting	Is the limit set correctly? Is the O_2 flow sufficient? Does the sensor see 21% O_2 in room air?	Calibrate O_2 sensor. Replace O_2 sensor. As sensors wear out, the measured % O_2 decreases.
Low Paw	Medium	Paw does not rise at least 4 cm from the lowest pressure measured during the last 20 sec.	Are circuit connections Ok? Look at the Paw gauge on the absorber.	Look for circuit disconnection.
Low Ve	Medium	Exhaled minute volume <low limit alarm setting. This alarm is suspended for 9 breaths after you change the ventilator settings.	Check patient condition. Check tubing connections. Check alarm settings.	- - -
Low Vte	Medium	Exhaled tidal volume <low limit alarm setting. This alarm is suspended for 9 breaths after you change the ventilator settings.	Check patient condition. Check tubing connections. Check alarm settings.	- - -

Message	Priority	Cause	Action/Concerns	Repair
Manifold Pressure Sensor Failure	Min. monitoring (Medium)	Ventilator malfunction.	Ventilate manuall.y	Contact a qualified service representative.
Memory (EEPROM) Fail	Low	The system cannot access some stored values.	Default settings are used. Ventilation is still possible but service is necessary.	Contact a qualified service representative.
Memory (flash) Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Memory (RAM) Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Memory (Redundant Storage) Fail	Min. monitoring (Medium)	Ventilator malfunction.	Ventilate manually. Monitoring is still available.	Contact a qualified service representative.
Memory (video) Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Minimum system shutdown	High	A severe malfunction prevents mechanical ventilation and monitoring. Other alarms may also occur.	Ventilate manually. Use a stand-alone monitor. Cycle system power (On-Standby-On). If the alarm clears, restart mechanical ventilation	Contact a qualified service representative.
Minimum Monitoring	Medium	A severe malfunction prevents mechanical ventilation.Other alarms may also occur.	Ventilate manually. Cycle system power (On-Standby-On). If the alarm clears, restart mechanical ventilation	Contact a qualified service representative.
No Exp Flow Sensor; No Insp Flow Sensor	Medium (low after acknow-ledged)	Electrical signals show the flow sensor is not connected .	Connect the flow sensors.	- - -

Message	Priority	Cause	Action/Concerns	Repair
No O_2 pressure	High (cannot be silenced)	The O_2 supply has failed.	Air flow will continue. Ventilate manually if necessary. Connect a pipeline supply or install an O_2 cylinder.	- - -
O2 Flush Failure	Low	The pressure switch that detects flush flow has seen a very long flush (≥30 sec).	This alarm occurs if you hold down the Flush button for more than 30 seconds.	If the alarm occurs when flush is not in use, contact a qualified service representative.
On Battery-Check Power	Medium (low after acknowledge)	The mains supply is not connected or has failed and the system is using battery power.	Ventilate manually to save power. At full charge, the battery permits approx. 30 min of mechanical ventilation.	Make sure power is connected and circuit breakers are closed. Check ventilator fuse.
Patient Circuit Leak	Medium	Exhaled volume <50% of inspired volume for at least 30 seconds of mechanical ventilation.	Check breathing circuit and flow sensor connections.	- - -
Paw < -10 cmH_2O	High	Subatmospheric pressure (<-10 cm H_2O)	Check patient condition, spontaneous activity? Increase fresh gas flow. Look for high flow through gas scavenging.	Calibrate the flow sensors.[2]With active scavenging, check the negative relief valve on the receiver.
Paw/manifold mismatch	Medium	The ariway pressure and an internal ventilator pressure do not track.	Ventilate manually.	Contact a qualified service representative.
PEEP Not Achieved	Low	Pmin does not reach within 2 cm H_2O of PEEP by the end of mechanical expiration for 6 consecutive breaths.	Check tubing connections. Rate and/or I:E ratio may prevent ventilator from reaching desired PEEP level.	You can turn off the alarm tone for this on the alarm settings page.

Message	Priority	Cause	Action/Concerns	Repair
Positive SIB Vref Out-of- Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Pres Control Available	Low	The ventilator is not fully functional but pressure control mode is available.	VT Compensation is Off. Ventilate manually or in the pressure control mode	- - -
Pres Control Not Avail.	Medium (pressure control); else low	Ventilator not fully functional and pressure control mode not available.	Ventilate manually or in the volume control mode.	Contact a qualified service representative.
Pres/Vol Mon Inactive	Medium (low after acknowledge)	Outlet selection switch is set to aux. gas outlet.	Connect the patient circuit to the aux. gas outlet or set the switch to the common gas outlet for normal operation.	- - -
Replace O_2 Sensor	Low	$O_2\% < 5\%$	Makes sure patient receives O_2. Does the sensor see 21% O_2 in room air? Use different monitor.	Calibrate O_2 sensor. Replace O_2 sensor.
Schedule Service Cal	Low	Internal calibrations are necessary for maximum accuracy.	The system is operational.	Contact a qualified service representative.
Select Gas Outlet	Medium	Fresh gas may not flow to the patient. Aux. gas outlet is On, but flow sensors have seen 3 breaths in patient circuit during the last 30 seconds.	Select the common gas outlet or connect the patient circuit to the aux. outlet.	Note: the bag arm will not ventilate a patient at the aux. outlet.
Software Watchdog Failure	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Sustained airway pressure	Min. shutdown (High)	Paw > 100 cm H_2O for 10 sec.	Check tubing for kinks, blockages, disconnects.	Calibrate the flow sensors.

Message	Priority	Cause	Action/Concerns	Repair
Sustained Paw	High	Paw > sustained pressure limit for 15 seconds[3]	Check tubing for kinks, blockages, disconnects.	Calibrate the flow sensors.
System Leak?	Low	Delivered volumes do not match set volumes.	If you are using Heliox, select Heliox on the ventilator setup menu. Look for leaks in the manifold. Compare set to delivered volumes.	Calibrate the flow sensors. Drain water buildup from the breathing system.
Unable to Drive Bellows	Low	The internal manifold pressure is higher than Paw + tolerance.	Fill the bellows if empty. Set the Bag/Vent switch to "Vent". Drain the drive gas hose.	- - -
Vaux_ref Out-of-Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Vext_ref Out-of-Range	Min. shutdown (High)	Ventilator malfunction.	Ventilate manually. Monitoring is not reliable.	Contact a qualified service representative.
Verify Low VE Limit	Low	The audible circuit leak alarm is Off (Alarm menu) but the low VE alarm is not set.	Set the low VE alarm.	- - -
Volume Apnea	Medium	No mechanical breaths or spontaneous breaths >20 mL in last 30 seconds.	Check patient. Bag as needed. Check for disconnects. If the patient is on a heart lung machine, select Cardiac Bypass on the alarm menu.	- - -
Volume Apnea > 2 min	High	No mechanical breaths or spontaneous breaths >20 mL in last 120 seconds.	See above.	- - -

Message	Priority	Cause	Action/Concerns	Repair
Vt Compensation Off	Medium (low after acknowledge)	The system supplies the set breath but cannot adjust ventilation for compliance and resistance losses, etc.	Adjust VT manually and continue without compensation, or change to the pressure control mode. In pressure control set Pinspir.	Replace the flow sensors and select the mode again. If the problem stops, inspect the two flow sensors.
Vt Not Achieved	Low	Tidal volume measured by inspiratory flow sensor < set value for 6 breaths in a row after the first minute of mechanical ventilation.	Adjust controls to supply adequate tidal volumes. Check I:E; PLimit; and volume settings.	Possible leak.
Vte > Insp Vt	Low	Expired volume > inspired volume for 6 breaths with a circle breathing system.	Check patient condition. Is the correct patient circuit selected (Ventilation Setup menu)?	- - -

1. When power is first turned on.
2. Flow sensors are also used to measure pressures.
3. The sustained pressure threshold is calculated from the pressure limit setting. When mechanical ventilation is on, the sustained limit is calculated as follows: for pressure limits < 30 cm H_2O, the sustained pressure limit is 6 cm H_2O; for Plimit between 30 and 60 cm H_2O, the sustained limit is 20% of the pressure limit (Plimit); for pressure limits >60 cm H2O, the sustained pressure limit is 12 cm H_2O. If both PEEP and Mechanical ventilation are on, the sustained pressure limit increases by PEEP - 2 cm H_2O (the compensated weight of the bellows). When mechanical ventilation is off, the sustained pressure limit is calculated as follows: for pressure limits ≤ 60 cm H_2O, the sustained pressure limit is50% of the pressure limit (Plimit); for pressure limits >60 cm H_2O, the sustained pressure limit is 30 cm H_2O.

Electrical problems (power failure, etc.)

⚠WARNING If a circuit breaker opens frequently, do not use the system. Have an approved service representative repair the system.

Symptom	Problem	Solution
Mains indicator is not ON.	The electrical power cable is not connected.	Connect the power cable.
	A circuit breaker or fuse is open (function of the power supply or auxiliary outlet box).	Close the circuit breaker. Refer to the outlet box information
	The power cable is damaged.	Replace the power cable.
	The electrical socket the power cable connects to has no power.	Use a different electrical socket.

Illustrated parts

In this section

Top level parts

Item	Description (Figure 6-1)	Stock Number
1	Exhalation valve assembly[1]	1503-3001-000
2	Dual hose Exhause Drive Gas	1503-3062-000
3	Inlet filter /bowl assembly complete	1500-3319-000
4	Filter maintence kit	1500-3320-000
5	Cable, O_2 sensor	1503-3087-000
6	O_2 sensor, cell	6050-0004-110
	O-ring	1406-3466-000
7	Adapter	1503-3084-000
8	Autoclavable Bellows Assembly[2]	1500-3382-000
9	Flow sensor (22 mm plastic)	1503-3067-000
	Flow sensor (15 mm plastic)	1503-3066-000
	Not Shown	**Stock Number**
	Circuit water trap assembly	1503-3147-000
	Bottle and o-ring for above	1503-3150-000
	Water trap o-ring (package of 5)	1503-8031-000
	GMS Bain Circuit Adapter Kit	0236-0483-800
	Stand Alone Bain Circuit Adapter	0216-6498-802

1. Figure 6-2 shows individual part
2. Figure 6-3 shows individual parts

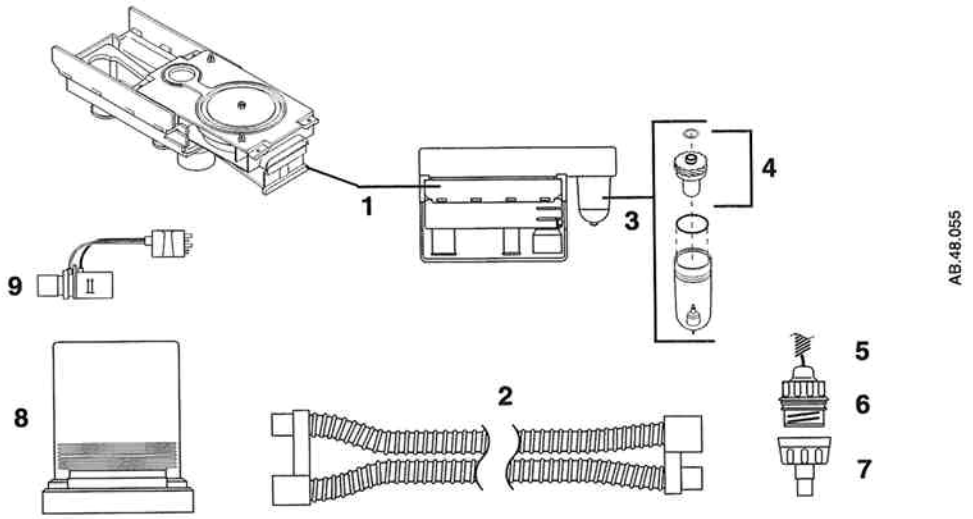


Figure 6-1 • Top level components

Expiratory valve parts

Item	Description (Figure 6-2)	Stock Number
1	Diaphragm/gasket assembly	1503-3000-000
2	Exhalation valve seal	Service kit
3	O-ring, large	1503-3059-000
4	O-ring, small	1503-3058-000
5	Exhalation manifold, lower body	In repair kit
6	Exhalation manifold, upper body	In repair kit
7	Gasket	1503-3048-000

Service kit; items 2-7, (1) each; item 1, qty (2)	1503-8004-000

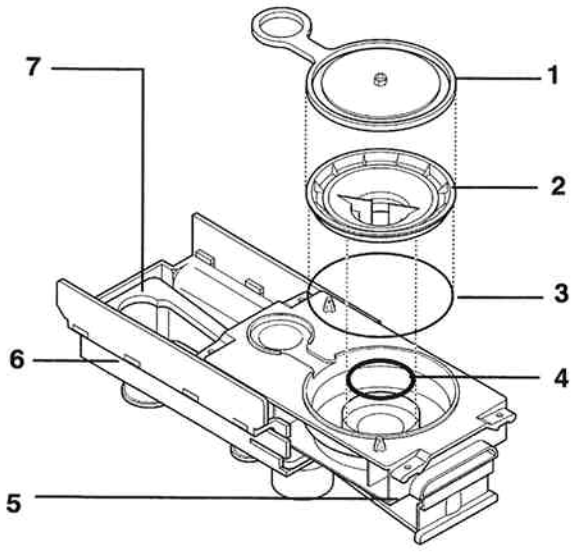


Figure 6-2 • Expiratory valve parts

Bellows parts

Item	Description (Figure 6-3)	Stock Number
1	Housing	1500-3117-000
2	Bellows	1500-3378-000
3	Rim	1500-3351-000
4	Pressure relief valve (complete)	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 (Figure 6-3)	**Stock Number**
	Mounting screws; qty 4; 10-32 x 1/2 sat	9211-1050-106
	Disc /ring/bumper assy for bellows	1500-3381-000
	GMS/ABA manifold	1503-3072-000

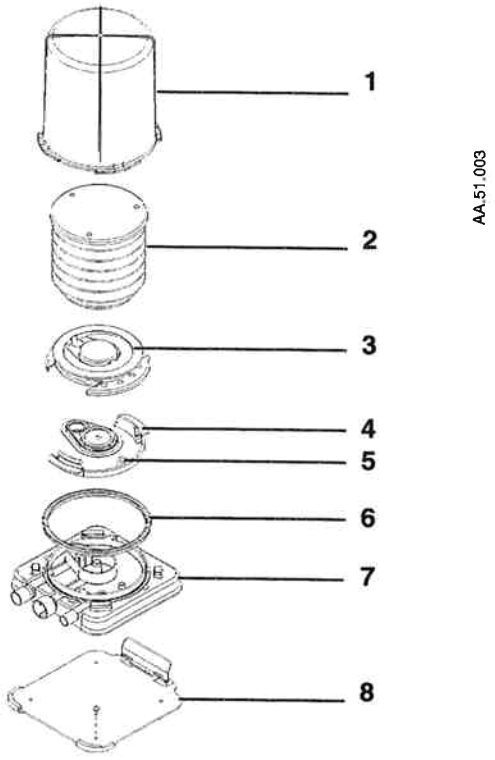
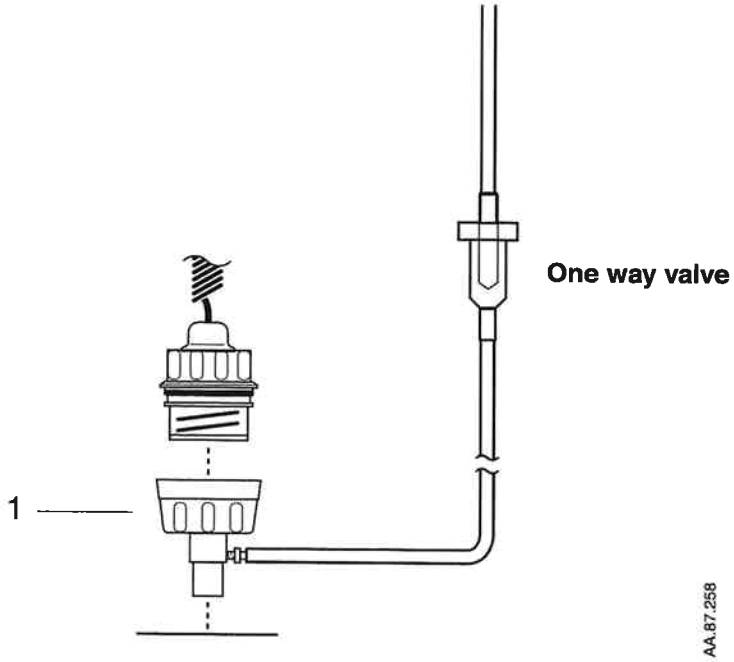


Figure 6-3 • Expiratory valve parts

O2 sensor connections for auxiliary com. gas outlet



Item	Description (Figure 6-3)	Stock Number
1	O_2 sensor adapter with T	1001-8866-000

Test tools

Description	Stock Number
Test lung	0219-7210-300
Test plug	2900-0001-000

External Communications

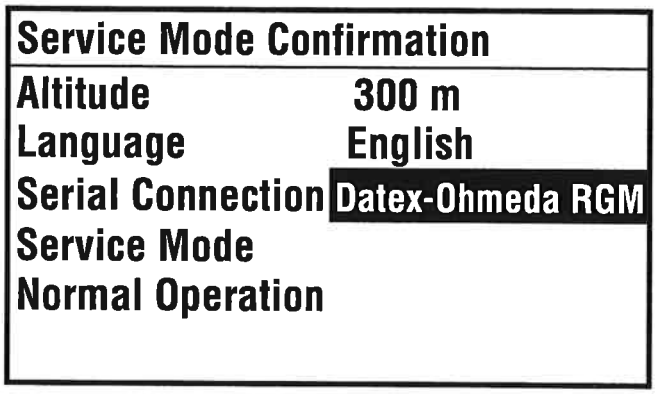
In this section

This section describes how to communicate between the ventilator and a data collection system or an external monitor. It also tells you what data can be sent and received.

External communications

The ventilator has electrical interfaces (RS-232C) on each of two connectors. These RS-232 connectors are used for serial input/output of commands and data. Both channels let you input and output commands and data.

Use the service menu to set external communications.



Protocol Selection	Application	Model /Version
Datex-Ohmeda RGM	Ohmeda RGM Resp. Gas. Monitor.	Version 3.0-5.1 (w/o gas comp data) Version 6.0 and later (includes gas composition data)
7800 Emulation	Monitors programmed to communicate with 7800	HP ACMS with compatible software. Use Datex-Ohmeda Cable 1503-3077-000
Datex-Ohmeda COM 1	HP ACMS Vue Link; monitors programmed for 7900 communication)	VueLink model M1032A with compatible driver and cable
Datex-Ohmeda COM 2	HP ACMS	HP ACMS with compatible software. Use Datex-Ohmeda Cable 1503-3077-000

Program devices not specifically listed using COM 1.

Protocol Description (Datex-Ohmeda Com 1)

Electrical Interface

- RS-232C signal standards
- 15 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 Com 2.0 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<CR>=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,?, - ; example: 1000 equals 10.00 L
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 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.

:VTQaaaabbbddddeeffgggghhiijjjkkkllllmmmnnnoooqrrrrrrrrrrrrc<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 (e.g. 650 = 65.0 L)
kkk	low minute volume alarm limit	L*10 (e.g. 050 = 5.0 L)
lll	high Vte limit	mL/10 (e.g. 150 =1500 ml)
mmm	low Vte limit	mL/10 (e.g. 090 =900 ml)
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

The status bytes are a string of 12 bytes, starting from the left (Byte 1) to the right (Byte 12). Each Byte has eight bits of data from D7 (MSB) to D0 (LSB).

bit **byte 1**

Vent. Message
D0 - High O_2
D1 - Low O_2
D2 - 1
D3 - 1
D4 - 1
D5 - Check O_2 Sensor
D6 - O_2 Calibration Error

bit **byte 2**

Vent. 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**

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

bit **byte 4**

Vent. 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**

Vent. 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

bit **byte 6**

Vent. Message
D0 - Bellows Empty
D1 - Flow Valve Failure
D2 - Gas Inlet Valve Failure
D3 - 12 Hour Test
D4 - "Bootup GIV Failure"
D5 - No O_2 Pressure
D6 - No Fresh Gas Flow

bit **byte 7**

Vent. 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**

Vent. 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**

Vent. 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**

Vent. 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**

Vent. 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**

Vent. Message
D0 - Volume Mode Active
D1 - Apnea Detect ON
D2 - Apnea Alarm Silenced
D3 - Very Low VE Limit
D4 - Alarms Silenced
D5 - 1
D6 - 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/Aestiva
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 H_2O
scale:

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

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

raw	scaled	xmit.
-100	512	"200"
0	2048	"800"
+100	3584	"E00"

Volume
range: 0 - 2 L
scale:

raw	scaled	xmit.
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.

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.

Volume

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.

Specifications and Theory of operation

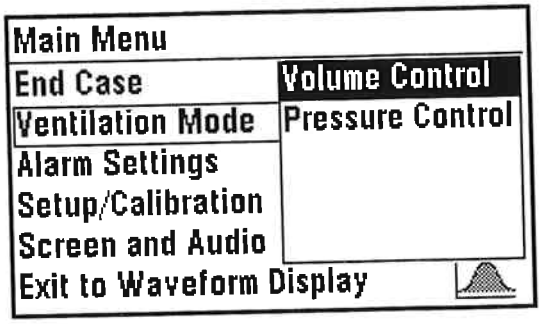
In this section

Ventilator Modes

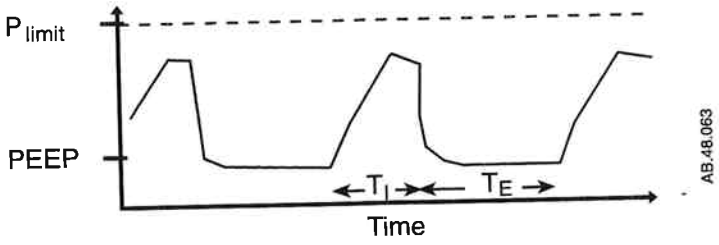
The system has two modes of mechanical ventilation:

- Volume control mode
- Pressure control mode

Use the main menu to set the mode.



Volume control mode



Volume control supplies the set tidal volume during inspiration. The ventilator calculates a set flow and the length of the inspiratory period from the I:E and frequency settings. An optional inspiratory pause can be set to improve gas distribution in the lungs.

To make sure that the set flow is actually delivered, the ventilator adjusts gas flow to the bellows based on measured inspiratory volumes. This is called tidal volume compensation.

Control settings

- V_T(tidal volume)
- Rate
- I:E
- Plimit
- PEEP

Pressure control mode

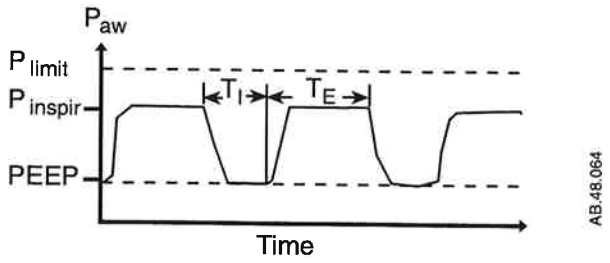


Figure 8-1 • Pressure control diagram

- Pressure control supplies a constant set pressure during inspiration. The ventilator calculates the inspiratory time from the frequency and I:E ratio settings. A high initial flow pressurizes the circuit to the set inspiratory pressure. The flow then decreases to maintain the set pressure (Pinspired).
- Pressure sensors in the ventilator measure patient airway pressure in the inspiratory limb and manifold pressure in the ventilator. These pressures permit the ventilator to adjust the flow to get set inspiratory pressure.

Control settings

- Pinsp (control pressure)
- Rate
- I:E
- PLimit (pressure limit)
- PEEP

How the ventilator operates (theory)

Basics:

The ventilator calculates inspiratory and expiratory times from the control settings.

The flow valve controls flow to the patient. During inspiration, flow through the valve closes the exhalation valve and pushes the bellows down. A small quantity of gas bleeds through a resistor to help keep the pressure on the exhalation valve constant. At high airway pressures, this can cause a slight hiss during inspiration

⚠WARNING Do not try to silence the pneumatic resistor. If it is blocked, the ventilator can malfunction and cause patient injury.

During expiration, the expiratory valve opens and the bellows fill. A small flow from the inspiratory valve may continue. This pressurizes the bellows housing and the expiratory valve to supply PEEP pressure.

Volume and pressure monitoring

The inspiratory flow sensor measures:

- Inspiratory pressure (used for Paw monitoring and to adjust output in the pressure control mode)
- Inspiratory flow (used to adjust output in the volume control mode and for self tests[1])

The expiratory flow sensor measures expiratory flow (used for volume monitoring and alarms).

The ventilator monitors electrical connections to the flow sensors to make sure they are connected.

Each sensor also contains calibration data stored at the time of manufacture. If the data cannot be read, the system shows "Flow Sensor Failure."

The flow sensors use a change in internal diameter to generate a pressure drop that is proportional to the flow through the sensor. The clear tubes connect to pressure transducers inside the anesthesia machine.

⚠WARNING Always connect the expiratory flow sensor. If it is not connected, the patient disconnect alarm can not operate correctly.

Volume control logic

The ventilator calculates the flow/sec that will supply the tidal volume, looks up the current the flow valve needs to supply this flow, and sets the initial valve current.

---

1. Self test example: If the expired tidal volume is larger than the inspired volume (physically impossible) the ventilator alarms.

The inspiratory flow sensor measures the actual volume and the valve current is adjusted until the actual volume equals the target volume.

Pressure control logic

The ventilator sets an initial current to the flow valve. Based on the pressure at the inspiratory flow sensor, the ventilator adjusts the current to supply the set inspiratory pressure (PEEP + Pinsp control).

Common questions

The ventilation setup menu asks me to select the type of breathing circuit - is this really necessary?

Yes. Different circuits have different flow patterns. If you select the incorrect circuit type, the ventilator will alarm for reverse flow and check flow sensor. Volume monitoring may also be less accurate.

For example, with a bain circuit:

- The inspiratory and expiratory flow sensors may see flow during both inspiration and expiration. In a circle system, this causes a reverse flow alarm.
- The expiratory flow sensor sees the tidal volume plus the fresh gas flow. In a circle system, this is a malfunction (out > in + tolerance).

The ventilation setup menu asks me to select Heliox mode On or Off - why?

To calculate volumes from pressure differences, the ventilator needs to know the gas density. The density of heliox mixtures is quite different from normal air/O2/N2O mixtures. If the heliox setting is incorrect, the measured volumes and airway pressures will be incorrect.

What is volume compensation?

The ventilator uses feedback from the inspiratory sensor to help supply the set breath.

The inspiratory flow and airway pressure are measured at the inspiratory flow sensor. The ventilator compares these values to the control settings and adjusts its output.

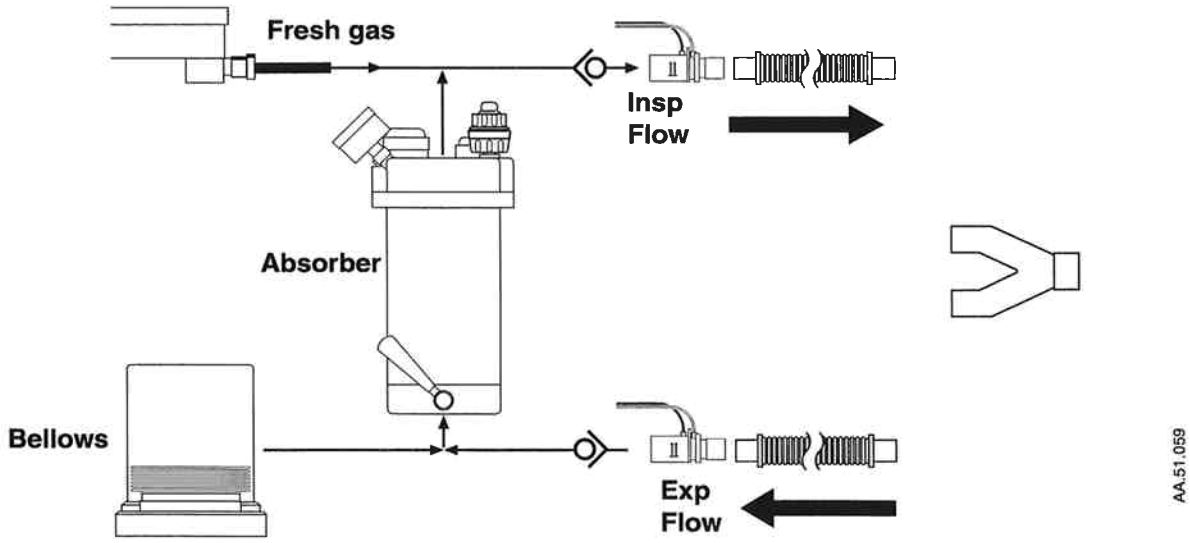
In pressure control mode, the ventilator compares the circuit pressure (Paw) to the inspiratory pressure (PEEP + Pinsp). Because Paw is the same throughout the circuit, compensation includes leaks and compression losses between the ventilator and the patient.

In volume control mode, the ventilator compares the flow at one location (inspiratory flow sensor). Losses after the flow sensor are not included.

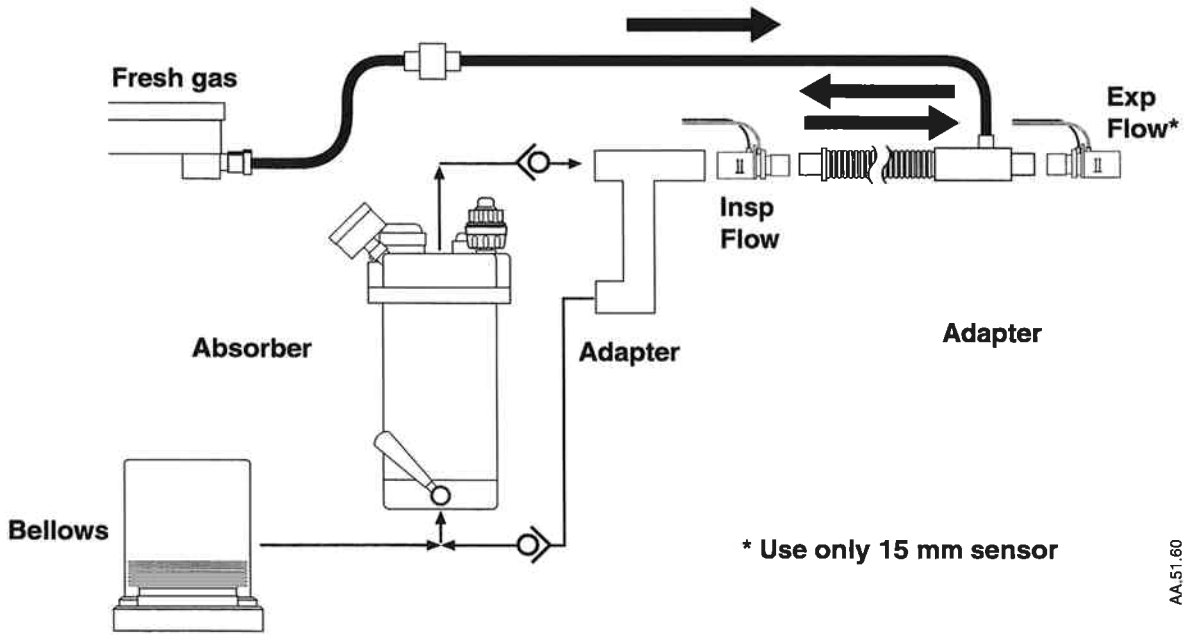
The same flow sensor cannot adjust and monitor. This means that volume compensation stops if one of the flow sensors fails, becomes disconnected, fills with water, etc.

Breathing system schematics

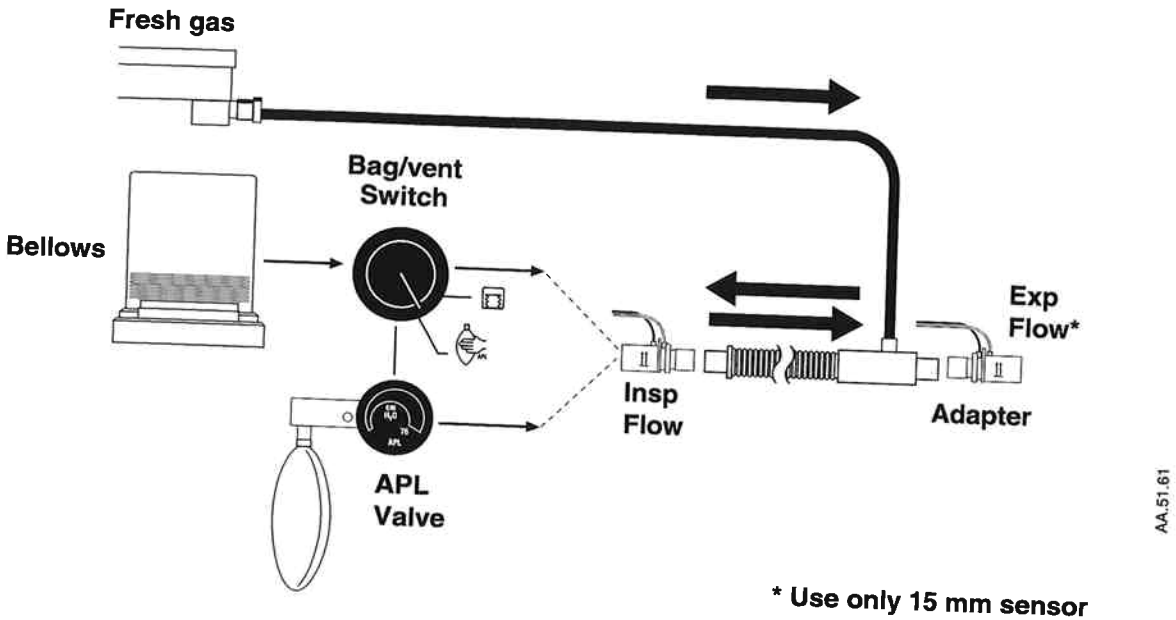
Standard circle



GMS Bain



Bain/Mapleson D



*** Use only 15 mm sensor**

Internal signal schematic

The schematic shows how the ventilator processes data. Pictures represent the parts that you can interact with outside the ventilator.

Text under the titles tells you what the different parts do. Two general terms are used, analog and digital:

- Digital is two level logic. A switch is open or closed, on or off, a voltage level is high (logic 1) or low (logic 0), etc.
- Analog is a continuous set of values. The airway pressure can be any value. Variable currents adjust how far open some electrical valves are. Etc.

The microprocessor uses digital logic and binary math (1 and 0). Two converters link the analog circuits to the microprocessor:

- The analog to digital converter changes analog signals (mostly from monitoring data) to the binary equivalent.
- The digital to analog converter changes digital signals (mostly commands and valve controls) to the current or voltage equivalents.

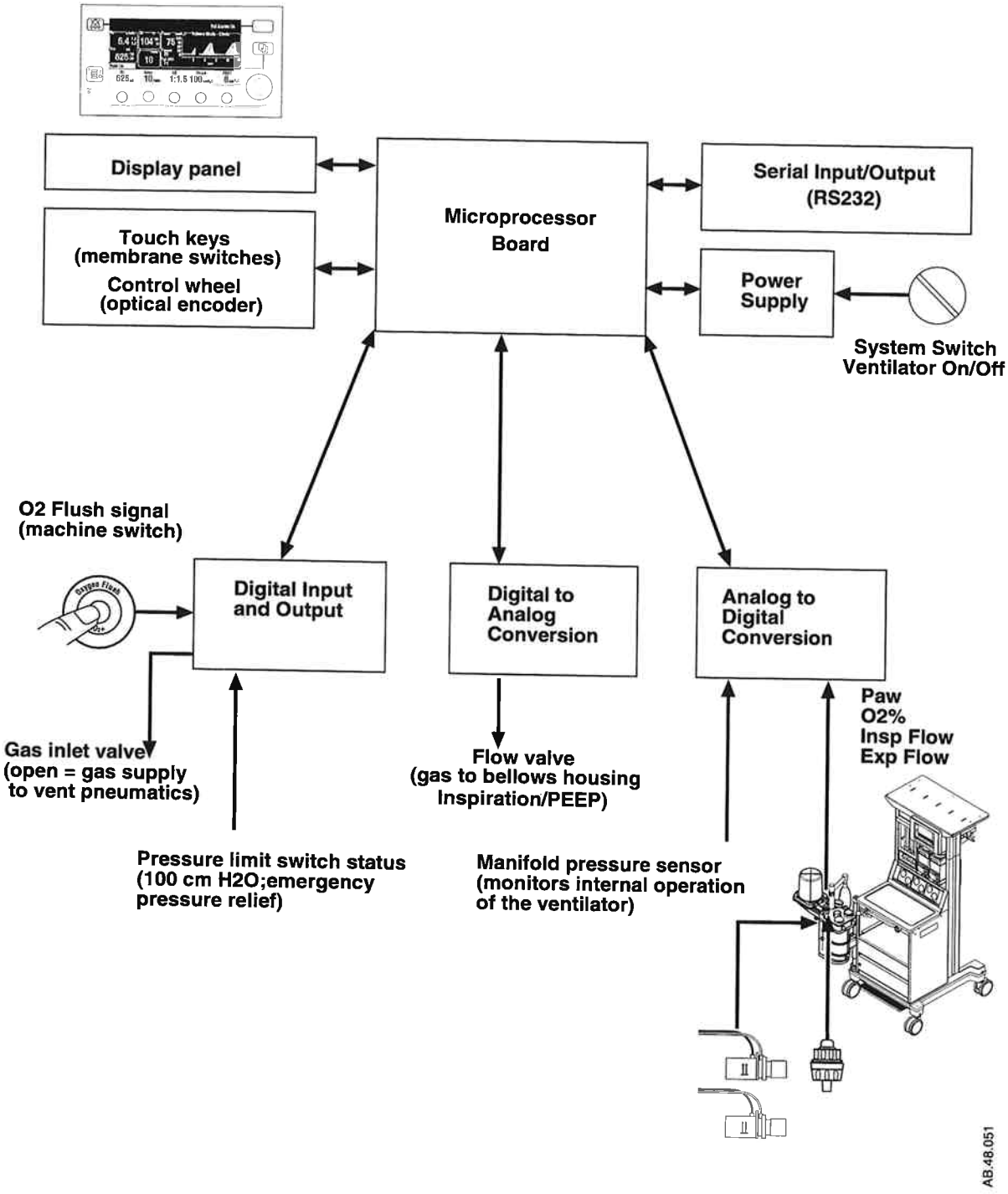


Figure 8-2 • Internal signals

Electrical power

Supply voltage

100-120 or 220-240 Vac ± 10% at 50 or 60 Hz

54.5 Watts

System leakage current limit - do not exceed

UL and CSA rated systems (USA and Canada) <100 µamps for the system and all systems connected to electrical outlets.

IEC rated systems (Not USA and Canada) <300 µamps for the system and all systems connected to electrical outlets.

Note: Products connected to the electrical outlets may increase the leakage current above these limits.

Resistance to ground:

<0.1 Ω

Battery Information

A sealed lead acid battery supplies battery backup for the SmartVent. The SmartVent is not a portable unit. Batteries are used as back up power in case of a power failure. Thus the battery is in a float charge state most of the time. Batteries meet the following:

1. Capacity to operate for 30 minutes.
2. Unit functions to specifications through the transition to battery power.
3. Long float charge life.
4. Battery pack is internally fused - in line replaceable
5. Battery terminals and connecting wires are protected against short circuits.

Only qualified service representatives are to replace the battery. Batteries must be disposed of in accordance with applicable regulatory requirements in effect at the time and place of disposal.

Electro-magnetic Compatibility

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

Immunity Levels: The SmartVent 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)

ImmunityIEC 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

Physical specifications

All specifications are approximate values and can change without notice.

Weight: 15 kg

Size
Height 15 cm
Width 25 cm
Depth 38 cm

Ventilator display: 7.6 x 15.2 cm

Environmental requirements

Temperature

Operation	10 to 40 °C, (Oxygen cell operates to specifications at 10 to 40 °C)
Storage	-20 to 70 °C Oxygen cell storage is -5 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	525 to 795 mmHg (3,000 to -100 meters)

Ventilation Operating Specifications

Pneumatics

Gas Source	Anesthesia System

Gas Composition	Medical Air or O_2
Nominal Supply Pressure	350 kPa
Pressure Range at Inlet	240 to 700 kPa
Peak Gas Flow	120 L/m @ 240 kPa, 0.75 seconds
Continuous Gas Flow	80 L/m @ 240 kPa
Flow valve range	1 to 120 L/min at 240kPa.

Fresh gas compensation

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

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	20 to 1500 mL
Minute volume	0.0 to 99.9 liters, 0.1 liter resolution
Breath rate	4 to 100 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 cell
Measurement range	0 to 100% O_2
Measurement accuracy	Better than ± 3% of full scale
Cell response time	35 seconds[1]
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.

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

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
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

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 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.)

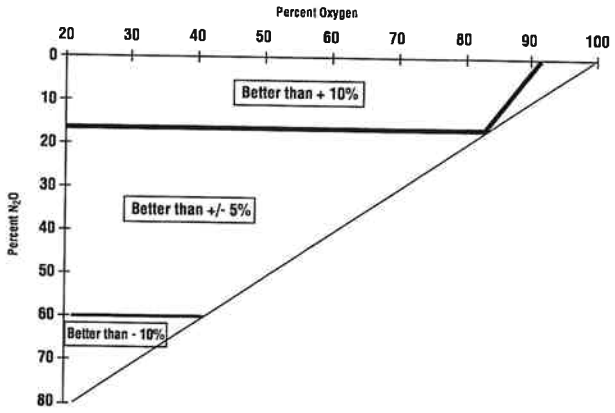


Figure 8-3 • Gas Composition Related Errors (Both Modes)

Heliox Mode

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

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

1. Accuracy evaluated at the ventilator outlet.
2. This is not a normal operating mode. The ventilator is operating in an irregular condition.

This Product is sold by Datex-Datex-Ohmeda under the warranties set forth in the following paragraphs. Such warranties are extended only with respect to the purchase of this Product directly from Datex-Ohmeda or Datex-Ohmeda's Authorized Dealers as new merchandise and are extended to the Buyer thereof, other than for the purpose of resale.

For a period of twelve (12) months from the date of original delivery to Buyer or to Buyer's order, but in no event for a period of more than two years from the date of original delivery by Datex-Ohmeda to an Datex-Ohmeda Authorized Dealer, this Product, other than its expendable parts, is warranted against functional defects in materials and workmanship and to conform to the description of the Product contained in this operation manual and accompanying labels and/or inserts, provided that the same is properly operated under the conditions of normal use, that regular periodic maintenance and service is performed and that replacements and repairs are made in accordance with the instructions provided. This same warranty is made for a period of thirty (30) days with respect to expendable parts. The foregoing warranties shall not apply if the Product has been repaired other than by Datex-Ohmeda or in accordance with written instructions provided by Datex-Ohmeda, or altered by anyone other than Datex-Ohmeda, or if the Product has been subject to abuse, misuse, negligence, or accident.

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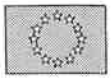

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