7900 Smart Vent

Supplement to the Excel SE and Modulus SE manuals


Setup
Cleaning and Sterilization
Maintence and Troubleshooting
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, 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.

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.

1503-0231-000 2/9/99
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Introduction

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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.
Introduction

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:

- On (power)
- 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
- 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
- Dangerous Voltage
- Input
- Output
- Stock Number
- Serial Number
Equipotential

Variability

Variability in steps

Plus, positive polarity

Minus, negative polarity

Lamp, lighting, illumination

Movement in one direction

Movement in two directions

Lock

Unlock

134°C

Autoclavable

Bag position/ manual ventilation

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.

Read top of float.

Vacuum inlet

Suction bottle outlet

O₂ Flush button

Cylinder

Isolation transformer

Linkage system

Risk of Explosion.

Low pressure leak test

Mechanical ventilation
Open drain (remove liquid)  

Inspiratory flow  

O₂ sensor connection.

Close drain  

Expiratory flow
# 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.

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

## Operator maintenance

### Minimum Frequency  Maintenance

<table>
<thead>
<tr>
<th>Daily</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clean the external surfaces.</td>
</tr>
<tr>
<td></td>
<td>21% O₂ calibration (circuit O₂ sensor).</td>
</tr>
<tr>
<td></td>
<td>Flow sensor calibration</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weekly</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Disconnect flow sensors (automatic calibration)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monthly</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% O₂ calibration (circuit O₂ sensor).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>During cleaning and setup</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inspect the parts for damage. Replace or repair as necessary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annually</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Replace the o-rings and gaskets in the expiratory valve.</td>
</tr>
<tr>
<td></td>
<td>Replace the o-ring on the supply gas hose.</td>
</tr>
<tr>
<td></td>
<td>Replace the supply gas filter (some models).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>As necessary</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drain the water trap (some models)</td>
</tr>
<tr>
<td></td>
<td>Replace the circuit O₂ sensor.</td>
</tr>
<tr>
<td></td>
<td>Replace the disposable flow sensors (plastic) ¹</td>
</tr>
</tbody>
</table>

1. Under typical use the sensor meets specifications for 3 months
**Datex-Ohmeda approved service**

<table>
<thead>
<tr>
<th>Minimum Frequency</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annually</td>
<td>Have an qualified service person do the service tests and scheduled service maintenance.</td>
</tr>
</tbody>
</table>
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 O₂ 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.

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Summary

Refer to your hospital's infection control policy.
Replace damaged parts with components made or sold by Datex-Ohmeda.

- Autoclave (134°C) or wash (mild detergent pH <10.5)
- Refer to cleaning/disinfection procedure.
- Wipe with a damp cloth.

Figure 2-1 • Summary
## Basic cleaning and sterilization

<table>
<thead>
<tr>
<th>Item</th>
<th>To clean</th>
<th>Autoclavable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control module</td>
<td>wipe with neutral detergent and rinse</td>
<td>No</td>
</tr>
<tr>
<td>Bellows assembly</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
<tr>
<td>Flow sensors (plastic)</td>
<td>refer to cleaning procedure</td>
<td>No</td>
</tr>
<tr>
<td>Exhalation valve block</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
<tr>
<td>Oxygen sensor</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>No</td>
</tr>
<tr>
<td>Oxygen sensor adapter</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
<tr>
<td>Clear plastic areas</td>
<td>water dampened cloth</td>
<td>No</td>
</tr>
<tr>
<td>Dual hose and manifold</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
<tr>
<td>GMS interface manifold</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
<tr>
<td>MAS interface manifold</td>
<td>wipe with neutral detergent (Ph 7 to 10.5) and rinse</td>
<td>Autoclavable</td>
</tr>
</tbody>
</table>
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 O₂ 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

Upside down

Normal
Special requirements

- To clean the circuit O₂ 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 O₂ sensor or flow sensor connector in liquid.

⚠️ Do not autoclave the Circuit O₂ 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. COMPLETELY 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 O₂ monitoring with this equipment. Refer to local standards for mandatory monitoring. European Standard EN 740 requires CO₂ monitoring during ventilation.

**Important**

**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.

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

**Δ** 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.

**Δ** 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.

**Δ** 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.

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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

Fresh gas

Insp Flow

Absorber

Exp Flow

Bellows

GMS Bain

Fresh gas

Insp Flow

Exp Flow*

Absorber

Adapter

Bellows

* You MUST use a proximal 15 mm sensor
7900 SmartVent

Bain/
Mapleson D

Fresh gas

Bellows

Bag/vent
Switch

Insp
Flow

Exp
Flow*

APL
Valve

Adapter

* You MUST use a proximal 15 mm sensor
Direct connection to auxiliary common gas outlet¹:

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 O₂ 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 O₂ equipment, such as Krytox²¹.

- Do not use lubricants that contain oil or grease. They burn or explode in high O₂ 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.

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</tbody>
</table>

²¹ 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.

Step 2
Remove the assembly:
- Lift the bar (A).
- Pull out the block (B).

Step 3
Remove the valve assembly:
- Gently pull back the tabs on both sides.
- Slide out the assembly.
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.

Step 2
Remove the container.

Step 3
Unscrew the stud and remove the filter.

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.

Step 2
Turn the housing counterclockwise and lift.

Step 3
Remove the bottom edge of the bellows from the rim.

Step 4
Remove the disk from the bellows.
Step 5
Remove the ring from inside the top of the bellows.

Step 6
Push the latch toward the center and remove the rim.

Step 7
Remove the pressure-relief assembly.

⚠️ 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.

Step 9

Remove the seal.

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.
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.

Step 3

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

Step 4

Close the 22 mm port. Then, turn the bellows right side up.
Step 5

The bellows must not fail 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.

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.
**O₂ sensor calibration - 21% O₂**

This procedure takes three minutes or less.
You must do the 21% O₂ calibration before the 100% O₂ calibration. During O₂ calibration the screen replaces O₂ data with - -.

**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 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 O2 sensor.

If the calibration passes, install the O2 sensor. If necessary, do the 100% O2 calibration.

Before you use the system, complete the preoperative test procedure. Refer to the operation and maintenance manual for the anesthesia machine.
O₂ sensor calibration - 100% O₂

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 O₂ sensor in the circuit, fill the circuit with 100% O₂:
- Push the flush button.
- Then flow 100% O₂ 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 O₂ 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.

Step 2

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

Step 3

Install the flow sensors.
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 CO₂ and the soda lime in the absorber.
At lower fresh gas flows more water builds up because less gas is scavenged and:
• More CO₂ 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 .............................................. 5-2
- Alphabetical list ........................................... 5-3
- Electrical problems (power failure, etc.) ................ 5-14
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.)

Alarms

Minimum system message

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.

<table>
<thead>
<tr>
<th>Priority</th>
<th>Alarm tone</th>
<th>Alarm silence</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>10 tones, 10 sec pause, repeat</td>
<td>120 Seconds or cannot be silenced</td>
<td>Reverse video. Screen shows elapsed time</td>
</tr>
<tr>
<td>Medium</td>
<td>3 tones, 25 sec pause, repeat</td>
<td>120 Seconds</td>
<td>----</td>
</tr>
<tr>
<td>Low</td>
<td>Single tone</td>
<td>Tone does not repeat</td>
<td>----</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Message</th>
<th>Priority</th>
<th>Cause</th>
<th>Action/Concerns</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>+15V Analog Out-of-Range</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>-15V Analog Out-of-Range</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>12 Hour Test</td>
<td>Low</td>
<td>System in use for more than 12 hours without a power-up self test.</td>
<td>To do the test, move the system switch from Standby to On.</td>
<td>Not necessary. Informational.</td>
</tr>
<tr>
<td>A/D Converter Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>All Vent modes Available</td>
<td>Low</td>
<td>A condition that prevented one of the ventilation modes has cleared.</td>
<td>None. Indicates a return to normal operation. Select pressure control of volume control ventilation.</td>
<td>- - -</td>
</tr>
<tr>
<td>Apnea Alarm in Standby</td>
<td>Low</td>
<td>Normal condition after End Case, power-up, or ACGO change from On to Off.</td>
<td>Monitoring resumes after first breath (mechanical) or 2 breaths within 30 sec (non-mechanical).</td>
<td>- - -</td>
</tr>
<tr>
<td>Apnea Alarm Off</td>
<td>Low</td>
<td>The cardiac bypass option is selected (alarm limit menu).</td>
<td>Apnea alarms are normally turned off when this option is selected.</td>
<td>- - -</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-------------------------</td>
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<td>-----------------------------------------------------------------------</td>
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<td>-----------------------------</td>
</tr>
<tr>
<td>Aux Comm Gas Outlet On</td>
<td>Medium</td>
<td>The outlet selection switch is set to the auxiliary common gas outlet.</td>
<td>Connect the patient circuit to the auxiliary outlet. For mechanical ventilation or manual ventilation with monitoring, select the common gas outlet.</td>
<td>- - -</td>
</tr>
<tr>
<td>Battery Charging</td>
<td>Low</td>
<td>The battery is not fully charged. If power fails, the total backup time will be less than 30 minutes.</td>
<td>Leave the system plugged in to charge the battery.</td>
<td>- - -</td>
</tr>
<tr>
<td>Battery Current High</td>
<td>Low</td>
<td>Battery current &gt; 4 amps for 10 seconds.</td>
<td>The system continues to operate but may fail.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Battery Failure High</td>
<td>Low</td>
<td>Battery voltage &gt; 16 V for 10 seconds.</td>
<td>The system continues to operate but may fail.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Battery Failure Low</td>
<td>Low</td>
<td>The battery voltage is too low (&lt;7 V) to supply the system if power fails.</td>
<td>The battery does not have enough charge to power the equipment if power fails. Leave the system plugged in to charge the battery.</td>
<td>If the battery does not charge in 24 hours, contact a service representative.</td>
</tr>
<tr>
<td>Calibrate Flow Sensors</td>
<td>Low</td>
<td>The last flow sensor calibration failed.</td>
<td>Calibrate the flow sensors. Look for water in the flow sensor tubes. Dry if necessary.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Calibrate O₂ Sensor</td>
<td>Low</td>
<td>O₂% measured by sensor is &gt;110%</td>
<td>Does the sensor measure 21% O₂ in room air?</td>
<td>Calibrate O₂ sensor.</td>
</tr>
<tr>
<td>Cardiac Bypass</td>
<td>Low</td>
<td>The alarm limit settings are set for a patient on cardiac bypass. Apnea alarms are off.</td>
<td>Use the alarm limits menu to change this setting.</td>
<td>- - -</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-----------------------------</td>
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<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Check Flow Sensors</td>
<td>Medium (low after acknowledged)</td>
<td>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).</td>
<td>Is the correct type of circuit selected (Ventilation setup menu)? Are the flow sensors correctly installed? Are the flow sensor connectors reversed?</td>
<td>Inspect one way valves Replace flow sensors. Check the condition of the flow sensor and its tubing.</td>
</tr>
<tr>
<td>Circuit Leak Audio Off</td>
<td>Low</td>
<td>Control setting on the Alarm limit menu.</td>
<td>This message tells you that the audio alarm for circuit leaks was turned off.</td>
<td>- - -</td>
</tr>
<tr>
<td>Connect O₂ Sensor</td>
<td>Low</td>
<td>The O₂ sensor is not connected to the cable.</td>
<td>Connect the sensor.</td>
<td>Contact a qualified service representative to replace the cable.</td>
</tr>
<tr>
<td>Control Settings Input has Failed</td>
<td>Min. monitoring (Medium)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is still available.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>CPU Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>CPU Internal Error</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Display Voltage Out Of Range</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Exp Flow Sensor Fail</td>
<td>Low</td>
<td>The system cannot read the calibration data stored in the sensor.</td>
<td>Operation continues with default values. Replace the flow sensor.</td>
<td>- - -</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>---------------------------------</td>
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<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Exp reverse flow</td>
<td>Medium (low after</td>
<td>Flow through the expiratory sensor during inspiration (for 6 breaths</td>
<td>Look at the check valves&lt;br&gt;Water build up in the flow sensor tubes?&lt;br&gt;Is a flow sensor tube cracked or broken?</td>
<td>Replace the expiratory check valve.</td>
</tr>
<tr>
<td></td>
<td>acknowledged)</td>
<td>in a row).</td>
<td></td>
<td>Check the condition of the flow sensor.</td>
</tr>
<tr>
<td>Flow Valve Failure (DAC)</td>
<td>Min. monitoring (Medium)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually.&lt;br&gt;Monitoring is still available.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Flow Valve Failure (current)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Inlet Valve Failure</td>
<td>Min. monitoring (Medium)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually.&lt;br&gt;Monitoring is still available.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td></td>
<td>or Min. shutdown (High)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware Watchdog Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually.&lt;br&gt;Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Heliox Mode is On</td>
<td>Low</td>
<td>Control setting on ventilation setup menu.</td>
<td>When heliox is used, the ventilator must adjust volume calculations.</td>
<td>- - -</td>
</tr>
<tr>
<td>High O₂</td>
<td>Medium</td>
<td>O₂% &gt; alarm high limit setting.</td>
<td>Is the limit set correctly?&lt;br&gt;What is the O₂ flow?&lt;br&gt;Did you just push Flush?&lt;br&gt;Does the sensor see 21% O₂ in room air?</td>
<td>Calibrate O₂ sensor. Replace O₂ sensor.</td>
</tr>
<tr>
<td>High Paw</td>
<td>High</td>
<td>Paw is greater than P-limit. The ventilator cycles to expiration.</td>
<td>Are P-limit and other controls set correctly?&lt;br&gt;Look for blockages.&lt;br&gt;Check the patient connection.</td>
<td>Calibrate the flow sensors.</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>----------------------------------</td>
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<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Pressure Limit Switch Failure</td>
<td>Min. monitoring</td>
<td>A pressure safety switch activated at a Paw &lt;90 cm H₂O.</td>
<td>Ventilate manually. Monitoring is still available. Extreme control combinations may cause this alarm. Check control settings.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>High Ve</td>
<td>Medium</td>
<td>The minute volume is greater than the set high limit. This alarm is suspended for 9 breaths after you change the ventilator settings.</td>
<td>Check patient for spontaneous breathing. Adjust control settings.</td>
<td></td>
</tr>
<tr>
<td>High Vte</td>
<td>Medium</td>
<td>VTE is greater than high alarm limit. This alarm is suspended for 9 breaths after you change the ventilator settings.</td>
<td>Check patient for spontaneous breathing. Check ventilator and alarm settings.</td>
<td></td>
</tr>
<tr>
<td>Insp Flow Sensor Fail</td>
<td>Low</td>
<td>The system cannot read the calibration data stored in the sensor.</td>
<td>Operation continues with default values. Replace the flow sensor.</td>
<td></td>
</tr>
<tr>
<td>Insp Reverse Flow</td>
<td>Medium (low after acknowledged)</td>
<td>Flow through the inspiratory sensor during expiration (for 6 breaths in a row).</td>
<td>Look at the check valves. Water build up in the flow sensor tubes? Is a flow sensor tube cracked or broken?</td>
<td>Replace the inspiratory check valve. Check the condition of the flow sensor.</td>
</tr>
<tr>
<td>Inspiration Stopped</td>
<td>High</td>
<td>Drive gas safety switch activated (high pressure).</td>
<td>Adjust control settings. Check systems for blockages.</td>
<td></td>
</tr>
<tr>
<td>Internal Ventilator Clock Too Fast</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Internal Ventilator Clock Too Slow</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low Battery Voltage</td>
<td>Medium</td>
<td>Voltage is $&lt;11.65V$ while using battery power.</td>
<td>Manually ventilate the patient to save power.</td>
<td>Make sure power is connected and circuit breakers are closed. Check ventilator fuse.</td>
</tr>
<tr>
<td>Low Drive Gas Pressure</td>
<td>Medium</td>
<td>The ventilator did not detect a rise in internal pressure when the flow valve opened.</td>
<td>Manually ventilate the patient.</td>
<td>Make sure that the appropriate gas supplies (O2 or air) are connected and pressurized.</td>
</tr>
<tr>
<td>Low O$_2$</td>
<td>High</td>
<td>O$_2$% $&lt; $ alarm low limit setting</td>
<td>Is the limit set correctly? Is the O$_2$ flow sufficient? Does the sensor see 21% O$_2$ in room air?</td>
<td>Calibrate O$_2$ sensor. Replace O$_2$ sensor. As sensors wear out, the measured % O$_2$ decreases.</td>
</tr>
<tr>
<td>Low Paw</td>
<td>Medium</td>
<td>Paw does not rise at least 4 cm from the lowest pressure measured during the last 20 sec.</td>
<td>Are circuit connections Ok? Look at the Paw gauge on the absorber.</td>
<td>Look for circuit disconnection.</td>
</tr>
<tr>
<td>Low Ve</td>
<td>Medium</td>
<td>Exhaled minute volume $&lt;$low limit alarm setting. This alarm is suspended for 9 breaths after you change the ventilator settings.</td>
<td>Check patient condition. Check tubing connections. Check alarm settings.</td>
<td>- - -</td>
</tr>
<tr>
<td>Low Vte</td>
<td>Medium</td>
<td>Exhaled tidal volume $&lt;$low limit alarm setting. This alarm is suspended for 9 breaths after you change the ventilator settings.</td>
<td>Check patient condition. Check tubing connections. Check alarm settings.</td>
<td>- - -</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-------------------------------</td>
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<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Manifold Pressure Sensor Failure</td>
<td>Min. monitoring (Medium)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Memory (EEPROM) Fail</td>
<td>Low</td>
<td>The system cannot access some stored values.</td>
<td>Default settings are used. Ventilation is still possible but service is necessary.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Memory (flash) Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Memory (RAM) Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Memory (Redundant Storage) Fail</td>
<td>Min. monitoring (Medium)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is still available.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Memory (video) Failure</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Minimum system shutdown</td>
<td>High</td>
<td>A severe malfunction prevents mechanical ventilation and monitoring. Other alarms may also occur.</td>
<td>Ventilate manually. Use a stand-alone monitor. Cycle system power (On-Standby-On). If the alarm clears, restart mechanical ventilation</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Minimum Monitoring</td>
<td>Medium</td>
<td>A severe malfunction prevents mechanical ventilation. Other alarms may also occur.</td>
<td>Ventilate manually. Cycle system power (On-Standby-On). If the alarm clears, restart mechanical ventilation</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>No Exp Flow Sensor; No Insp Flow Sensor</td>
<td>Medium (low after acknowledged)</td>
<td>Electrical signals show the flow sensor is not connected.</td>
<td>Connect the flow sensors.</td>
<td>- - -</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>No O₂ pressure</td>
<td>High (cannot be silenced)</td>
<td>The O₂ supply has failed.</td>
<td>Air flow will continue. Ventilate manually if necessary. Connect a pipeline supply or install an O₂ cylinder.</td>
<td>- - -</td>
</tr>
<tr>
<td>O₂ Flush Failure</td>
<td>Low</td>
<td>The pressure switch that detects flush flow has seen a very long flush (≥30 sec).</td>
<td>This alarm occurs if you hold down the Flush button for more than 30 seconds.</td>
<td>If the alarm occurs when flush is not in use, contact a qualified service representative.</td>
</tr>
<tr>
<td>On Battery-</td>
<td>Medium (low after acknowledge)</td>
<td>The mains supply is not connected or has failed and the system is using battery power.</td>
<td>Ventilate manually to save power. At full charge, the battery permits approx. 30 min of mechanical ventilation.</td>
<td>Make sure power is connected and circuit breakers are closed. Check ventilator fuse.</td>
</tr>
<tr>
<td>Check Power</td>
<td></td>
<td></td>
<td></td>
<td>- - -</td>
</tr>
<tr>
<td>Patient Circuit</td>
<td>Medium</td>
<td>Exhaled volume &lt;50% of inspired volume for at least 30 seconds of mechanical ventilation.</td>
<td>Check breathing circuit and flow sensor connections.</td>
<td>- - -</td>
</tr>
<tr>
<td>Leak</td>
<td></td>
<td></td>
<td></td>
<td>- - -</td>
</tr>
<tr>
<td>Paw &lt; -10</td>
<td>High</td>
<td>Subatmospheric pressure (&lt;-10 cm H₂O)</td>
<td>Check patient condition, spontaneous activity? Increase fresh gas flow. Look for high flow through gas scavenging.</td>
<td>Calibrate the flow sensors. With active scavenging, check the negative relief valve on the receiver.</td>
</tr>
<tr>
<td>cmH₂O</td>
<td></td>
<td></td>
<td></td>
<td>- - -</td>
</tr>
<tr>
<td>Paw/manifold</td>
<td>Medium</td>
<td>The airway pressure and an internal ventilator pressure do not track.</td>
<td>Ventilate manually.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>mismatch</td>
<td></td>
<td></td>
<td></td>
<td>- - -</td>
</tr>
<tr>
<td>PEEP Not Achieved</td>
<td>Low</td>
<td>Pmin does not reach within 2 cm H₂O of PEEP by the end of mechanical expiration for 6 consecutive breaths.</td>
<td>Check tubing connections. Rate and/or I:E ratio may prevent ventilator from reaching desired PEEP level.</td>
<td>You can turn off the alarm tone for this on the alarm settings page.</td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------</td>
<td>----------------------------------------------------------------------</td>
<td>------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Positive SIB Vref</td>
<td>Min. shutdown</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Out-of- Range (High)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pres Control Available</td>
<td>Low</td>
<td>The ventilator is not fully functional but pressure control mode is available.</td>
<td>VT Compensation is Off. Ventilate manually or in the pressure control mode</td>
<td></td>
</tr>
<tr>
<td>Pres Control Not Avail.</td>
<td>Medium (pressure control); else low</td>
<td>Ventilator not fully functional and pressure control mode not available.</td>
<td>Ventilate manually or in the volume control mode.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Pres/Vol Mon Inactive</td>
<td>Medium (low after acknowledge)</td>
<td>Outlet selection switch is set to aux. gas outlet.</td>
<td>Connect the patient circuit to the aux. gas outlet or set the switch to the common gas outlet for normal operation.</td>
<td></td>
</tr>
<tr>
<td>Replace O₂ Sensor</td>
<td>Low</td>
<td>O₂% &lt; 5%</td>
<td>Makes sure patient receives O₂. Does the sensor see 21% O₂ in room air? Use different monitor.</td>
<td>Calibrate O₂ sensor. Replace O₂ sensor.</td>
</tr>
<tr>
<td>Schedule Service Cal</td>
<td>Low</td>
<td>Internal calibrations are necessary for maximum accuracy.</td>
<td>The system is operational.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Select Gas Outlet</td>
<td>Medium</td>
<td>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.</td>
<td>Select the common gas outlet or connect the patient circuit to the aux. outlet.</td>
<td>Note: the bag arm will not ventilate a patient at the aux. outlet.</td>
</tr>
<tr>
<td>Software Watchdog Failure</td>
<td>Min. shutdown</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td></td>
<td>(High)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustained airway pressure</td>
<td>Min. shutdown</td>
<td>Paw &gt; 100 cm H₂O for 10 sec.</td>
<td>Check tubing for kinks, blockages, disconnects.</td>
<td>Calibrate the flow sensors.</td>
</tr>
<tr>
<td></td>
<td>(High)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Message</td>
<td>Priority</td>
<td>Cause</td>
<td>Action/Concerns</td>
<td>Repair</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Sustained Paw</td>
<td>High</td>
<td>Paw &gt; sustained pressure limit for 15 seconds³</td>
<td>Check tubing for kinks, blockages, disconnects.</td>
<td>Calibrate the flow sensors.</td>
</tr>
<tr>
<td>System Leak?</td>
<td>Low</td>
<td>Delivered volumes do not match set volumes.</td>
<td>If you are using Heliox, select Heliox on the ventilator setup menu. Look for leaks in the manifold. Compare set to delivered volumes.</td>
<td>Calibrate the flow sensors. Drain water buildup from the breathing system.</td>
</tr>
<tr>
<td>Unable to Drive Bellows</td>
<td>Low</td>
<td>The internal manifold pressure is higher than Paw + tolerance.</td>
<td>Fill the bellows if empty. Set the Bag/Vent switch to &quot;Vent&quot;. Drain the drive gas hose.</td>
<td>- - -</td>
</tr>
<tr>
<td>Vaux_ref Out-of-Range</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Vext_ref Out-of-Range</td>
<td>Min. shutdown (High)</td>
<td>Ventilator malfunction.</td>
<td>Ventilate manually. Monitoring is not reliable.</td>
<td>Contact a qualified service representative.</td>
</tr>
<tr>
<td>Verify Low VE Limit</td>
<td>Low</td>
<td>The audible circuit leak alarm is Off (Alarm menu) but the low VE alarm is not set.</td>
<td>Set the low VE alarm.</td>
<td>- - -</td>
</tr>
<tr>
<td>Volume Apnea</td>
<td>Medium</td>
<td>No mechanical breaths or spontaneous breaths &gt;20 mL in last 30 seconds.</td>
<td>Check patient. Bag as needed. Check for disconnects. If the patient is on a heart lung machine, select Cardiac Bypass on the alarm menu.</td>
<td>- - -</td>
</tr>
<tr>
<td>Volume Apnea &gt; 2 min</td>
<td>High</td>
<td>No mechanical breaths or spontaneous breaths &gt;20 mL in last 120 seconds.</td>
<td>See above.</td>
<td>- - -</td>
</tr>
</tbody>
</table>
### Alarms and Troubleshooting

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

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 H₂O, the sustained pressure limit is 6 cm H₂O; for PLimit between 30 and 60 cm H₂O, the sustained limit is 20% of the pressure limit (PLimit); for pressure limits > 60 cm H₂O, the sustained pressure limit is 12 cm H₂O. If both PEEP and Mechanical ventilation are on, the sustained pressure limit increases by PEEP - 2 cm H₂O (the compensated weight of the bellows). When mechanical ventilation is off, the sustained pressure limit is calculated as follows: for pressure limits < 60 cm H₂O, the sustained pressure limit is 50% of the pressure limit (PLimit); for pressure limits > 60 cm H₂O, the sustained pressure limit is 30 cm H₂O.
**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.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mains indicator is not ON.</td>
<td>The electrical power cable is not connected.</td>
<td>Connect the power cable.</td>
</tr>
<tr>
<td></td>
<td>A circuit breaker or fuse is open (function of the power supply or auxiliary outlet box).</td>
<td>Close the circuit breaker. Refer to the outlet box information</td>
</tr>
<tr>
<td></td>
<td>The power cable is damaged.</td>
<td>Replace the power cable.</td>
</tr>
<tr>
<td></td>
<td>The electrical socket the power cable connects to has no power.</td>
<td>Use a different electrical socket.</td>
</tr>
</tbody>
</table>
Illustrated parts

In this section

- Top level parts ........................................... 6-2
- Expiratory valve parts .................................. 6-3
- Bellows parts ............................................. 6-4
- O₂ sensor connections for auxiliary com. gas outlet 6-5
- Test tools .................................................. 6-5
## Top level parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description (Figure 6-1)</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exhalation valve assembly¹</td>
<td>1503-3001-000</td>
</tr>
<tr>
<td>2</td>
<td>Dual hose Exhause Drive Gas</td>
<td>1503-3062-000</td>
</tr>
<tr>
<td>3</td>
<td>Inlet filter /bowl assembly complete</td>
<td>1500-3319-000</td>
</tr>
<tr>
<td>4</td>
<td>Filter maintence kit</td>
<td>1500-3320-000</td>
</tr>
<tr>
<td>5</td>
<td>Cable, O₂ sensor</td>
<td>1503-3087-000</td>
</tr>
<tr>
<td>6</td>
<td>O₂ sensor, cell</td>
<td>6050-0004-110</td>
</tr>
<tr>
<td></td>
<td>O-ring</td>
<td>1406-3466-000</td>
</tr>
<tr>
<td>7</td>
<td>Adapter</td>
<td>1503-3084-000</td>
</tr>
<tr>
<td>8</td>
<td>Autoclavable Bellows Assembly²</td>
<td>1500-3382-000</td>
</tr>
<tr>
<td>9</td>
<td>Flow sensor (22 mm plastic)</td>
<td>1503-3067-000</td>
</tr>
<tr>
<td></td>
<td>Flow sensor (15 mm plastic)</td>
<td>1503-3066-000</td>
</tr>
</tbody>
</table>

**Not Shown**

- 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

2/8/99 1503-0231-000
# Expiratory valve parts

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

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

![Figure 6-2 • Expiratory valve parts](image)
## Bellows parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description (Figure 6-3)</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Housing</td>
<td>1500-3117-000</td>
</tr>
<tr>
<td>2</td>
<td>Bellows</td>
<td>1500-3378-000</td>
</tr>
<tr>
<td>3</td>
<td>Rim</td>
<td>1500-3351-000</td>
</tr>
<tr>
<td>4</td>
<td>Pressure relief valve (complete)</td>
<td>1500-3377-000</td>
</tr>
<tr>
<td>5</td>
<td>Latch</td>
<td>1500-3352-000</td>
</tr>
<tr>
<td>6</td>
<td>Seal</td>
<td>1500-3359-000</td>
</tr>
<tr>
<td>7</td>
<td>Base</td>
<td>1500-3350-000</td>
</tr>
<tr>
<td>8</td>
<td>Mounting plate</td>
<td>1500-3379-000</td>
</tr>
</tbody>
</table>

### Not Shown (Figure 6-3)  

<table>
<thead>
<tr>
<th>Description</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting screws; qty 4; 10-32 x 1/2 sat</td>
<td>9211-1050-106</td>
</tr>
<tr>
<td>Disc /ring/bumper assy for bellows</td>
<td>1500-3381-000</td>
</tr>
<tr>
<td>GMS/ABA manifold</td>
<td>1503-3072-000</td>
</tr>
</tbody>
</table>

---

![Diagram of Bellows parts](Image)

**Figure 6-3 • Expiratory valve parts**
O2 sensor connections for auxiliary com. gas outlet

<table>
<thead>
<tr>
<th>Item</th>
<th>Description (Figure 6-3)</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>O₂ sensor adapter with T</td>
<td>1001-8866-000</td>
</tr>
</tbody>
</table>

Test tools

<table>
<thead>
<tr>
<th>Description</th>
<th>Stock Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test lung</td>
<td>0219-7210-300</td>
</tr>
<tr>
<td>Test plug</td>
<td>2900-0001-000</td>
</tr>
</tbody>
</table>
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.

Protocol Description (Ohmeda Com 1) ................................... 7-3
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  Serial Communication Parameters ................................. 7-3
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  Waveform Data Response ........................................ 7-9
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.

<table>
<thead>
<tr>
<th>Service Mode Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude</td>
</tr>
<tr>
<td>Language</td>
</tr>
<tr>
<td>Serial Connection</td>
</tr>
<tr>
<td>Service Mode</td>
</tr>
</tbody>
</table>

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

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:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;ESC&gt;VTD</td>
<td>DISABLE CHECKSUM</td>
</tr>
<tr>
<td>&lt;ESC&gt;VTE</td>
<td>ENABLE CHECKSUM</td>
</tr>
<tr>
<td>&lt;ESC&gt;VTQ</td>
<td>ENABLE COMPRESSED MODE</td>
</tr>
<tr>
<td>&lt;ESC&gt;VTS</td>
<td>SLAVE MODE (RESETS AUTO MODE)</td>
</tr>
<tr>
<td>&lt;ESC&gt;VTX</td>
<td>AUTO MODE</td>
</tr>
<tr>
<td>&lt;ESC&gt;VT$</td>
<td>SEND SETUP DATA</td>
</tr>
<tr>
<td>&lt;ESC&gt;VT?</td>
<td>SEND ALL DATA</td>
</tr>
<tr>
<td>&lt;ESC&gt;VTW</td>
<td>ENABLE WAVEFORM DATA</td>
</tr>
</tbody>
</table>

**Response Headers:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>:VTD</td>
<td>MEASURED DATA RESPONSE</td>
</tr>
<tr>
<td>:VTM</td>
<td>SETUP DATA RESPONSE</td>
</tr>
<tr>
<td>:VTN</td>
<td>NACK (negative acknowledge)</td>
</tr>
<tr>
<td>:VTQ</td>
<td>STATUS DATA RESPONSE</td>
</tr>
<tr>
<td>:VTW</td>
<td>WAVEFORM DATA RESPONSE</td>
</tr>
</tbody>
</table>
7900 SmartVent

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>:VTR</td>
<td>ALARM SILENCE SWITCH PRESS</td>
</tr>
<tr>
<td></td>
<td>E RESPONSE</td>
</tr>
<tr>
<td>:VTY</td>
<td>ACK (positive acknowledge)</td>
</tr>
</tbody>
</table>

**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$<CR>` Send Setup Data

Enable Waveform Data Mode
- `<ESC>VTWabc<CR>` Send Waveform Data
- `<ESC>VTWCR>` = 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)

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>turn waveform data OFF</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>include Pressure Data</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>include Flow Data</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>include Volume</td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>checksum</td>
</tr>
<tr>
<td>&lt;CR&gt;</td>
<td></td>
<td>terminator</td>
</tr>
</tbody>
</table>

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>`)
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.

:VTDaabbbdeeffggghhiiijc<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

<table>
<thead>
<tr>
<th>Entry</th>
<th>Description</th>
<th>Unit(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>aaaa</td>
<td>measured tidal volume</td>
<td>mL, ?, -</td>
</tr>
<tr>
<td>bbbb</td>
<td>measured minute volume</td>
<td>L*100, ?, -; example: 1000 equals 10.00 L</td>
</tr>
<tr>
<td>ddd</td>
<td>measured respiratory rate</td>
<td>/min, ?, -</td>
</tr>
<tr>
<td>eee</td>
<td>measured oxygen level</td>
<td>% O₂, ?, -</td>
</tr>
<tr>
<td>fff</td>
<td>measured max positive pressure</td>
<td>cm H₂O, ?</td>
</tr>
<tr>
<td>ggg</td>
<td>measured inspiratory plateau pres</td>
<td>cm H₂O, ?</td>
</tr>
<tr>
<td>hhh</td>
<td>measured mean pressure</td>
<td>cm H₂O, ?</td>
</tr>
<tr>
<td>iii</td>
<td>minimum pressure</td>
<td>cm H₂O, ?</td>
</tr>
<tr>
<td>j</td>
<td>measured data status</td>
<td>01000000x (bit 0=1=new breath data; bit 0=0=10 second data)</td>
</tr>
<tr>
<td>c</td>
<td>checksum</td>
<td></td>
</tr>
</tbody>
</table>
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.

:VTQaaaabbbddddeeffggghhiijjkkklmmmmnnnooorrrrrrrrrrrcc<CR>

Compressed Data Status Data Response

<table>
<thead>
<tr>
<th>aaaa</th>
<th>set tidal volume</th>
<th>mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>bbb</td>
<td>set tidal volume</td>
<td>/min</td>
</tr>
<tr>
<td>dddd</td>
<td>set I:E ratio</td>
<td>1:e.e.e.e</td>
</tr>
<tr>
<td>ee</td>
<td>inspiratory pause</td>
<td>% Pause</td>
</tr>
<tr>
<td>ff</td>
<td>set PEEP</td>
<td>cm H$_2$O</td>
</tr>
<tr>
<td>ggg</td>
<td>set peak pressure limit</td>
<td>cm H$_2$O</td>
</tr>
<tr>
<td>hh</td>
<td>set inspired pressure</td>
<td>cm H$_2$O</td>
</tr>
<tr>
<td>ii</td>
<td>set sustained pressure alarm limit</td>
<td>cm H$_2$O</td>
</tr>
<tr>
<td>jjj</td>
<td>high minute volume alarm limit</td>
<td>L$\times$10 (e.g. 650 = 65.0 L)</td>
</tr>
<tr>
<td>kkk</td>
<td>low minute volume alarm limit</td>
<td>L$\times$10 (e.g. 050 = 5.0 L)</td>
</tr>
<tr>
<td>lll</td>
<td>high Vte limit</td>
<td>mL/10 (e.g. 150 =1500 ml)</td>
</tr>
<tr>
<td>mmm</td>
<td>low Vte limit</td>
<td>mL/10 (e.g. 090 =900 ml)</td>
</tr>
<tr>
<td>nnn</td>
<td>high oxygen alarm limit</td>
<td>% O$_2$</td>
</tr>
<tr>
<td>ooo</td>
<td>low oxygen alarm limit</td>
<td>% O$_2$</td>
</tr>
<tr>
<td>q</td>
<td>ventilation mode: 'v' = volume mode, 'p' = pressure mode, 'b' = VT compensation off, '-' = bag mode only</td>
<td></td>
</tr>
<tr>
<td>rrrrrrrrr</td>
<td>status bytes (see bitmaps below)</td>
<td></td>
</tr>
<tr>
<td>c</td>
<td>checksum</td>
<td></td>
</tr>
</tbody>
</table>
**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).

<table>
<thead>
<tr>
<th>bit</th>
<th>byte 1</th>
<th>bit</th>
<th>byte 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
</tr>
<tr>
<td>D0 - High O₂</td>
<td></td>
<td>D0 - High Paw</td>
<td></td>
</tr>
<tr>
<td>D1 - Low O₂</td>
<td></td>
<td>D1 - Low Paw</td>
<td></td>
</tr>
<tr>
<td>D2 - 1</td>
<td></td>
<td>D2 - Sustained Paw (shutdown)</td>
<td></td>
</tr>
<tr>
<td>D3 - 1</td>
<td></td>
<td>D3 - Sustained Paw</td>
<td></td>
</tr>
<tr>
<td>D4 - 1</td>
<td></td>
<td>D4 - Sub-Atmos Paw</td>
<td></td>
</tr>
<tr>
<td>D5 - Check O₂ Sensor</td>
<td></td>
<td>D5 - 1</td>
<td></td>
</tr>
<tr>
<td>D6 - O₂ Calibration Error</td>
<td></td>
<td>D6 - 1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bit</th>
<th>byte 3</th>
<th>bit</th>
<th>byte 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
</tr>
<tr>
<td>D0 - Pinspired Not Achieved</td>
<td></td>
<td>D0 - Low VE</td>
<td></td>
</tr>
<tr>
<td>D1 - PEEP Not Achieved</td>
<td></td>
<td>D1 - High VE</td>
<td></td>
</tr>
<tr>
<td>D2 - No Pressure Mode/PEEP</td>
<td></td>
<td>D2 - Low Vte</td>
<td></td>
</tr>
<tr>
<td>D3 - Manifold Pressure Sensor Failure</td>
<td></td>
<td>D3 - High Vte</td>
<td></td>
</tr>
<tr>
<td>D4 - Inspiratory Overshoot</td>
<td></td>
<td>D4 - Vt Not Achieved</td>
<td></td>
</tr>
<tr>
<td>D5 - Inspiration Stopped</td>
<td></td>
<td>D5 - Volume Apnea</td>
<td></td>
</tr>
<tr>
<td>D6 - High Pressure Limit Reached (min sys)</td>
<td></td>
<td>D6 - Volume Apnea &gt; 2 min</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bit</th>
<th>byte 5</th>
<th>bit</th>
<th>byte 6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
</tr>
<tr>
<td>D0 - No Insp Flow Sensor</td>
<td></td>
<td>D0 - Bellows Empty</td>
<td></td>
</tr>
<tr>
<td>D1 - No Exp Flow Sensor</td>
<td></td>
<td>D1 - Flow Valve Failure</td>
<td></td>
</tr>
<tr>
<td>D2 - Insp Reverse Flow</td>
<td></td>
<td>D2 - Gas Inlet Valve Failure</td>
<td></td>
</tr>
<tr>
<td>D3 - Exp Reverse Flow</td>
<td></td>
<td>D3 - 12 Hour Test</td>
<td></td>
</tr>
<tr>
<td>D4 - Check Flow Sensors</td>
<td></td>
<td>D4 - &quot;Bootup Gilv Failure&quot;</td>
<td></td>
</tr>
<tr>
<td>D5 - Insp VvVte Mismatch</td>
<td></td>
<td>D5 - No O₂ Pressure</td>
<td></td>
</tr>
<tr>
<td>D6 - Vdel Mismatch</td>
<td></td>
<td>D6 - No Fresh Gas Flow</td>
<td></td>
</tr>
<tr>
<td>bit</td>
<td>byte 7</td>
<td>bit</td>
<td>byte 8</td>
</tr>
<tr>
<td>-----</td>
<td>--------</td>
<td>-----</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
</tr>
<tr>
<td>D0</td>
<td>+Vanalog Failure</td>
<td>D0</td>
<td>A/D Converter Failure</td>
</tr>
<tr>
<td>D1</td>
<td>-Vanalog Failure</td>
<td>D1</td>
<td>CPU Failure</td>
</tr>
<tr>
<td>D2</td>
<td>+15V SIB Out-of-Range</td>
<td>D2</td>
<td>Memory (EEPROM) Failure</td>
</tr>
<tr>
<td>D3</td>
<td>+15V Manifold Out-of-Range</td>
<td>D3</td>
<td>Memory (flash) Failure</td>
</tr>
<tr>
<td>D4</td>
<td>Display Voltage Out-of-Range</td>
<td>D4</td>
<td>Memory (RAM) Failure</td>
</tr>
<tr>
<td>D5</td>
<td>Vaux_ref Out-of-Range</td>
<td>D5</td>
<td>Memory (video) Failure</td>
</tr>
<tr>
<td>D6</td>
<td>Vext_ref Out-of-Range</td>
<td>D6</td>
<td>Bootup Memory Failure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bit</th>
<th>byte 9</th>
<th>bit</th>
<th>byte 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
</tr>
<tr>
<td>D0</td>
<td>Software Watchdog Failure</td>
<td>D0</td>
<td>On Battery</td>
</tr>
<tr>
<td>D1</td>
<td>Hardware Watchdog Failure</td>
<td>D1</td>
<td>No Battery</td>
</tr>
<tr>
<td>D2</td>
<td>Internal Vent. Clock Too Fast</td>
<td>D2</td>
<td>Low Battery Charge</td>
</tr>
<tr>
<td>D3</td>
<td>Internal Vent. Clock Too Slow</td>
<td>D3</td>
<td>Low Battery</td>
</tr>
<tr>
<td>D4</td>
<td>CPU Internal Error</td>
<td>D4</td>
<td>Low Battery (shutdown)</td>
</tr>
<tr>
<td>D5</td>
<td>Memory (redundant storage) Fail</td>
<td>D5</td>
<td>Fail Batt. Volt. Out Of Range</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>bit</th>
<th>byte 11</th>
<th>bit</th>
<th>byte 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Vent. Message</strong></td>
<td></td>
<td><strong>Vent. Message</strong></td>
</tr>
<tr>
<td>D0</td>
<td>Circuit Auxiliary</td>
<td>D0</td>
<td>Volume Mode Active</td>
</tr>
<tr>
<td>D1</td>
<td>Auxiliary Breathing Circuit</td>
<td>D1</td>
<td>Apnea Detect ON</td>
</tr>
<tr>
<td>D2</td>
<td>&quot;no confirmation of changed setting&quot;</td>
<td>D2</td>
<td>Apnea Alarm Silenced</td>
</tr>
<tr>
<td>D3</td>
<td>Control Settings Input Has Failed</td>
<td>D3</td>
<td>Very Low VE Limit</td>
</tr>
<tr>
<td>D4</td>
<td>Heliox Mode is ON</td>
<td>D4</td>
<td>Alarms Silenced</td>
</tr>
<tr>
<td>D5</td>
<td>Volume Compensation Off</td>
<td>D5</td>
<td>1</td>
</tr>
<tr>
<td>D6</td>
<td>Mechanical Ventilation On</td>
<td>D6</td>
<td>Sensor(s) Cal Due</td>
</tr>
</tbody>
</table>
Setup Data Response

:VTMaaaabddefghc<CR>Setup Data Response

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

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]<CR>Waveform Data Response for each [max. of 2] waveform signal selected

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>aaa</td>
<td>1st 16 ms waveform sample (0 -&gt; &quot;000&quot;, 512 -&gt; &quot;200&quot;, 4095 -&gt; &quot;FFF&quot;)</td>
<td></td>
</tr>
<tr>
<td>bbb</td>
<td>2nd 16 ms waveform sample</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nnn</td>
<td>14th 16 ms waveform sample</td>
<td></td>
</tr>
<tr>
<td>ooo</td>
<td>15th 16 ms waveform sample</td>
<td></td>
</tr>
</tbody>
</table>

Waveform Data shall be scaled as follows:

Pressure
range: -20 - 120 cm H₂O
scale:

<table>
<thead>
<tr>
<th>raw</th>
<th>scaled</th>
<th>xmit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-20</td>
<td>0</td>
<td>&quot;000&quot;</td>
</tr>
<tr>
<td>0</td>
<td>512</td>
<td>&quot;200&quot;</td>
</tr>
<tr>
<td>120</td>
<td>3584</td>
<td>&quot;E00&quot;</td>
</tr>
</tbody>
</table>
Flow
range: -100 - +100 L/M
scale:

<table>
<thead>
<tr>
<th>raw</th>
<th>scaled</th>
<th>xmit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100</td>
<td>512</td>
<td>&quot;200&quot;</td>
</tr>
<tr>
<td>0</td>
<td>2048</td>
<td>&quot;800&quot;</td>
</tr>
<tr>
<td>+100</td>
<td>3584</td>
<td>&quot;E00&quot;</td>
</tr>
</tbody>
</table>

Volume
range: 0 - 2 L
scale:

<table>
<thead>
<tr>
<th>raw</th>
<th>scaled</th>
<th>xmit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>512</td>
<td>&quot;200&quot;</td>
</tr>
<tr>
<td>2</td>
<td>3584</td>
<td>&quot;E00&quot;</td>
</tr>
</tbody>
</table>

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.
### In this section

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<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
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<td>Ventilator Modes</td>
<td>8-2</td>
</tr>
<tr>
<td>How the ventilator operates (theory)</td>
<td>8-4</td>
</tr>
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<td>Breathing system schematics</td>
<td>8-6</td>
</tr>
<tr>
<td>Internal signal schematic</td>
<td>8-8</td>
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<tr>
<td>Electrical power</td>
<td>8-10</td>
</tr>
<tr>
<td>Battery Information</td>
<td>8-10</td>
</tr>
<tr>
<td>Electro-magnetic Compatibility</td>
<td>8-10</td>
</tr>
<tr>
<td>Physical specifications</td>
<td>8-11</td>
</tr>
<tr>
<td>Weight:</td>
<td>8-11</td>
</tr>
<tr>
<td>Size</td>
<td>8-11</td>
</tr>
<tr>
<td>Ventilator display</td>
<td>8-11</td>
</tr>
<tr>
<td>Environmental requirements</td>
<td>8-11</td>
</tr>
<tr>
<td>Temperature</td>
<td>8-11</td>
</tr>
<tr>
<td>Humidity</td>
<td>8-11</td>
</tr>
<tr>
<td>Altitude</td>
<td>8-11</td>
</tr>
<tr>
<td>Ventilation Operating Specifications</td>
<td>8-11</td>
</tr>
<tr>
<td>Ventilator Accuracy Data</td>
<td>8-14</td>
</tr>
</tbody>
</table>
Ventilator Modes

The system has two modes of mechanical ventilation:

- Volume control mode
- Pressure control mode

Use the main menu to set the mode.

### Main Menu

<table>
<thead>
<tr>
<th>End Case</th>
<th>Volume Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation Mode</td>
<td>Pressure Control</td>
</tr>
<tr>
<td>Alarm Settings</td>
<td></td>
</tr>
<tr>
<td>Setup/Calibration</td>
<td></td>
</tr>
<tr>
<td>Screen and Audio</td>
<td></td>
</tr>
<tr>
<td>Exit to Waveform Display</td>
<td></td>
</tr>
</tbody>
</table>

### 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
- P_{limit}
- PEEP
Pressure control mode

![Pressure control diagram](image)

**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.
Specifications and Theory of Operation

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

* Use only 15 mm sensor
Specifications and Theory of Operation

Bain/Mapleson D

Fresh gas

Bellows

Bag/vent Switch

APL Valve

Insp Flow

Exp Flow*

Adapter

* 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.
Specifications and Theory of Operation

Figure 8-2 • Internal signals
Electrical power

Supply voltage
100-120 or 220-240 V ac ± 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.

Electromagnetic 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)

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
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**

<table>
<thead>
<tr>
<th>Operation</th>
<th>10 to 40 °C, (Oxygen cell operates to specifications at 10 to 40 °C)</th>
</tr>
</thead>
</table>
| Storage       | -20 to 70 °C  
Oxygen cell storage is -5 to 50°C, 10 to 95% Rh, 500 to 800 mm Hg |

**Humidity**

<table>
<thead>
<tr>
<th>Operation</th>
<th>15 to 95% Rh, non-condensing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>10 to 100% Rh, include condensing</td>
</tr>
</tbody>
</table>

**Altitude**

<table>
<thead>
<tr>
<th>Operation</th>
<th>500 to 800 mm Hg (3565 to -440 meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>375 to 800 mm Hg (5860 to -440 meters)</td>
</tr>
<tr>
<td>Compensation range</td>
<td>525 to 795 mmHg (3,000 to -100 meters)</td>
</tr>
</tbody>
</table>

Ventilation Operating Specifications

**Pneumatics**

<table>
<thead>
<tr>
<th>Gas Source</th>
<th>Anesthesia System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Composition</td>
<td>Medical Air or O₂</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Nominal Supply Pressure</td>
<td>350 kPa</td>
</tr>
<tr>
<td>Pressure Range at Inlet</td>
<td>240 to 700 kPa</td>
</tr>
<tr>
<td>Peak Gas Flow</td>
<td>120 L/min @ 240 kPa, 0.75 seconds</td>
</tr>
<tr>
<td>Continuous Gas Flow</td>
<td>80 L/min @ 240 kPa</td>
</tr>
<tr>
<td>Flow valve range</td>
<td>1 to 120 L/min at 240kPa</td>
</tr>
</tbody>
</table>

**Fresh gas compensation**

<table>
<thead>
<tr>
<th>Flow Compensation Range</th>
<th>200 mL/min. to 15 L/min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Composition</td>
<td>O₂, N₂O, N₂ Air, Heliox, CO₂ Anesthetic Agents</td>
</tr>
</tbody>
</table>

**Pressure**

<table>
<thead>
<tr>
<th>Patient airway pressure range</th>
<th>-20 to +120 cm H₂O +/-2 cm H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>High pressure alarm set range</td>
<td>12 to 100 cm H₂O, 1 cm increment</td>
</tr>
<tr>
<td>Sustained pressure alarm range</td>
<td>6 to 30 cm H₂O, 1 cm increment</td>
</tr>
<tr>
<td>Display range</td>
<td>-20 to 120 cm H₂O</td>
</tr>
</tbody>
</table>
### Specifications and Theory of Operation

#### Volume

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume display range</td>
<td>0 to 9999 mL, 1 mL resolution</td>
</tr>
<tr>
<td>Setting range</td>
<td>20 to 1500 mL</td>
</tr>
<tr>
<td>Minute volume</td>
<td>0.0 to 99.9 liters, 0.1 liter resolution</td>
</tr>
<tr>
<td>Breath rate</td>
<td>4 to 100 bpm (breaths per minute), 1 bpm resolution</td>
</tr>
<tr>
<td>Volume sensor type</td>
<td>Variable flow orifice</td>
</tr>
</tbody>
</table>

#### Oxygen

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display range</td>
<td>0 to 110% $O_2$</td>
</tr>
<tr>
<td>Display resolution</td>
<td>1% increments</td>
</tr>
<tr>
<td>Sensor type</td>
<td>Galvanic fuel cell</td>
</tr>
<tr>
<td>Measurement range</td>
<td>0 to 100% $O_2$</td>
</tr>
<tr>
<td>Measurement accuracy</td>
<td>Better than ±3% of full scale</td>
</tr>
<tr>
<td>Cell response time</td>
<td>35 seconds$^1$</td>
</tr>
<tr>
<td>Low $O_2$ alarm range</td>
<td>21% to 100%</td>
</tr>
<tr>
<td>High $O_2$ alarm setting</td>
<td>21% to 100%</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong>: 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.</td>
</tr>
<tr>
<td>Expected cell life</td>
<td>Four months of shelf life (23 °C room air) and one year of normal operation</td>
</tr>
</tbody>
</table>

---

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% O₂)

<table>
<thead>
<tr>
<th>Volume delivery accuracy:</th>
<th>&gt; 210 mL tidal volume - accuracy better than 7%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 210 mL tidal volume - accuracy better than 15 mL</td>
</tr>
<tr>
<td></td>
<td>&lt; 60 mL tidal volume - accuracy better than 10 mL</td>
</tr>
<tr>
<td>Volume monitoring accuracy</td>
<td>&gt; 210 mL tidal volume - accuracy better than 9%</td>
</tr>
<tr>
<td></td>
<td>&lt; 210 mL tidal volume - accuracy better than 18 mL</td>
</tr>
<tr>
<td></td>
<td>&lt; 60 mL tidal volume - accuracy better than 10 mL</td>
</tr>
</tbody>
</table>

**Pressure Mode**  
(100% O₂)

<table>
<thead>
<tr>
<th>Inspiratory pressure delivery accuracy</th>
<th>greater of ± 10% or ± 3 cm H₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP delivery accuracy</td>
<td>± 1.5 cm H₂O</td>
</tr>
<tr>
<td>Pressure monitoring accuracy</td>
<td>greater of ± 5% or ± 2 cm H₂O</td>
</tr>
<tr>
<td>Volume monitoring accuracy</td>
<td>&gt; 210 mL tidal volume - accuracy better than 9%</td>
</tr>
<tr>
<td></td>
<td>&lt; 210 mL tidal volume - accuracy better than 18 mL</td>
</tr>
<tr>
<td></td>
<td>&lt; 60 mL tidal volume - accuracy better than 10 mL</td>
</tr>
</tbody>
</table>
Specifications and Theory of Operation

**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)](image)

### 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.
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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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