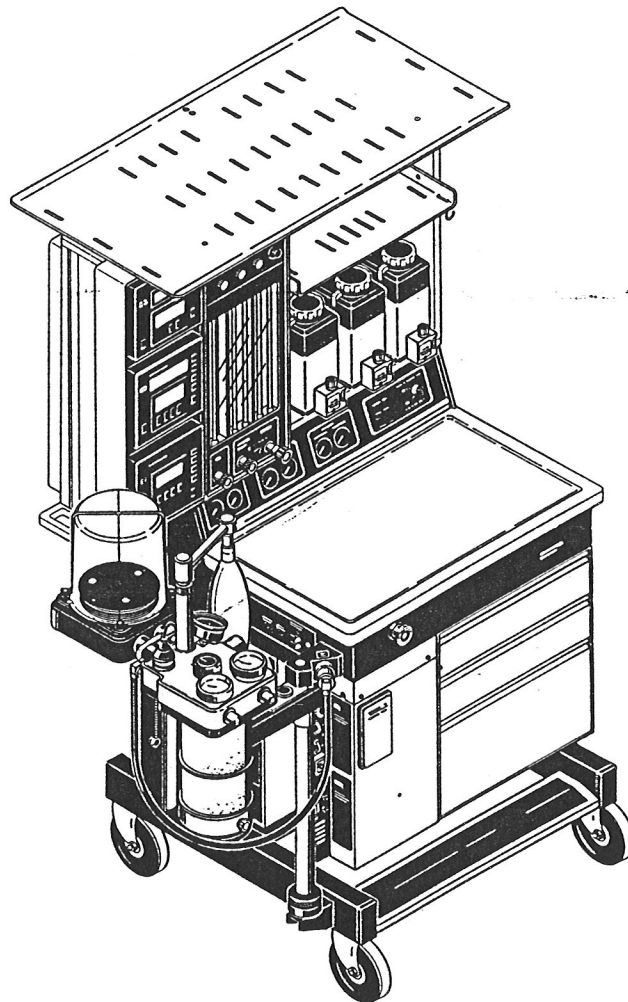


Modulus II Plus Anesthesia System

Software Version 2.X

Operation and Maintenance Manual



A BOC Health Care
Company
Critical Care
Worldwide

THE HISTORY OF THE UNITED STATES

BY JAMES M. SMITH

OF THE UNIVERSITY OF CHICAGO



THE HISTORY OF THE UNITED STATES
BY JAMES M. SMITH
OF THE UNIVERSITY OF CHICAGO

Preoperative Checklist

Ohmeda 7810 Ventilator

1. Verify proper hose connection between bellows assembly and control unit.
2. Verify proper connection between bellows assembly and Patient Circuit.
3. Verify properly functioning scavenger system is connected to 19 mm port (**Exhaust**) on bellows assembly. Do not connect ventilator exhaust directly to the vacuum source.
4. Verify louvers on back of control unit are not occluded.
5. Verify proper connection of the pressure sensing tube, volume sensor, and O₂ sensor to the Patient Breathing System.
6. Verify operation and select the desired set points for user controlled alarms and the **Inspiratory Pressure Limit**.
7. Verify Tidal Volume, Rate, and Inspiratory Flow (I:E Ratio) controls are set to desired positions.
8. Verify **Inspiratory Pause** and **Mechanical Ventilation** switches are in desired position.

⚠ WARNING: User shall read all Operation and Maintenance manuals, all accompanying documents and understand the operation of this ventilator before use. Improper use of this ventilator can cause significant patient injury.

Ohmeda

Ohmeda
Ohmeda Drive
Madison WI 53707 7550
A Division of The BOC Group Inc



A BOC Health Care
Company
Critical Care
Worldwide

Preoperative Checklist

Ohmeda Anesthesia Systems

1. Verify adequate pipeline supply and reserve cylinder supply.
2. Verify integrity of low pressure gas circuitry.
3. Verify proper functioning of electrical systems.
4. Verify proper functioning of gas flow control systems.
5. Verify integrity of patient breathing circuit.
6. Verify integrity and proper functioning of vaporizer(s).
7. Verify adequate vacuum source.
8. Verify integrity and proper functioning of gas scavenging interface valve.
9. Verify integrity and proper functioning of ventilator.
10. Verify integrity and proper functioning of monitoring system(s).

For detailed description of testing procedures refer to applicable Operation and Maintenance Manual or Technical Literature.

⚠ WARNING: User shall read all Operation and Maintenance manuals, all accompanying documents, and understand anesthesia system operation before use. Improper use of this anesthesia system can cause significant patient injury.

Ohmeda

Ohmeda
Ohmeda Drive
Madison WI 53707 7550
A Division of The BOC Group Inc



A BOC Health Care
Company
Critical Care
Worldwide

THE UNIVERSITY OF CHICAGO
LIBRARY



1. The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the atom. It is shown that the theory of the structure of the atom is a special case of the more general theory of the structure of the molecule.

2. The second part of the paper is devoted to a discussion of the general principles of the theory of the structure of the molecule. It is shown that the theory of the structure of the molecule is a special case of the more general theory of the structure of the crystal.

3. The third part of the paper is devoted to a discussion of the general principles of the theory of the structure of the crystal. It is shown that the theory of the structure of the crystal is a special case of the more general theory of the structure of the solid.



4. The fourth part of the paper is devoted to a discussion of the general principles of the theory of the structure of the solid. It is shown that the theory of the structure of the solid is a special case of the more general theory of the structure of the liquid.



Preoperative Checklist

Ohmeda GMS™ Absorber

1. Verify condensate has been drained and Drain Port/Sight Glass is completely closed.
2. Verify desired APL Setting with Selector Knob in Bag/APL position.
3. Verify Bag/APL - Ventilator Selector Knob is turned to desired position.
4. Verify integrity of Patient Breathing Circuit and all other connections.
5. Verify canister seal with lever in full Lock position and ensure adequate capacity of Soda Lime.
6. Verify proper assembly and functioning of Inhalation and Exhalation Check Valves.
7. Verify Oxygen Monitor Sensor is in place.

⚠ WARNING: When Oxygen Monitor Sensor is not used, Sensor Port must be capped to help prevent loss of Patient Gas.

⚠ WARNING: User shall read all Operation and Maintenance manuals, all accompanying documents, and understand the operation of this breathing system before use. Improper use of this breathing system can cause significant patient injury.

Ohmeda

Ohmeda
Ohmeda Drive
Madison WI 53707 7550
A Division of BOC Health Care Inc



**A BOC Health Care
Company
Critical Care
Worldwide**

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

REPORT OF THE PHYSICS DEPARTMENT

FOR THE YEAR 1964-1965

DEPARTMENT OF PHYSICS

UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

1965

DEPARTMENT OF PHYSICS

UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

1965

DEPARTMENT OF PHYSICS

UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

Table of Contents

| | | | |
|---|------|---|------|
| List of Illustrations | ii | 4.5 Testing The Breathing System | 4-4 |
| Precautions | iv | A. General Breathing System Checks | 4-4 |
| Warnings | iv | B. Testing The Absorber Bag/APL Circuit | 4-4 |
| Cautions | v | C. Testing The Ventilator Circuit | 4-5 |
| 1/Introduction | 1-1 | 4.6 Testing The Ventilator Alarms | 4-5 |
| 1.1 Introduction | 1-1 | A. Testing The Low And High Oxygen | |
| 1.2 How To Use This Manual | 1-1 | Alarms | 4-5 |
| 2/Getting Started | 2-1 | B. Testing The Low Minute Volume, | |
| 2.1 Unpacking | 2-1 | Reverse Flow, And Apnea Alarms | 4-6 |
| 2.2 Installing The Ohmeda GMS Absorber | 2-1 | C. Testing The High, Low, | |
| 2.3 Mounting The Waste Gas Scavenging | | And Sustained Pressure Alarms | 4-8 |
| Interface Valve | 2-2 | 4.7 Checking The Ventilator Connections | 4-9 |
| 2.4 Connecting The Bellows Assembly | 2-3 | 4.8 Checking The Monitoring Connections | 4-10 |
| A. Connecting The Bellows Assembly | | 4.9 Testing The Scavenging Interface | |
| To The Absorber | 2-3 | Relief Valve | 4-12 |
| B. Connecting The Bellows Assembly | | 4.10 Checking The Battery | 4-12 |
| To The Ventilator Control Module | 2-3 | 5/Operating The System | 5-1 |
| 2.5 Making The Monitoring Connections | 2-4 | 5.1 Preparing The System For Operation | 5-1 |
| A. Connecting The Pressure Sensing Tube | 2-4 | A. Adjusting The Monitor Pod Viewing | |
| B. Connecting The Volume Sensor | 2-5 | Angle | 5-1 |
| C. Connecting The Oxygen Sensor | 2-7 | B. Connecting The Optional Manual Blood | |
| 2.6 Preparing The Anesthesia System | 2-8 | Pressure Gauge Inflation System | 5-1 |
| A. Using The Shelves And Mounting Track | 2-8 | C. Filling The Vaporizers | 5-2 |
| B. Installing The Gas Cylinders | 2-10 | 5.2 Powering The System On | 5-3 |
| C. Installing The Vaporizers | 2-11 | 5.3 Using The Ventilator's Setup Page | 5-4 |
| D. Adjusting The Position Of The Absorber | 2-11 | 5.4 Setting The Alarm Limits | 5-5 |
| 2.7 Making The Anesthesia System Gas | | 5.5 Setting The Gas Flow | 5-6 |
| Connections | 2-12 | 5.6 Setting The Vaporizers | 5-7 |
| A. Making The Gas Pipeline Connections | 2-12 | 5.7 Setting The Ventilation Parameters, | |
| B. Making The Waste Gas Scavenging | | Beginning Ventilation | 5-7 |
| Connections | 2-12 | 5.8 Adjusting The Scavenging Interface | |
| C. Making The Breathing System | | Needle Valve | 5-9 |
| Connections | 2-14 | 5.9 Responding To Alarms | 5-9 |
| 3/General Information | 3-1 | A. Responding To Anesthesia Machine | |
| 3.1 System Overview | 3-1 | Alarms | 5-9 |
| 3.2 The Controls, Connectors, Devices, | | Electrical Disconnect/Failure Alarm | 5-9 |
| and Screen | 3-2 | Oxygen Supply Failure Alarm | 5-9 |
| A. The Anesthesia Machine | 3-2 | B. Responding To Ventilator Alarms | 5-9 |
| B. The Anesthesia Machine's | | APNEA xxx SEC | 5-9 |
| Internal Devices | 3-10 | LOW OXYGEN! | 5-10 |
| C. The Absorber | 3-11 | HIGH OXYGEN! | 5-10 |
| D. The Ventilator | 3-11 | HIGH PRESSURE! | 5-10 |
| E. The Ventilator's Control Module | | LOW PRESSURE! | 5-11 |
| Front Panel | 3-12 | SUSTAINED PRES! | 5-11 |
| F. The Ventilator's Control Module | | SUB-ATMOS. PRES! | 5-11 |
| Rear Panel | 3-14 | LOW MINUTE VOL! | 5-11 |
| 3.3 Theory Of Operation | 3-15 | LOW BATTERY! or POWER FAIL! | 5-12 |
| A. The Ventilation Cycle | 3-15 | LIMIT SET ERROR! | 5-12 |
| B. Volume Monitoring | 3-16 | VENT SET ERROR! | 5-12 |
| C. Airway Pressure Monitoring | 3-17 | CHECK O2 PROBE! /CHECK GAS | |
| D. Oxygen Monitoring | 3-17 | SUPPLY | 5-12 |
| E. Control Range Computation | 3-18 | REVERSE FLOW! | 5-12 |
| F. Tidal Volume Compensation | 3-20 | LOW SUPPLY PRES! | 5-13 |
| 3.4 The Ventilator Modes | 3-22 | VENT. FAIL x! or DRIVE CKT. OPEN! | 5-13 |
| 3.5 The Alarm System | 3-22 | APNEA ALARM OFF! | 5-13 |
| A. The Anesthesia Machine Alarms | 3-22 | MAX. PRESS=xxx CM | |
| B. The Ventilator Alarms | 3-22 | — — — For The Tidal Volume | |
| 4/Preoperative Checkout Procedures | 4-1 | Reading | 5-14 |
| 4.1 Checking The Pipeline And Reserve Cylinder | | If The Alarm Silence Button Will Not | |
| Supply | 4-1 | Silence The Alarm | 5-14 |
| 4.2 Checking The Low Pressure Gas Circuitry | 4-2 | VOL MON STANDBY! | 5-14 |
| 4.3 Checking The Gas Flow Controls | 4-3 | ??? Is Displayed In Place Of VE, VT, | |
| 4.4 Testing The Anesthesia Machine Electrical | | Or Rate Readings | 5-14 |
| Alarms | 4-4 | 5.10 Shutting Down The System | 5-14 |

Table of Contents

| | |
|---|-------------|
| 6/Maintaining The System | 6-1 |
| 6.1 Maintenance Schedule | 6-1 |
| 6.2 Cleaning And Sterilizing | 6-1 |
| A. Cleaning The Control Module | 6-1 |
| B. Cleaning And Sterilizing The Bellows Assembly | 6-1 |
| C. Cleaning And Sterilizing The Volume Sensor Clip Assembly | 6-4 |
| D. Cleaning And Sterilizing The Volume Sensor Cartridge | 6-4 |
| E. Cleaning And Sterilizing The Oxygen Sensor Assembly | 6-5 |
| F. Cleaning And Sterilizing The Oxygen Sensor Cartridge | 6-6 |
| G. Cleaning The Anesthesia Machine | 6-7 |
| H. Sterilizing The Anesthesia Machine | 6-7 |
| I. Cleaning The Scavenging Interface Relief Valve | 6-8 |
| 6.3 Checking The Volume Sensor | 6-8 |
| 6.4 Maintaining The Oxygen Sensor | 6-9 |
| 6.5 Replacing The Oxygen Sensor Cartridge | 6-9 |
| 6.6 Calibrating The Oxygen Sensor | 6-10 |
| 6.7 Lubricating The Anesthesia Machine | 6-10 |
| 6.8 Maintaining The Gas Supply Module | 6-10 |
| 7/Service Procedures | 7-1 |
| 7.1 Repair Policy | 7-1 |
| 7.2 Troubleshooting Guide | 7-1 |
| A. Troubleshooting System Problems | 7-1 |
| B. Troubleshooting Ventilator Problems | 7-2 |
| C. Troubleshooting Ventilator Failure Messages | 7-3 |
| 7.3 Resetting Circuit Breakers | 7-5 |
| 7.4 Removing The Ventilator Control Module | 7-5 |
| 7.5 Reinstalling The Ventilator Control Module | 7-7 |
| Appendix | 8-1 |
| Appendix A—Specifications | 8-1 |
| A. The Anesthesia Machine | 8-1 |
| Electrical | 8-1 |
| Pneumatics | 8-1 |
| Gas-Supply Modules | 8-1 |
| Physical Characteristics | 8-2 |
| B. The Ventilator | 8-3 |
| Electrical | 8-3 |
| Monitoring | 8-3 |
| Alarms | 8-3 |
| Performance Characteristics | 8-4 |
| Physical Characteristics | 8-4 |
| Appendix B—Optional Accessories | 8-4 |
| Appendix C—Replaceable Parts | 8-5 |
| Appendix D—Monitoring Locations On Non-Ohmeda GMS Absorbers | 8-5 |
| Appendix E—Connecting A Remotely Mounted Bellows Assembly | 8-6 |
| Appendix F—Checking The Absorber Pressure Gauge Location | 8-6 |
| Appendix G—Ventilator Communications Protocol | 8-7 |
| Appendix H—Using A Bain Circuit | 8-10 |
| Index | 8-11 |
| Warranty | 8-17 |

List of Illustrations

| | | |
|-------------|--|------|
| Figure 2-1 | Mounting the absorber | 2-1 |
| Figure 2-2 | Attaching the scavenging interface valve to its mounting plate | 2-2 |
| Figure 2-3 | Mounting the scavenging interface valve to the side of the anesthesia machine | 2-2 |
| Figure 2-4 | Mounting the scavenging interface valve to the absorber arm | 2-2 |
| Figure 2-5 | Connecting the bellows assembly to the absorber | 2-3 |
| Figure 2-6 | Connecting the drive-oxygen tube to the control module | 2-3 |
| Figure 2-7 | Connecting the drive-oxygen tube to the absorber interface manifold | 2-3 |
| Figure 2-8 | Attaching the drive-oxygen tube to the mounting bracket | 2-4 |
| Figure 2-9 | Connecting the pressure-sensing tube to the absorber's pressure gauge | 2-5 |
| Figure 2-10 | Connecting the pressure-sensing tube to the control module | 2-5 |
| Figure 2-11 | Plugging the volume sensor plug into the patient interface panel | 2-5 |
| Figure 2-12 | Inserting the volume sensor cartridge into the distal location of the breathing system's expiratory limb | 2-6 |
| Figure 2-13 | Inserting the volume sensor cartridge at the proximal end of the "Y" connector | 2-6 |
| Figure 2-14 | Attaching the volume sensor cartridge to its clip | 2-6 |
| Figure 2-15 | Disassembling the oxygen sensor probe | 2-7 |
| Figure 2-16 | The oxygen sensor, exploded view | 2-7 |
| Figure 2-17 | Reassembling the oxygen probe | 2-7 |
| Figure 2-18 | Connecting the oxygen probe to the absorber and the patient interface panel | 2-8 |
| Figure 2-19 | Adjusting the top shelf's latching strut | 2-8 |
| Figure 2-20 | Adjusting the shelves' straps | 2-9 |
| Figure 2-21 | Installing the cylinders | 2-10 |
| Figure 2-22 | Installing a vaporizer | 2-11 |
| Figure 2-23 | Adjusting the position of the absorber | 2-11 |
| Figure 2-24 | The gas inlets | 2-12 |
| Figure 2-25 | Making the gas scavenging connections to a high vacuum disposal system | 2-13 |
| Figure 2-26 | Making the gas scavenging connections to a passive disposal system | 2-13 |
| Figure 2-27 | Attaching the inlet adapter to the common gas outlet | 2-14 |
| Figure 2-28 | Connecting the absorber to the common gas outlet | 2-14 |

Table of Contents

| | | | | | |
|-------------|--|------|-------------|--|------|
| Figure 3-1 | The Ohmeda Modulus II Plus Anesthesia System, front view | 3-1 | Figure 5-6 | Filling a vaporizer through its keyed filler port | 5-2 |
| Figure 3-2 | The Ohmeda Modulus II Plus Anesthesia System, rear view | 3-2 | Figure 5-7 | Filling a vaporizer through its funnel port | 5-3 |
| Figure 3-3 | The pressure gauge window panel | 3-3 | Figure 5-8 | The system master switch | 5-3 |
| Figure 3-4 | The pressure gauges and regulators | 3-3 | Figure 5-9 | The ventilator's setup page | 5-4 |
| Figure 3-5 | The flowmeters and flow control valves | 3-4 | Figure 5-10 | The alarm pushwheels and inspiratory pressure limit dial | 5-5 |
| Figure 3-6 | The system master switch | 3-5 | Figure 5-11 | The flow control knobs and flowmeters | 5-6 |
| Figure 3-7 | The oxygen flush button and common gas outlet | 3-6 | Figure 5-12 | Vaporizer controls | 5-7 |
| Figure 3-8 | The patient interface panel | 3-6 | Figure 5-13 | The control module's front panel | 5-7 |
| Figure 3-9 | The monitor pod | 3-7 | Figure 5-14 | Adjusting the scavenging interface valve | 5-9 |
| Figure 3-10 | The electrical pod | 3-8 | Figure 6-1 | Disconnecting hoses from the bellows assembly | 6-1 |
| Figure 3-11 | The vaporizer manifold | 3-9 | Figure 6-2 | Detaching the bellows assembly from the absorber | 6-2 |
| Figure 3-12 | The lighting panel | 3-9 | Figure 6-3 | Removing the adult bellows housing | 6-2 |
| Figure 3-13 | The waste gas scavenging interface valve assembly | 3-10 | Figure 6-4 | Removing the pediatric bellows housing | 6-2 |
| Figure 3-14 | The Ohmeda GMS Absorber | 3-11 | Figure 6-5 | Adult and pediatric bellows assemblies, exploded views | 6-3 |
| Figure 3-15 | The ventilator's control module | 3-11 | Figure 6-6 | Removing the pediatric bellows assembly's base ring | 6-4 |
| Figure 3-16 | The ventilator's bellows assembly | 3-11 | Figure 6-7 | Disconnecting the volume sensor cartridge from its clip | 6-4 |
| Figure 3-17 | The ventilator control module's front panel | 3-12 | Figure 6-8 | Disconnecting the oxygen sensor from the absorber and patient interface panel | 6-5 |
| Figure 3-18 | The ventilator control module's rear panel | 3-14 | Figure 6-9 | Opening the oxygen sensor | 6-6 |
| Figure 3-19 | The ventilation cycle | 3-15 | Figure 6-10 | Oxygen sensor, exploded view | 6-6 |
| Figure 3-20 | Gas entering the volume sensor cartridge | 3-16 | Figure 6-11 | Cleaning the oxygen-sensor cartridge | 6-6 |
| Figure 3-21 | The path of gas through the volume sensor cartridge | 3-16 | Figure 6-12 | The scavenging interface valve, exploded view | 6-8 |
| Figure 3-22 | The volume sensor clip's optical transducers and detectors | 3-17 | Figure 6-13 | Removing the volume sensor cartridge from the expiratory limb of the patient circuit | 6-8 |
| Figure 3-23 | Diagram of the ventilator's range | 3-19 | Figure 6-14 | Removing the volume sensor cartridge from the distal position of the patient circuit | 6-9 |
| Figure 4-1 | The low-pressure leak-testing device | 4-2 | Figure 6-15 | Opening the oxygen sensor | 6-9 |
| Figure 4-2 | The Ohmeda GMS absorber | 4-4 | Figure 6-16 | Oxygen sensor, exploded view | 6-9 |
| Figure 4-3 | Occluding the "Y" connector | 4-4 | Figure 6-17 | Replacing a strainer nipple on a gas supply module | 6-10 |
| Figure 4-4 | Occluding the "Y" connector | 4-5 | Figure 7-1 | Location of the circuit breakers | 7-5 |
| Figure 4-5 | Removing the oxygen sensor from the absorber | 4-5 | Figure 7-2 | Disconnecting the drive oxygen from the control module | 7-5 |
| Figure 4-6 | Removing the volume sensor cartridge from the expiratory limb of the patient circuit | 4-6 | Figure 7-3 | Disconnecting the pressure sensing tube from the control module | 7-5 |
| Figure 4-7 | Removing the volume sensor cartridge from the distal position of the patient circuit | 4-6 | Figure 7-4 | Removing the control module | 7-6 |
| Figure 4-8 | Fitting the volume sensor cartridge to the common gas outlet | 4-7 | Figure 7-5 | Removing the center section of the three-part connector | 7-6 |
| Figure 4-9 | The pressure sensing tube's connection to the control module | 4-8 | Figure 7-6 | Connecting the drive oxygen to the control module | 7-7 |
| Figure 4-10 | The pressure sensing tube's connection to the absorber | 4-8 | Figure 7-7 | Connecting the pressure sensing tube to the control module | 7-7 |
| Figure 4-11 | Opening the patient circuit at the "Y" connector | 4-8 | Figure 8-1 | Monitoring adapters for alternate devices | 8-5 |
| Figure 4-12 | Occluding the patient circuit at the "Y" connector | 4-8 | Figure 8-2 | Remotely mounted bellows | 8-6 |
| Figure 4-25 | Testing the scavenging interface valve | 4-12 | Figure 8-3 | The bellows assembly's ports | 8-6 |
| Figure 4-26 | Location of the battery test button | 4-12 | Figure 8-4 | The absorber's ports | 8-6 |
| Figure 5-1 | Adjusting the monitor pod's viewing angle | 5-1 | Figure 8-5 | Printed sample of serial output | 8-9 |
| Figure 5-2 | The optional manual blood pressure gauge inflation system | 5-1 | Figure 8-6 | Correct placement of the volume sensor when used with a Bain circuit | 8-10 |
| Figure 5-3 | Vaporizer with keyed filler port | 5-2 | Figure 8-7 | Schematic of the anesthesia machine | 8-15 |
| Figure 5-4 | Vaporizer with funnel filler port | 5-2 | | | |
| Figure 5-5 | Opening a vaporizer's keyed filler port | 5-2 | | | |

Precautions

▲Warnings

Position the pressure-sensing tube so that the absorber arm cannot pinch the tube. If the tube is pinched, the system's pressure monitoring will not function correctly.

Take care not to crack or break the volume sensor cartridge. When you are placing the cartridge on the absorber, be certain to obtain a secure fit, but do not force the cartridge in place as tightly as possible. Avoid striking the cartridge. A broken or cracked cartridge could cause a circuit disconnection and a break in the breathing circuit.

The volume sensor cartridge and sensor must be correctly installed at either the distal location in the breathing system's expiratory limb or the proximal end of the "Y" connector. If the cartridge and sensor are installed incorrectly, volume data will be inaccurate and associated alarms, including the apnea and low minute volume alarms, will not function properly.

Destroy old or malfunctioning volume sensor cartridges to prevent inadvertent reuse. Using malfunctioning volume-sensor cartridges may result in compromised patient data.

Position the volume sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's volume monitoring may not function correctly.

Defective oxygen sensor cartridges may leak potassium hydroxide, which is caustic. Use care when handling oxygen sensor cartridges. Do not use any oxygen sensor cartridge that shows signs of leaking. If you get the potassium hydroxide solution in your eyes, immediately flush with water, then seek medical attention.

Position the oxygen sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's oxygen monitoring may not function correctly.

Do not leave gas cylinder valves open if the pipeline supply is in use and the system master switch is turned to "On." Pressures from both supplies may become equal and, if simultaneously used, cylinder supplies could be depleted, leaving an insufficient reserve supply in case of pipeline failure.

Remain clear of exiting gases.

Do not use any vaporizer that is visibly misaligned on the manifold or that, when its lever is locked, can be lifted off the manifold. Incorrect mounting may result in incorrect delivery of gases.

Do not connect the ventilator exhaust directly to a vacuum source. The vacuum may remove required gases from the breathing system.

Before using the anesthesia system: the inlet adapter must be placed completely onto the common gas outlet and then turned clockwise until it is secured by both protruding pins; the anti-disconnect nipple end must be placed securely into the absorber's common gas anti-disconnect fitting; and, to allow gas to flow to the breathing system, both ends of the outlet tubing assembly must be secured. Failure to correctly connect the breathing system may result in injury to the patient.

Do not use flammable anesthetics. A possibility of explosion will exist if the system is used in the presence of flammable anesthetics.

The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen/nitrous-oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. *Hypoxic mixtures may be delivered if gases other than oxygen, nitrous oxide and/or air are used, or when operating at low oxygen flow rates.* When using carbon dioxide, helium or nitrogen as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

Connecting equipment to the auxiliary AC outlets may increase electrical hazards if a protective ground conductor is defective.

Writing to the ventilator's RS232 port can alter the operation of the ventilator's software, which may result in unpredictable performance. Do not alter the ventilator's hardware or software.

Always correctly set the low minute volume alarm and use CO₂ monitoring to aid in the detection of breathing system disconnections.

The reverse flow alarm will function correctly only if the volume sensor cartridge is working correctly and is properly placed in the distal position of the expiratory limb of the breathing system.

When the volume sensor is in the distal position of the breathing system, check the ventilator's Setup Page to confirm that the reverse flow alarm is enabled. Do not use the system with the reverse flow alarm disabled if the volume sensor is in the distal position.

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

Leaking gases and vapors (downstream of the flow control valves and Oxygen Flush valve) may deprive the patient of metabolic gases and anesthetic agent and may pollute the atmosphere. Tests that detect such leaks must be performed frequently. If detected, leakage must be reduced to an acceptable level.

Do not use the anesthesia system after performing the low-pressure leak test until the vaporizer circuits have been purged with oxygen. Using a system that has not been purged with oxygen may result in incorrect gas mixtures, and injury to the patient.

Precautions

Do not use the anesthesia system if the Ohmeda Link 25 Proportion Limiting Control System does not operate within permitted ranges. Using an incorrectly operating control system may result in incorrect gas mixtures, and injury to the patient.

When occluding the breathing system for test purposes, do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

Do not use the anesthesia system if the backup battery is not in good condition. If the backup battery does not function correctly, the anesthesia system's backup power will not function correctly, which may result in a loss of both mechanical ventilation and the ventilator's integrated monitoring if the system's primary power source is removed.

A vaporizer is calibrated and labeled for one agent only. Do not introduce any other than the designated agent into the vaporizer.

If a vaporizer is filled with the wrong agent, draining will not eliminate the agent, because the wick will have absorbed some of the agent. The wick must be thoroughly cleaned and dried by trained service personnel.

Incomplete sealing of the vaporizer's funnel cap will result in loss of gases. To help prevent such loss, make sure the cap-sealing O-ring is in good condition and the funnel cap is securely tightened before using the vaporizer.

If an alarm condition cannot be resolved, do not continue to use the system.

If you remove the sensor clip from the volume sensor cartridge before switching on the anesthesia system, the apnea alarms will be inoperative. Do not use the ventilator without the sensor clip properly attached to the volume sensor cartridge.

Ventilator failure messages indicate that a problem exists in the ventilator. Do not attempt to use the ventilator while a ventilator failure message is displayed.

Do not attempt to use the ventilator if the alarm silence button will not silence alarms.

Liquids or any foreign materials trapped in the driving-gas circuit of the pop-off valve or the bellows base can impair the valve's operation. Do not use the pop-off valve or bellows base if you suspect that materials are trapped. Have the assembly repaired by trained service personnel.

Sterilize the bellows assembly periodically to minimize the risk of cross-infecting patients. Use a sterilization schedule that complies with your institution's infection-control and risk-management policies. Use Ohmeda-approved sterilization methods.

Liquids or any foreign materials trapped in the driving-gas circuit of the pop-off valve or the bellows base can impair the valve's operation. Do not use the pop-off valve or bellows base if you suspect that materials are trapped. Have the assembly repaired by trained service personnel.

Do not inhale any fumes generated by the oxygen-sensor cleaning procedure. Such fumes can cause respiratory system or skin damage. This material is caustic.

Talc, zinc stearate, calcium carbonate, or corn starch that have been used to prevent tackiness of rubber articles could contaminate a patient's respiratory tract.

Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote™ is the recommended oxygen service lubricant (Stock number 0220-0091-300).

After performing any maintenance or repair procedure, always verify proper operation of the Ohmeda waste gas scavenging interface valve.

Do not use the anesthesia system without proper, functioning oxygen monitoring installed.

After installing the ventilator, perform the ventilator's preoperative checkout before using the system.

The Ohmeda Modulus II Plus Anesthesia System is restricted to use with nonflammable anesthetic agents.

After installing the Ohmeda GMS PEEP Valve, perform the Preoperative Checkout Procedures before using the system.

After installing the pediatric bellows assembly, perform the Preoperative Checkout Procedures before using the system.

When used, the oxygen-sensor adapter and the pressure-sensor's patient-circuit adapter must be connected to the inspiratory side of the breathing system. If these devices are not correctly connected to the inspiratory side of the breathing system, oxygen and pressure monitoring and related alarms will not function properly.

▲Cautions

Federal law in U.S.A. and Canada restricts this device to sale by or on the order of a licensed medical practitioner.

Do not remove oxygen sensor cartridges from their protective packaging until just before you install the cartridges. Oxygen sensor cartridges left exposed to room air may develop an oxide coating that can temporarily degrade oxygen-monitoring performance.

Precautions

The oxygen probe must be plugged into the patient interface panel for at least 12 hours, and the anesthesia system's electrical power must be on for at least five minutes, before calibrating or using the probe. Otherwise the probe may not function properly.

When in use, the oxygen sensor probe should always point down to help reduce condensation on the sensor surfaces. Condensation on the sensor may affect patient data.

Do not place materials weighing more than 11.3 kg (25 lb.) on the lower, stationary shelf, or more than 27.2 kg (60 lb.) on the upper, tilting shelf. Overloading may damage the shelves or cause instability.

Secure any equipment placed on the shelves.

To avoid stripping threads, do not use wrenches on the yoke gate tee screws.

Always use a yoke plug and cylinder gasket to seal any unused yokes. Yoke check valves alone may not provide a leak-free seal.

Use only one cylinder gasket per yoke. Using more than one gasket can cause cylinder gas leakage or can defeat the pin index system.

Open cylinder valves s-l-o-w-l-y to avoid damaging the regulators.

To help prevent operating room pollution, cap all unused connectors.

All Ohmeda monitors, the Ohmeda Anesthesia Record Keeper, the vaporizers, and the Ohmeda GMS Absorber, have their own operation-and-maintenance manuals. Before using the system, read the manuals for all the installed devices.

Make the electrical connection at an appropriate hospital grade receptacle only.

The vaporizers must be completely upright for the sight glass to properly indicate agent levels.

If the language displayed is other than "*English-Standard*," have an Ohmeda-trained service representative reset the ventilator. Certain languages the system displays have associated operating parameters that are not described in this manual.

Use cleaning solution sparingly. Do not saturate system components. Excessive solution can damage internal devices.

Do not cover the system with any type of fabric or plastic covering. These types of coverings can generate static charges that may damage the equipment.

The bases for the adult and pediatric bellows assemblies use different seals and are not interchangeable. Do not mix parts for these two assemblies. Interchanging parts for these assemblies may cause the bellows assembly to malfunction.

Perform the Preoperative Checkout Procedure after cleaning and sterilizing the bellows assembly.

Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

Never immerse any part of the volume sensor assembly in cleaning solution. Immersion will destroy the clip's electrical contacts.

Never insert cleaning brushes or other foreign objects through the cartridge vanes. Contacting the sensor's moving vane may damage its precision movement.

Always perform the preoperative checkout procedures for volume sensing functions after cleaning or replacing the volume sensor cartridge.

Never immerse any part of the oxygen sensor assembly in cleaning solution. Immersion will destroy the sensor cartridge's electrical contacts.

Do not use cold sterilization, solvents or cleaning agents to clean the oxygen-sensor cartridge. These substances may damage the oxygen-sensor cartridge.

Always perform the preoperative checkout procedures for oxygen-sensing functions after replacing the sensor cartridge.

No repair should ever be undertaken or attempted by anyone not having proper qualifications and equipment.

Do not pull on the wires leading to the ventilator's electrical connectors. Pulling directly on the ventilator's electrical wires may cause the ventilator to malfunction.

The voltage for this system was set in the factory. Do not change the original factory setting. Other system changes must be made before changing the voltage setting. If the available voltage differs from the voltage setting, call a qualified service representative to make all the required system changes.

1/Introduction

1.1 Introduction

Thank you for selecting the Ohmeda Modulus II Plus Anesthesia System. This system, which is intended for both adult and pediatric applications, features a vaporizer interlock; a back-up battery for temporary, continued ventilation during power failures; extensive storage space on two shelves and in three drawers; optional, integrated monitoring; and the Ohmeda Link 25 Proportion Limiting Control System, which ensures that any oxygen/nitrous-oxide mixture delivered at the common gas outlet will contain a minimum of about 25 percent oxygen.

Also included in this system is an Ohmeda 7810 Ventilator. This instrument combines an electronically-controlled, pneumatically-driven ventilator with built-in monitoring for exhaled volume, inspired oxygen concentration, and airway pressure. The ventilator also features controls with clinically significant ranges, selectable inspiratory pause, and an adjustable, inspiratory pressure limit control.

Before using this system, familiarize yourself with the Ohmeda Modulus II Plus Anesthesia System by reading through this entire manual. Also read the manuals for any optional monitors and accessories, such as the Ohmeda GMS Absorber, installed in the system.

Pay special attention to the Warnings and Cautions that appear throughout this manual and are summarized in the PRECAUTIONS section. Warnings alert you to conditions or actions that may cause harm to humans. Cautions alert you to conditions or actions that may result in damage to equipment.

Read the User Responsibility statement; it describes what is expected of you to maintain the system. Read the Warranty; it describes Ohmeda's responsibility in case of a functional defect.

Keep this manual with the system for answering questions that arise about the system's operation, maintenance or, if necessary, repair.

1.2 How To Use This Manual

This manual is designed both as a guide for you to follow when you are learning to operate the Ohmeda Modulus II Plus Anesthesia System, and as a reference tool for you to use once you are familiar with the system.

If you are setting up the system for the first time, refer to all of the sections starting with section two "Getting Started."

If the system is already in place, but you haven't used it before, pay particular attention to all of the sections starting with section three "General Information."

If you have used the Ohmeda Modulus II Plus Anesthesia System before, but need reminding about details of using the system, refer to sections four "Preoperative Setup Procedures" and five "Operating The System."

Sections six, "Maintaining The System" and seven, "Service Procedures," are included to inform you about routine maintenance of the system and to help you solve problems that might occur with the system.

No matter which part of the manual you are using, you should always be familiar with the Cautions and Warnings listed in the "Precautions" section at the beginning of the manual.

Many of the sections in this manual apply only when the Ohmeda Modulus II Plus Anesthesia System is used with the Ohmeda GMS Absorber™; if you plan to use this system with a different absorber or other anesthesia-system accessories, consult Ohmeda for more information.

We have used, in this manual, the terms "left side" or "right side" to refer to locations of devices as you face the anesthesia machine. For example, the common gas outlet, which—when you face the front of anesthesia machine—is on your left, is said to be on the system's left side. And the AC electrical outlets, which—as you face the back of the anesthesia machine—are on your right, are said to be on the system's right side.

Throughout this manual we have provided step-by-step instructions to simplify the system's operation. To further clarify the instructions, we have used a special typeface to identify messages that appear on the ventilator's screen. Messages from the ventilator are represented by a dot-matrix typeface that simulates the messages' actual appearance. A low minute volume alarm message will look like this:

LOW MINUTE VOL!

Pay attention to the **WARNINGS** and **CAUTIONS** that are included both in this manual and on the Ohmeda Modulus II Plus Anesthesia System itself. Warnings are intended to alert you to conditions that could result in injury to a person. Cautions are intended to alert you to conditions that could result in damage to the system. Warnings and cautions that are on the anesthesia system are marked with this symbol:



2/Getting Started

Many of the steps in the following sections will be performed when a service representative installs the system. And certain of the system's accessories have installation instructions that describe in greater detail the procedures described in this section. However, during use, maintenance, or sterilization the system components may be left disconnected or may be reconnected incorrectly. Read through the "Getting Started" sections to confirm that your system is set-up properly. Perform any steps necessary to correctly connect your system's components.

The following sections tell you how to mount an Ohmeda GMS Absorber, how to mount the Ohmeda waste gas scavenging interface valve, how to install and connect the ventilator's bellows assembly, how to install the monitoring sensors, how to prepare the system, and how to make the gas connections. Although these steps are straightforward, they should be performed only by someone experienced in working with anesthesia and monitoring equipment.

2.1 Unpacking

Upon delivery, inspect the system and its accessories for signs of damage that may have occurred during shipment. Before opening the shipping carton, check the tip indicator to ensure that the system was not tipped unacceptably during shipping. If you do find any damage, immediately notify the transportation company and file a damage claim. Save the original shipping container and materials, and any manuals or instructions.

The Ohmeda Modulus II Plus Anesthesia System's functions should be completely checked as soon as possible. Follow the steps in section two, or any other instruction packages included with accessories, to install the system. Then, after you have used this manual to familiarize yourself with the Ohmeda Modulus II Plus Anesthesia System, confirm that it is working correctly by performing the preoperative setup procedures described in section four.

Before using the system with a patient, always check each item on the Preoperative Checklist, which is at the front of this binder.

2.2 Installing The Ohmeda GMS Absorber

This section tells you how to install the Ohmeda GMS Absorber. If you are using a different type of absorber, refer to the operation manual for that device.

1. Turn the absorber mounting release, which is next to the absorber's locking lever, counterclockwise as far as it will go. (See figure 2-1.)
2. The anesthesia machine's swivel arm supports the absorber. Place the absorber on the arm's mounting pin.
3. Turn the absorber mounting release clockwise until it is tight, but do not over tighten this knob.

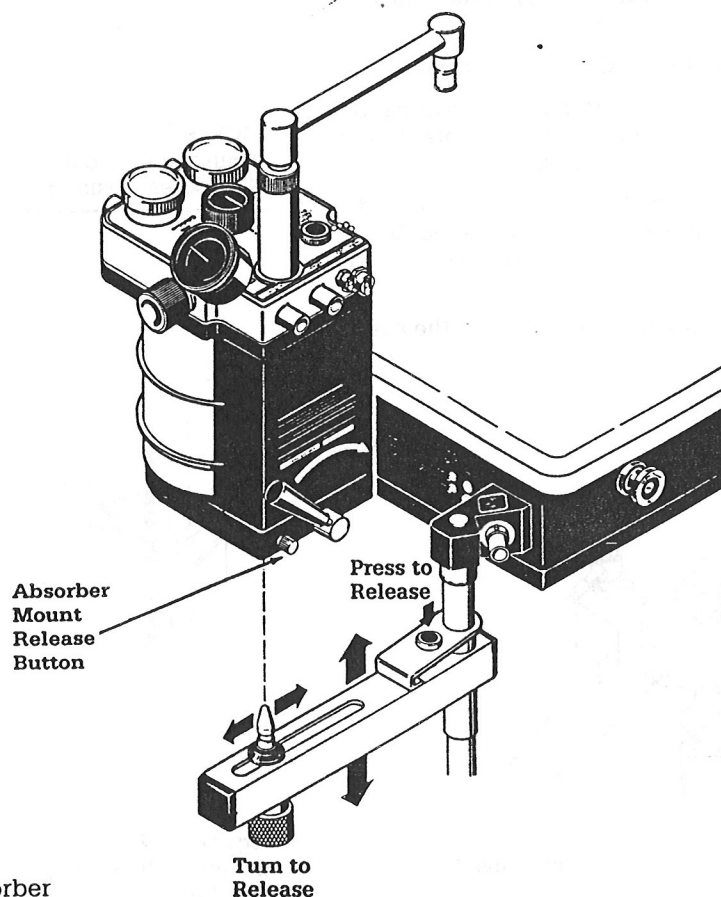


Figure 2-1
Mounting the absorber

2/Getting Started

2.3 Mounting The Waste Gas Scavenging Interface Valve

The Ohmeda waste gas scavenging interface valve provides a central manifold for channeling waste gas from the breathing system to a waste-gas disposal system. You can mount this assembly in either of two locations: the left side of the anesthesia machine; or the absorber swivel arm. For most applications, mounting the assembly directly to the side of the anesthesia machine is preferable; when the assembly is mounted to the absorber arm, it may contact and damage the anesthesia machine's electronics module that is used for certain system configurations.

To mount the assembly to the side of the anesthesia machine:

1. The assembly uses a plate (stock number 234-1039-500) that slides into a bracket mounted on the side of the anesthesia machine. Hold this plate to the valve assembly so the holes on the plate align with the holes on the assembly's long, flat rear surface. The plate must extend downward, away from the assembly's needle-valve knob.
2. Insert the two screws through the holes on the side of the assembly opposite the mounting plate.
3. Tighten the screws.
4. The bracket mounted on the anesthesia machine serves two purposes; it secures the 17-mm oxygen tube that runs from the ventilator's control module to the bellows assembly; and it attaches the valve assembly to the side of the machine. Slide the waste gas scavenging interface valve assembly onto this bracket.

To mount the assembly to the absorber arm:

1. If the mounting plate is attached to the assembly, remove the two screws that hold it in place; then store the plate but retain the screws.
2. Hold the valve assembly so that its notched side faces the absorber swivel arm, and so that the assembly's two holes align with the two tapped holes in the arm.
3. Insert the two screws into the holes in the assembly.
4. Tighten the screws.

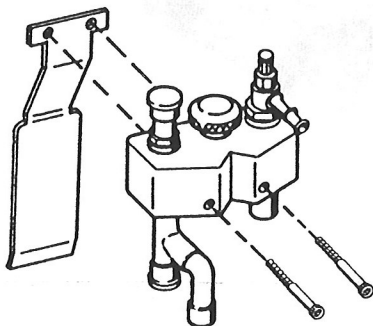


Figure 2-2
Attaching the scavenging interface valve to its mounting plate

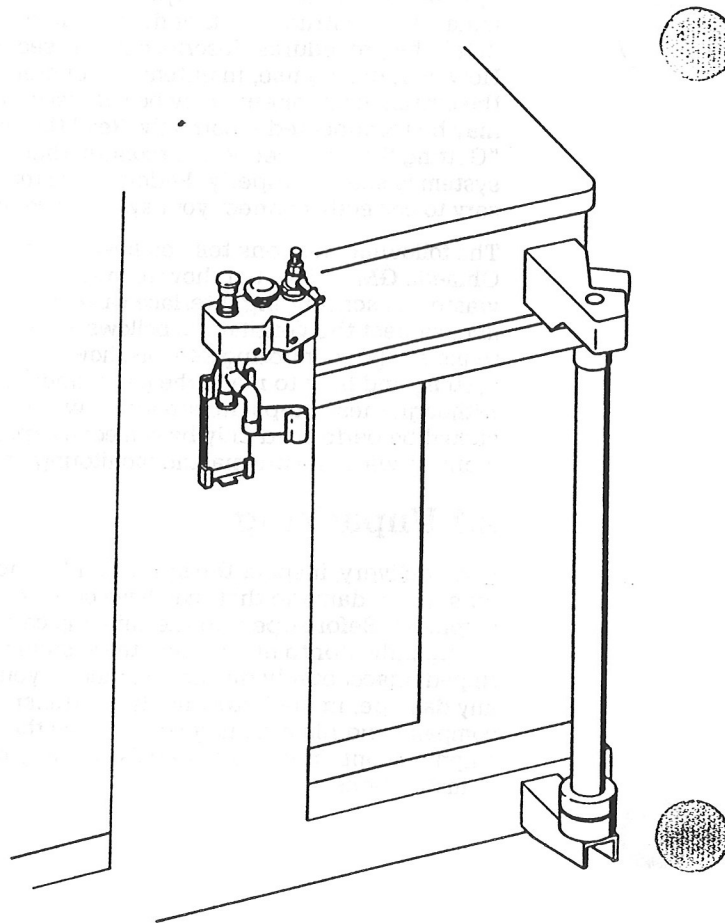


Figure 2-3
Mounting the scavenging interface valve to the side of the anesthesia machine

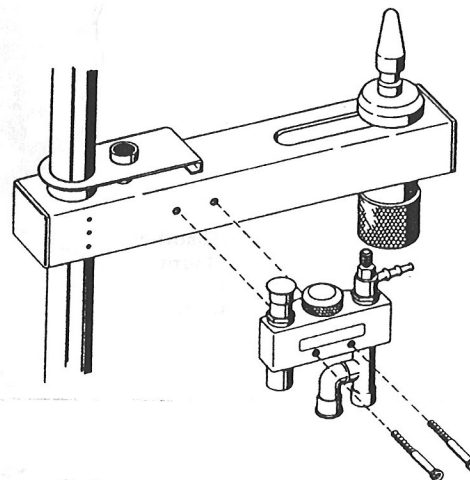


Figure 2-4
Mounting the scavenging interface valve to the absorber arm

2/Getting Started

2.4 Connecting The Bellows Assembly

This section describes the connections between the bellows assembly and the anesthesia system, and it tells you how to use the absorber interface manifold to connect the bellows assembly to the Ohmeda GMS Absorber. If you plan to mount the bellows assembly on the anesthesia system's side rather than on the Ohmeda GMS absorber, refer to Appendix E.

A. Connecting The Bellows Assembly To The Absorber

1. Align the two square-shaped support guides on the bottom of the bellows assembly with the two support pins on the back of the absorber. (See figure 2-5.)
2. Insert the support pins into the support guides and slide the bellows assembly toward the absorber until the interface manifold touches the absorber's ports.
3. Align the bellows assembly's locking rod with the threaded hole between the two screws on the absorber's support-pin block.
4. Turn the bellows assembly's locking knob clockwise until the absorber interface manifold is securely connected to the absorber and the knob won't turn further.

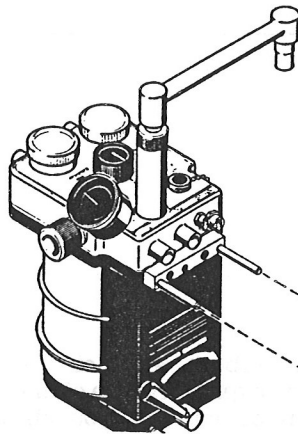


Figure 2-5
Connecting the bellows assembly to the absorber

B. Connecting the Bellows Assembly To The Ventilator Control Module

1. A 17-mm corrugated tube carries drive oxygen from the control module to the bellows assembly. Connect one end of this tube to the 90-degree adapter that connects to the control module. The 90-degree adapter has an internal O-ring; make sure it is in place.
2. Use the set screws on the 90-degree adapter to attach the adapter to the connector labelled "Connect to Bellows Ass'y" on the control module's rear panel. (See figure 2-6.)
3. Hanger tabs bundle the corrugated tube and the 1/8-inch pressure-sensing tube. Lead the corrugated tube's free end through the larger ring on each hanger tab.
4. Position the hanger tabs evenly along the corrugated tube.
5. Connect the free end of the 17-mm corrugated tube to the absorber interface manifold's 17-mm, barbed connector. (See figure 2-7.)
6. The bracket mounted on the anesthesia machine secures the 17-mm oxygen tube to the side of the machine. Insert the 17-mm corrugated tube into the clip on the anesthesia system's side. (See figure 2-8.)

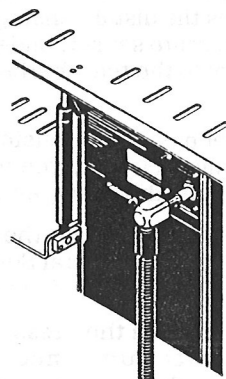
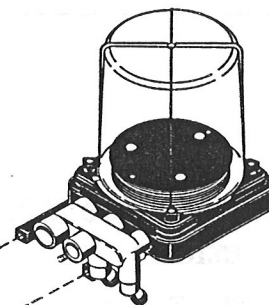


Figure 2-6
Connecting the drive-oxygen tube to the control module

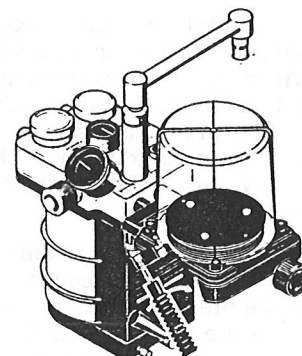


Figure 2-7
Connecting the drive-oxygen tube to the absorber interface manifold

2/Getting Started

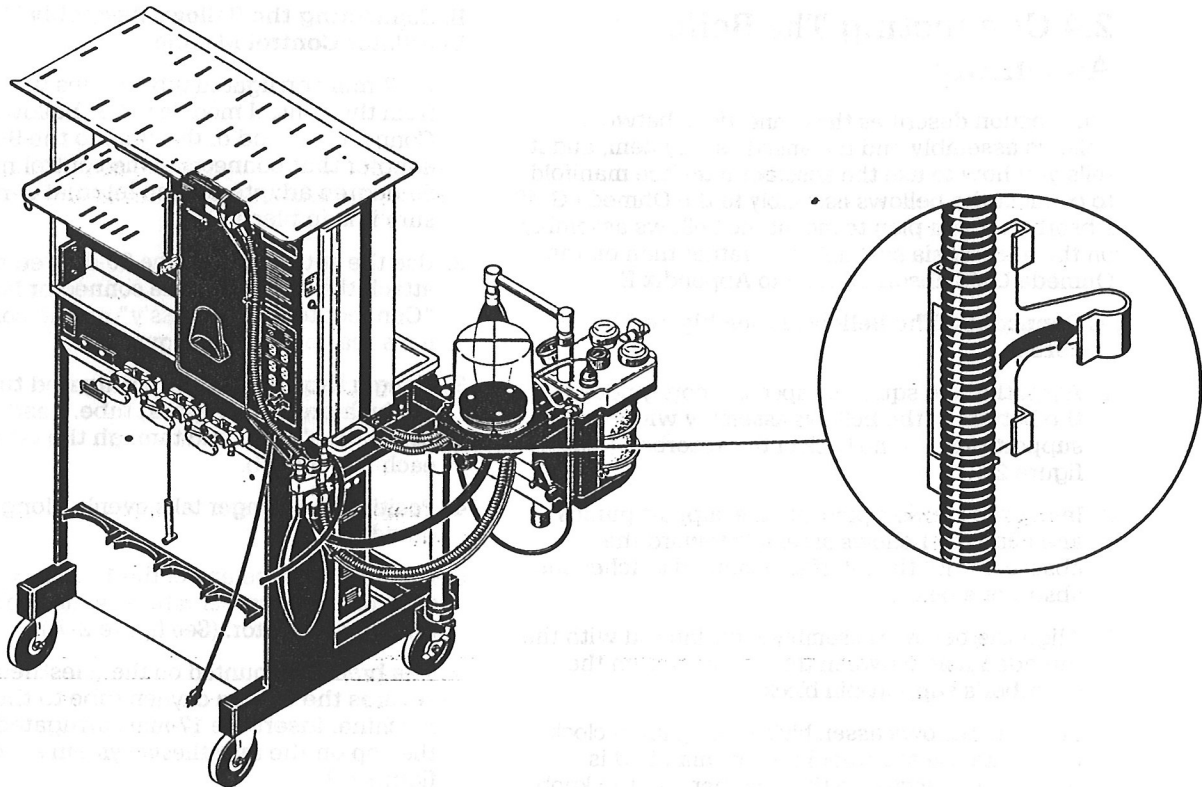


Figure 2-8
Attaching the drive-oxygen tube to the mounting bracket

2.5 Making The Monitoring Connections

A. Connecting The Pressure Sensing Tube

The airway pressure sensor is housed in the ventilator control module. A clear, 1/8-inch tube connects between the control module and the distal-sensing tee, which is in the inspiratory limb of the breathing system, located between the absorber and the absorber's pressure gauge. This tee can also be installed on older Ohmeda GMS Absorbers; the kit for this upgrade is stock number 0236-6152-870.

This section tells you how to connect the pressure-sensing tube on systems that include an Ohmeda GMS Absorber. If you want to use the ventilator without an Ohmeda GMS absorber, you must install an optional, in-line, pressure-sensing tee (patient circuit adapter stock number 6050-0000-456) in the inspiratory limb of the breathing system. (See Appendix D.)

For pressure monitoring to function correctly, the distal-sensing tee must connect to the inspiratory side of the breathing system. Although all Ohmeda GMS Absorbers manufactured after January 1, 1986 have their pressure gauges connected to the inspiratory side, certain older, unmodified Ohmeda GMS

Absorbers have their pressure gauges connected to the expiratory side of the breathing system. If you are not sure that your absorber's pressure gauge—and distal sensing tee—is in the inspiratory side of the breathing system, perform the test in Appendix F.

1. A barbed connector on the absorber's pressure gauge provides the distal-sensing tee for the ventilator's pressure sensor. Slide one end of the sensing tube onto the tee's barbed fitting. (See figure 2-9.)
2. String the other end of the sensing tube through the small openings on the three hanger tabs that are attached to the drive oxygen line.
3. Slide the tube's free end onto the barbed connector marked "Connect to Distal Sensing Tee" on the control module's rear panel. (See figure 2-10.)

WARNING: Position the pressure-sensing tube so that the absorber arm cannot pinch the tube. If the tube is pinched, the system's pressure monitoring will not function correctly.

2/Getting Started

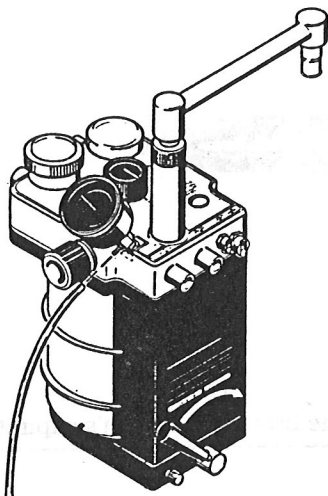


Figure 2-9
Connecting the pressure-sensing tube to the absorber's pressure gauge

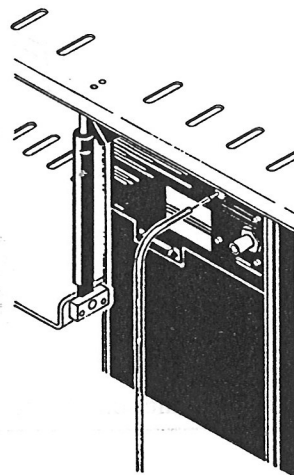


Figure 2-10
Connecting the pressure-sensing tube to the control module

B. Connecting The Volume Sensor

To provide information about the volume of each exhaled patient breath, the ventilator measures the amount of gas that passes through a sensor inserted in the breathing system. The ventilator makes calculations based on this measurement, and then displays the calculated tidal volume, minute volume, and breath rate.

The volume sensor assembly includes a cartridge with a vane whose rotational speed varies depending on the gas flow rate, and a sensor clip that translates the direction and speed of the vane's rotation into electrical pulses. This cartridge must be placed in the expiratory limb of the breathing system, either in the distal or proximal position. Placing the cartridge at the distal position in the expiratory limb lets the system detect reverse flow and generate reverse flow alarms. You may also place the volume sensor cartridge at the proximal end of the "Y" connector; however, you then must use the Setup Page to disable the reverse flow alarms that would otherwise be generated when the patient inhales. If you are using a Bain circuit and Bain circuit adapter, the volume sensor cartridge must be placed in the proximal position, between the end of the Bain circuit and the patient connector to the ET

tube or mask. (See Appendix H for details of using the volume sensor assembly with a Bain circuit.)

To install the volume sensor assembly:

1. Insert the sensor cable plug into the receptacle marked "Volume Monitor" on the anesthesia machine's patient interface panel. (See figure 2-11.)
2. Install the sensor cartridge between the absorber's exhalation port and the expiratory limb of the breathing system. You may also install the cartridge at the proximal end of the "Y" connector. (See figures 2-12 and 2-13.) When a Bain circuit and Bain circuit adapter is used with the system, the cartridge must be placed in the proximal position. (See Appendix H for details of using the volume sensor assembly with a Bain circuit.) If you do choose the proximal position, each time you switch on the system, you must use the Setup Page to disable the reverse flow alarm.
3. Clip the sensor over the cartridge. The arrows on the sensor must point in the direction of gas flow during expiration; the arrows must point toward the absorber and away from the patient. (See figure 2-14.)

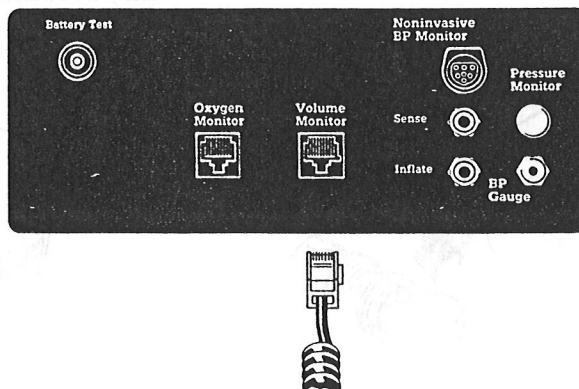


Figure 2-11
Plugging the volume sensor plug into the patient interface panel

2/Getting Started

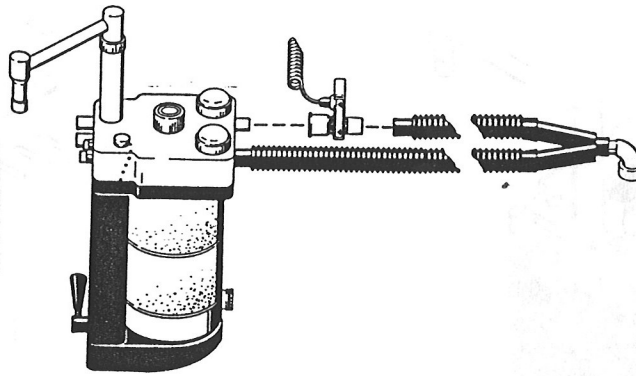


Figure 2-12

Inserting the volume sensor cartridge into the distal location of the breathing system's expiratory limb

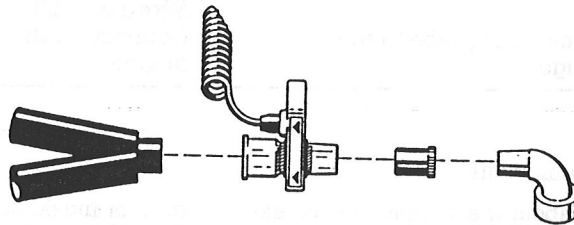


Figure 2-13

Inserting the volume sensor cartridge at the proximal end of the "Y" connector

4. Check the volume sensor as described in section 6.3.

Replace the volume sensor cartridge at least every thirty days.

WARNING: Take care not to crack or break the volume sensor cartridge. When you are placing the cartridge on the absorber, be certain to obtain a secure fit, but do not force the cartridge in place as tightly as possible. Avoid striking the cartridge. A broken or cracked cartridge could cause a circuit disconnection and a break in the breathing circuit.

WARNING: The volume sensor cartridge and sensor must be correctly installed at either the distal location in the breathing system's expiratory limb or the proximal end of the "Y" connector. If the cartridge and sensor are installed incorrectly, volume data will be inaccurate and associated alarms, including the apnea and low minute volume alarms, will not function properly.

WARNING: Destroy old or malfunctioning volume sensor cartridges to prevent inadvertent reuse. Using malfunctioning volume sensor cartridges may result in compromised patient data.

WARNING: Position the volume sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's volume monitoring may not function correctly.

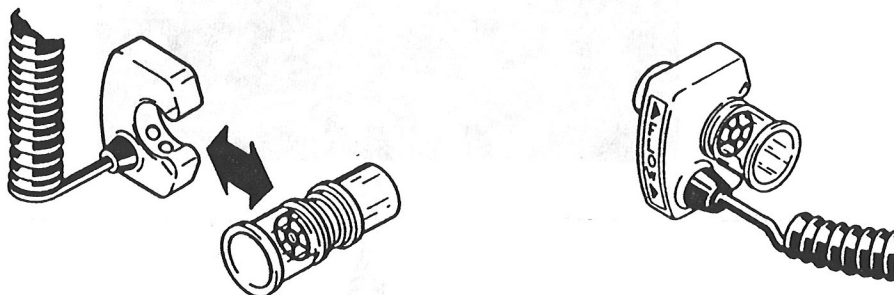


Figure 2-14

Attaching the volume sensor cartridge to its clip

2/Getting Started

C. Connecting The Oxygen Sensor

This section tells you how to assemble the oxygen probe, connect the probe cable to the patient interface panel, and insert the probe into the Ohmeda GMS Absorber. If you want to use the ventilator without an Ohmeda GMS absorber, you must install an optional, in-line oxygen-sensor adapter (stock number 0212-0763-100) in the inspiratory side of the breathing system. (See Appendix D.)

1. The actual oxygen sensing device is a cartridge that you must install in the oxygen probe before you insert the probe into the absorber. To install the oxygen probe's cartridge:
 - a. Hold the probe housing so the cable hangs down and the probe points up.
 - b. Grasp the housing's knurled surfaces and turn the housing's probe end counterclockwise until it is free.
 - c. Set the probe section aside.
 - d. Remove an oxygen sensor cartridge from its protective package. This package contains an inert atmosphere intended to prolong the cartridge's shelf life. Do not remove the cartridge from its package until you are ready to install it.

CAUTION: Do not remove oxygen sensor cartridges from their protective packaging until just before you install the cartridges. Oxygen sensor cartridges left exposed to room air may develop an oxide coating that can temporarily degrade oxygen-monitoring performance.

- e. Insert the cartridge so its screen faces out of the housing, and so the three metallic, concentric rings at its other end contact the gold-colored terminals at the cable end of the probe housing.
 - f. Thread the housing's probe section back onto the cable section. Turn the probe section until it is finger tight. Make sure the sections are tight enough to compress the housing's O-rings, which form a gas-tight seal.

WARNING: Defective oxygen sensor cartridges may leak potassium hydroxide, which is caustic. Use care when handling oxygen sensor cartridges. Do not use any oxygen sensor cartridge that shows signs of leaking. If you get the potassium hydroxide solution in your eyes, immediately flush with water, then seek medical attention.

2. Insert the sensor cable plug into the receptacle marked "Oxygen Monitor" on the anesthesia machine's patient interface panel. If the oxygen sensor probe is not plugged into the panel, an oxide coating will accumulate on the cartridge's sensor screen. The sensor can be properly calibrated and checked only when the sensor's screen is free of this coating. Plugging the probe into the patient interface panel will gradually remove this oxide coating; plug the probe into the panel for at least 12 hours, and switch on the anesthesia system for at least five minutes, before using the oxygen probe.

CAUTION: The oxygen probe must be plugged into the patient interface panel for at least 12 hours, and the anesthesia system's electrical power must be on for at least five minutes, before calibrating or using the probe. Otherwise the probe may not function properly.

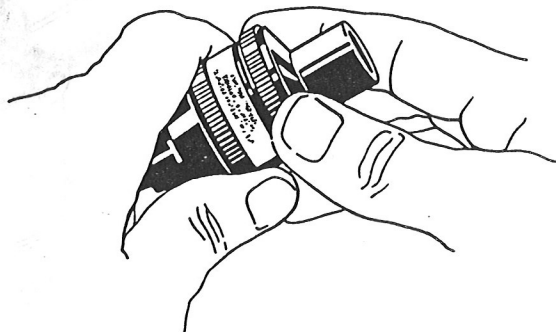


Figure 2-15
Disassembling the oxygen sensor probe

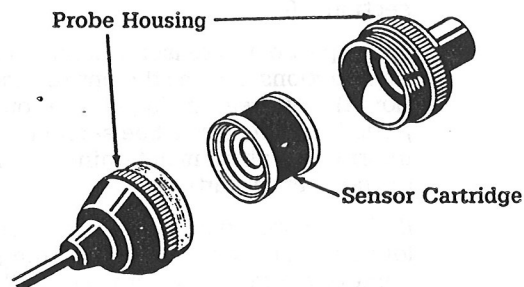


Figure 2-16
The oxygen sensor, exploded view

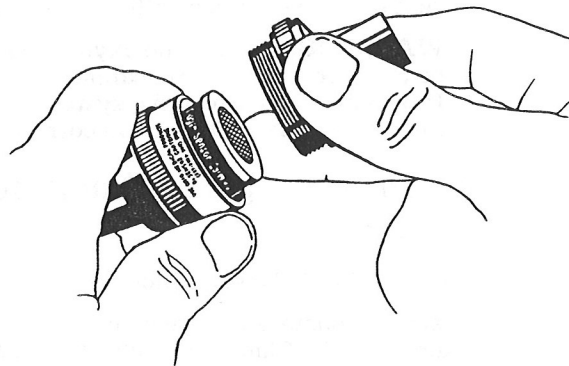


Figure 2-17
Reassembling the oxygen probe

2/Getting Started

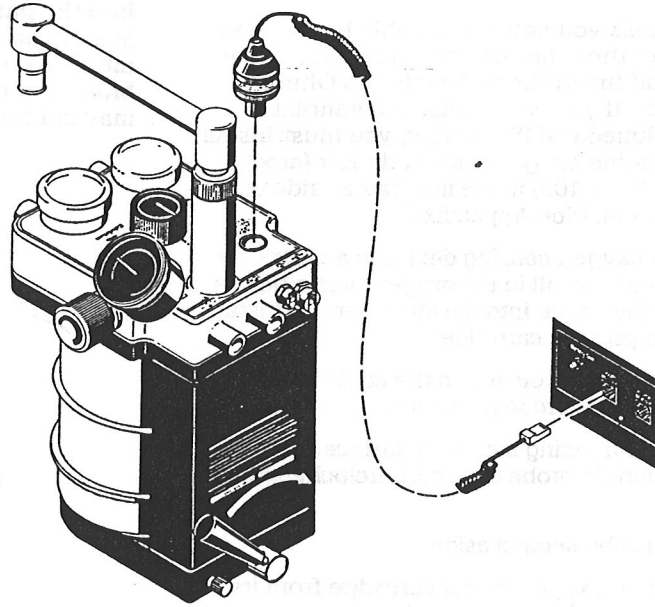


Figure 2-18

Connecting the oxygen probe to the absorber and the patient interface panel

3. Remove the cap from the absorber's oxygen sensor port, which is labeled "Oxygen Sensor."
4. Insert the probe into the absorber's sensor port.
5. Calibrate the oxygen sensor as described in section 6.6.

If any part of the sensor assembly is damaged or malfunctions, replace the entire assembly. In addition, the oxygen cartridges wear out and must be periodically replaced. See sections 6.4 and 6.5 for information about maintaining and replacing the oxygen sensor cartridge.

If, during operation, the sensor's temperature is lower than or equal to the breathing-gas dew-point temperature, water vapor will condense on the probe's sensor screen. This condensate may reduce the amount of oxygen reaching the sensor's screen, which will cause the ventilator to display lower than actual oxygen concentration values.

CAUTION: When in use, the oxygen sensor probe should always point down to help reduce condensation on the sensor surfaces. Condensation on the sensor may affect patient data.

WARNING: Position the oxygen sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's oxygen monitoring may not function correctly.

other, underneath, is a smaller, fixed shelf. A set of clips and straps is used to secure equipment to these shelves. Sliding brackets attach equipment to the mounting tracks, which are on the machine's sides.

CAUTION: Do not place materials weighing more than 11.3 kg (25 lb.) on the lower, stationary shelf, or more than 27.2 kg (60 lb.) on the upper, tilting shelf. Over-loading may damage the shelves or cause instability.

Adjusting The Top Shelf's Angle

A latching strut lets you adjust the top shelf's angle. To increase the angle, grasp the shelf at the rear near the strut and use your thumb to squeeze the strut's lever. To decrease the shelf's angle, squeeze the lever and pull down on the shelf. When the shelf has reached the position you want to use, release the lever.

CAUTION: Secure any equipment placed on the shelves.

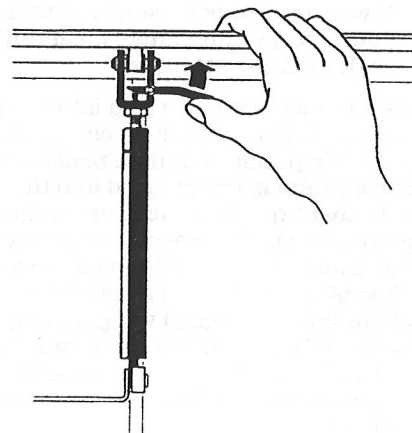


Figure 2-19

Adjusting the top shelf's latching strut

2.6 Preparing The Anesthesia System

A. Using The Shelves And Mounting Track

To accommodate additional monitors and other equipment, the Ohmeda Modulus II Plus Anesthesia System uses both a vertical mounting track and two horizontal shelves: one, at the system's top, is a long, deep shelf, whose angle can be adjusted; and the

2/Getting Started

C. Connecting The Oxygen Sensor

This section tells you how to assemble the oxygen probe, connect the probe cable to the patient interface panel, and insert the probe into the Ohmeda GMS Absorber. If you want to use the ventilator without an Ohmeda GMS absorber, you must install an optional, in-line oxygen-sensor adapter (stock number 0212-0763-100) in the inspiratory side of the breathing system. (See Appendix D.)

1. The actual oxygen sensing device is a cartridge that you must install in the oxygen probe before you insert the probe into the absorber. To install the oxygen probe's cartridge:
 - a. Hold the probe housing so the cable hangs down and the probe points up.
 - b. Grasp the housing's knurled surfaces and turn the housing's probe end counterclockwise until it is free.
 - c. Set the probe section aside.
 - d. Remove an oxygen sensor cartridge from its protective package. This package contains an inert atmosphere intended to prolong the cartridge's shelf life. Do not remove the cartridge from its package until you are ready to install it.

CAUTION: Do not remove oxygen sensor cartridges from their protective packaging until just before you install the cartridges. Oxygen sensor cartridges left exposed to room air may develop an oxide coating that can temporarily degrade oxygen-monitoring performance.

- e. Insert the cartridge so its screen faces out of the housing, and so the three metallic, concentric rings at its other end contact the gold-colored terminals at the cable end of the probe housing.
 - f. Thread the housing's probe section back onto the cable section. Turn the probe section until it is finger tight. Make sure the sections are tight enough to compress the housing's O-rings, which form a gas-tight seal.

WARNING: Defective oxygen sensor cartridges may leak potassium hydroxide, which is caustic. Use care when handling oxygen sensor cartridges. Do not use any oxygen sensor cartridge that shows signs of leaking. If you get the potassium hydroxide solution in your eyes, immediately flush with water, then seek medical attention.

2. Insert the sensor cable plug into the receptacle marked "Oxygen Monitor" on the anesthesia machine's patient interface panel. If the oxygen sensor probe is not plugged into the panel, an oxide coating will accumulate on the cartridge's sensor screen. The sensor can be properly calibrated and checked only when the sensor's screen is free of this coating. Plugging the probe into the patient interface panel will gradually remove this oxide coating; plug the probe into the panel for at least 12 hours, and switch on the anesthesia system for at least five minutes, before using the oxygen probe.

CAUTION: The oxygen probe must be plugged into the patient interface panel for at least 12 hours, and the anesthesia system's electrical power must be on for at least five minutes, before calibrating or using the probe. Otherwise the probe may not function properly.

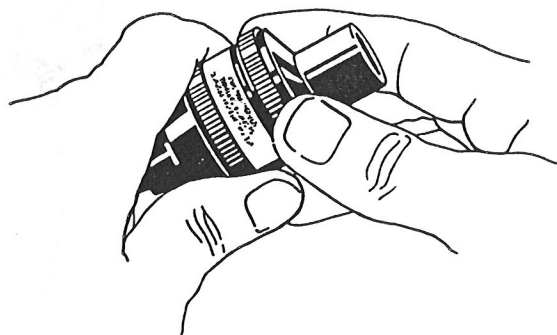


Figure 2-15
Disassembling the oxygen sensor probe

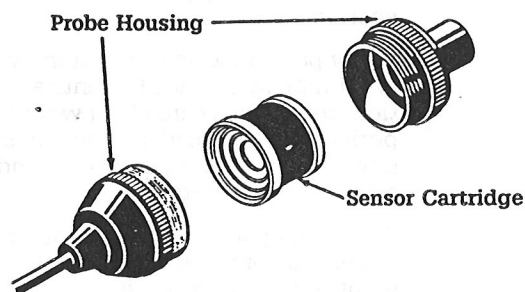


Figure 2-16
The oxygen sensor, exploded view

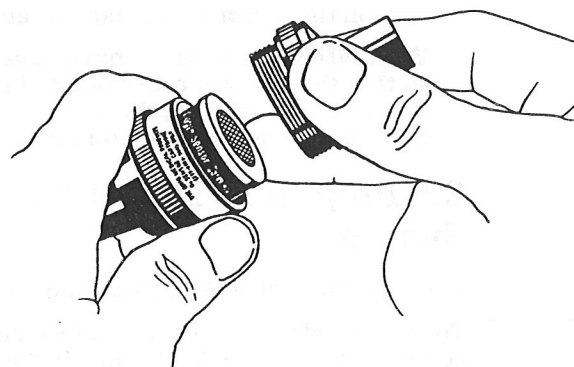


Figure 2-17
Reassembling the oxygen probe

2/Getting Started

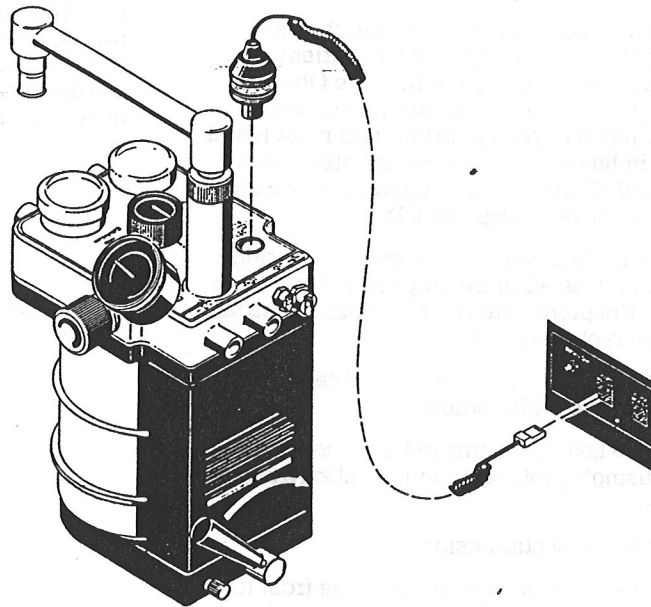


Figure 2-18

Connecting the oxygen probe to the absorber and the patient interface panel

3. Remove the cap from the absorber's oxygen sensor port, which is labeled "Oxygen Sensor."
4. Insert the probe into the absorber's sensor port.
5. Calibrate the oxygen sensor as described in section 6.6.

If any part of the sensor assembly is damaged or malfunctions, replace the entire assembly. In addition, the oxygen cartridges wear out and must be periodically replaced. See sections 6.4 and 6.5 for information about maintaining and replacing the oxygen sensor cartridge.

If, during operation, the sensor's temperature is lower than or equal to the breathing-gas dew-point temperature, water vapor will condense on the probe's sensor screen. This condensate may reduce the amount of oxygen reaching the sensor's screen, which will cause the ventilator to display lower than actual oxygen concentration values.

CAUTION: When in use, the oxygen sensor probe should always point down to help reduce condensation on the sensor surfaces. Condensation on the sensor may affect patient data.

WARNING: Position the oxygen sensor's cable so that the absorber arm cannot pinch the cable. If the cable is pinched, the system's oxygen monitoring may not function correctly.

2.6 Preparing The Anesthesia System

A. Using The Shelves And Mounting Track

To accommodate additional monitors and other equipment, the Ohmeda Modulus II Plus Anesthesia System uses both a vertical mounting track and two horizontal shelves: one, at the system's top, is a long, deep shelf, whose angle can be adjusted; and the

other, underneath, is a smaller, fixed shelf. A set of clips and straps is used to secure equipment to these shelves. Sliding brackets attach equipment to the mounting tracks, which are on the machine's sides.

CAUTION: Do not place materials weighing more than 11.3 kg (25 lb.) on the lower, stationary shelf, or more than 27.2 kg (60 lb.) on the upper, tilting shelf. Over-loading may damage the shelves or cause instability.

Adjusting The Top Shelf's Angle

A latching strut lets you adjust the top shelf's angle. To increase the angle, grasp the shelf at the rear near the strut and use your thumb to squeeze the strut's lever. To decrease the shelf's angle, squeeze the lever and pull down on the shelf. When the shelf has reached the position you want to use, release the lever.

CAUTION: Secure any equipment placed on the shelves.

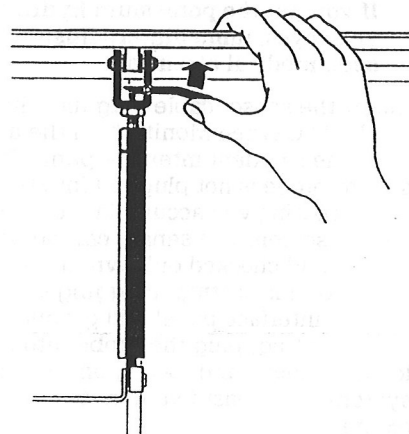


Figure 2-19

Adjusting the top shelf's latching strut

2/Getting Started

C. Installing The Vaporizers

Ohmeda recommends that your institution establish a standard mounting sequence for all vaporizer manifolds in use. You can, however, mount Ohmeda Tec 4 Vaporizers in any order; when the vaporizers are properly mounted on an Ohmeda vaporizer manifold, gas flow enters only the vaporizer that is switched on. The order in which vaporizers are mounted has no effect on vaporizer performance. Refer to the Ohmeda Tec 4 Continuous Flow Vaporizer Operators Manual for complete instructions on using the vaporizers.

To mount a vaporizer:

1. Move the vaporizer control knob to "Off." (See figure 2-22.)
2. Turn the vaporizer locking lever, which is next to the vaporizer control knob, counterclockwise as far as it will go.
3. Carefully lower the vaporizer onto the manifold so the vaporizer's interlock block covers the two manifold port valves.
4. Turn the locking lever clockwise to lock the vaporizer onto the manifold.

To check for proper vaporizer mounting:

1. Check that the tops of all vaporizers are level and at the same height. Remount any vaporizer that is visibly misaligned.
2. When all vaporizers appear level, are at the same height, and are locked in place, gently attempt to lift each vaporizer off the manifold. Remount any vaporizer that can be lifted off the manifold.

WARNING: Do not use any vaporizer that is visibly misaligned on the manifold or that, when its lever is locked, can be lifted off the manifold. Incorrect mounting may result in incorrect delivery of gases.

To remove vaporizers:

1. Move the vaporizer control knob to "Off." If the vaporizer is not switched completely off, it will not release from the manifold.
2. Turn the vaporizer locking lever fully counterclockwise to release the vaporizer.
3. Carefully lift the vaporizer straight up and off the manifold.

D. Adjusting The Position Of The Absorber

You can adjust the absorber's position four ways: by rotating the absorber in place on the absorber arm; by swinging the absorber arm on its mounting tube; by moving the absorber along its mounting track on the arm; and by adjusting the height of the arm along its mounting tube. If you want to rotate the absorber or swing the absorber's arm, just push the absorber to the position you want to use; the absorber will move freely. To keep the absorber arm from swinging too easily, tighten the knurled knob on the mounting tube, near the anesthesia machine's base.

To change the position of the absorber along the absorber arm:

1. A knob under the absorber's mounting pin on the arm secures the pin to the mounting track. Loosen this knob about one turn. (See figure 2-23.)
2. Slide the absorber to its new position.
3. Tighten the knob to lock the absorber in place on the track.

To adjust the height of the absorber arm:

1. Place one hand under the absorber on the arm.
2. With your free hand, grasp the absorber swivel arm near its mounting post.
3. Use your thumb to press the vertical adjustment button on the arm's locking plate, which is mounted to the arm and post. Continue pressing the button, pull up on the absorber swivel arm, and slide the arm to the position you want to use; then release the button.

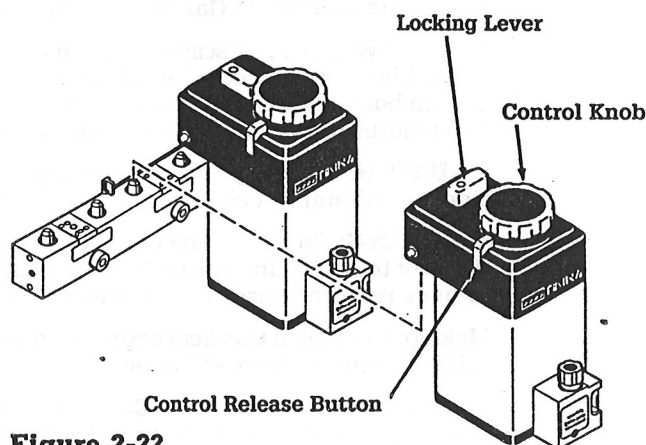


Figure 2-22
Installing a vaporizer

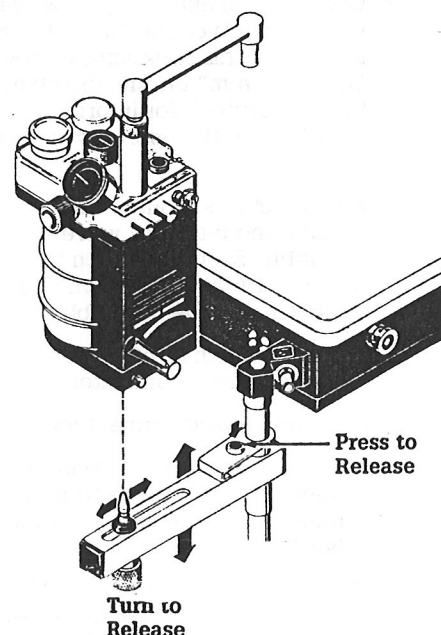


Figure 2-23
Adjusting the position of the absorber

2/Getting Started

2.7 Making The Anesthesia System Gas Connections

A. Making The Gas Pipeline Connections

Each of the pipeline gases your system uses is introduced to the anesthesia machine through a labeled pipeline inlet. The inlets for the pipeline gases are mounted next to the corresponding gas cylinder yokes on the back of the machine.

1. If gas cylinders are installed, use the cylinder wrench to close the cylinder valves.
2. Connect the hospital's oxygen pipeline to the system's oxygen pipeline inlet, which is labeled "O₂ Pipeline Inlet." (See figure 2-24.)
3. Connect the hospital's nitrous oxide pipeline to the system's nitrous oxide inlet, which is labeled "N₂O Pipeline Inlet."
4. If you are using air, connect the hospital's air pipeline to the system's air inlet, which is labeled "Air Pipeline Inlet."

B. Making The Waste Gas Scavenging Connections

Provided with the gas scavenging interface valve assembly—and marked with yellow bands—are a 19-mm bore, three-liter, disposable, reservoir bag, and lengths of 19-mm ID, corrugated tubing.

CAUTION: To help prevent operating room pollution, cap all unused connectors.

WARNING: Do not connect the ventilator exhaust directly to a vacuum source. The vacuum may remove required gases from the breathing system.

Making The Waste Gas Scavenging Connections To A High Vacuum Disposal System:

1. Mount the Ohmeda Waste Gas Scavenging Interface Valve Assembly on either the absorber arm or the bracket on the left side of the anesthesia machine.
2. Connect one end of a yellow-banded, 19-mm tube to the 19-mm connector on the absorber interface manifold. This connector is labeled "Excess Gas Outlet 19-mm" on the absorber. (See figure 2-25.) See Appendix E for information about using the ventilator with absorbers other than Ohmeda GMS Absorbers.
3. A connector is mounted next to the waste gas scavenging interface valve on the interface valve assembly. Securely attach the free end of yellow-banded, 19-mm tube to an unused connector at the bottom of the assembly.
4. Securely attach a three-liter reservoir bag to another unused connector.
5. Cap any unused connectors.
6. Connect a 1/4-inch ID vacuum hose to the barbed connector that extends from the side of the swivel connection on the vacuum adjustment needle valve.
7. Connect the free end of the 1/4-inch ID vacuum hose to a vacuum pipeline system that has a vacuum level of at least 245-mm hg (10-inches hg).

Making The Waste Gas Scavenging Connections To A Passive Disposal System:

1. Mount the Ohmeda Waste Gas Scavenging Interface Valve Assembly on either the absorber arm or the bracket on the left side of the anesthesia machine.
2. Connect one end of a yellow-banded, 19-mm tube to the 19-mm connector on the absorber interface manifold. This connector is labeled "Excess Gas Outlet 19-mm" on the absorber. See Appendix E for information about using the ventilator with absorbers other than Ohmeda GMS Absorbers.
3. A connector is mounted next to the waste gas scavenging interface valve on the interface valve assembly. Securely attach the free end of yellow-banded, 19-mm tube to an unused connector at the bottom of the assembly. (See figure 2-26.)
4. Attach one end of a yellow-banded, 19-mm tube to an unused connector remaining on the interface valve assembly.
5. Connect the other end of the 19-mm tube to the non-recirculating ventilation system.
6. Cap any unused connectors.
7. Turn the vacuum adjustment valve's knob fully clockwise to shut the valve.

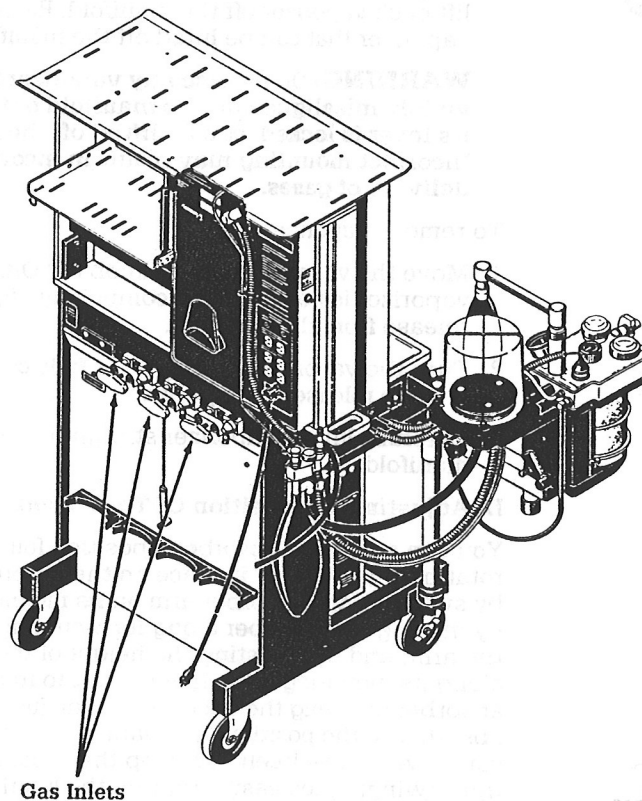


Figure 2-24
The gas inlets

2/Getting Started

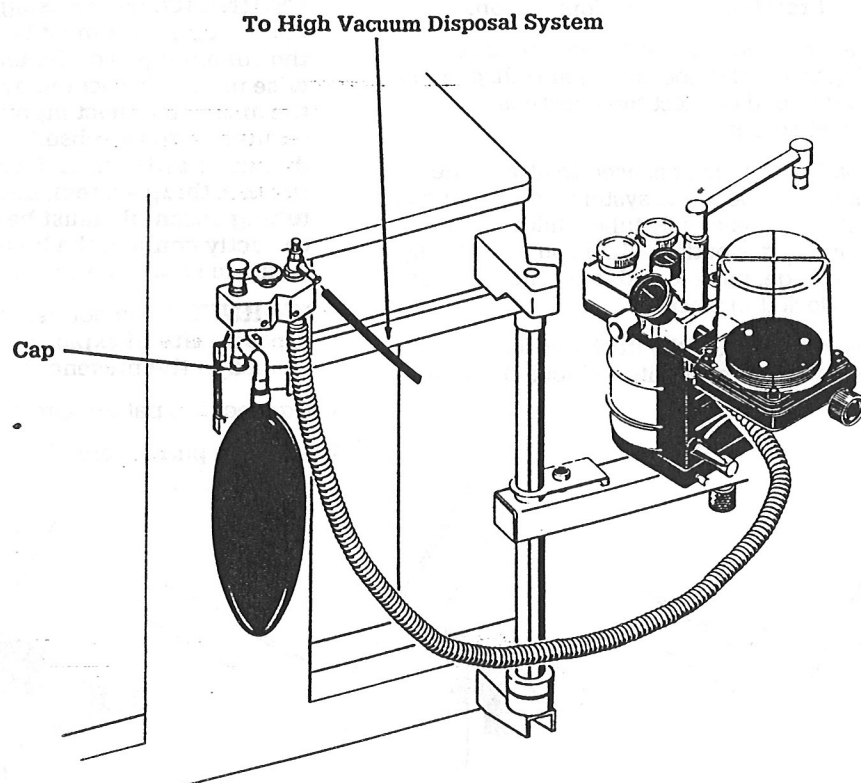


Figure 2-25
Making the gas scavenging connections to a high vacuum disposal system

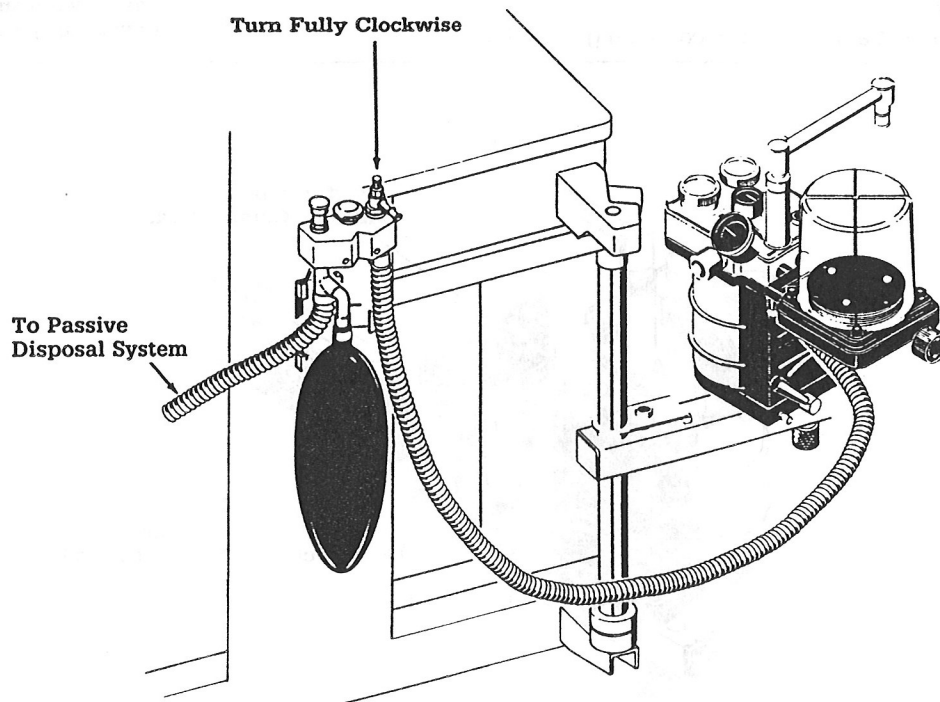


Figure 2-26
Making the gas scavenging connections to a passive disposal system

2/Getting Started

C. Making The Breathing System Connections

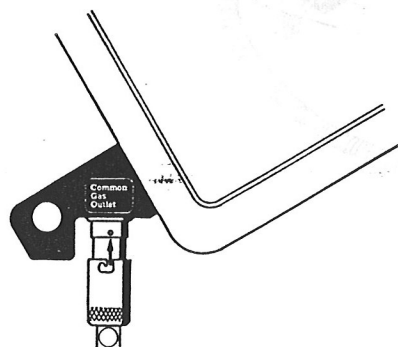
A spring-loaded common gas outlet adapter at one end of a fresh gas supply tube and an anti-disconnect fitting at the other end connect the anesthesia machine to the absorber.

1. A spring-loaded connector is used to attach the fresh gas supply tube to the system's common gas outlet. Insert this gas-supply tube's inlet adapter into the common gas outlet. While you are holding near its front edge, push in and twist the adapter clockwise to lock it in place.
2. Connect the other end of the fresh gas supply tube to the anti-disconnect fitting labeled "Common Gas" on the absorber.

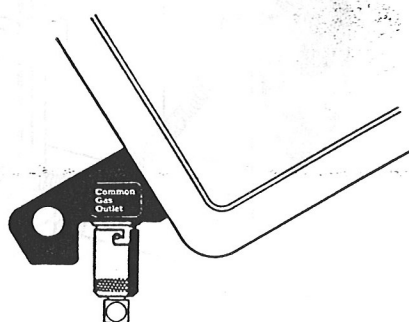
WARNING: Before using the anesthesia system: the inlet adapter must be placed completely onto the common gas outlet and then turned clockwise until it is secured by both protruding pins; the anti-disconnect nipple end must be placed securely into the absorber's common gas anti-disconnect fitting; and, to allow gas to flow to the breathing system, both ends of the outlet tubing assembly must be secured. Failure to correctly connect the breathing system may result in injury to the patient.

WARNING: Do not use flammable anesthetics. A possibility of explosion will exist if the system is used in the presence of flammable anesthetics.

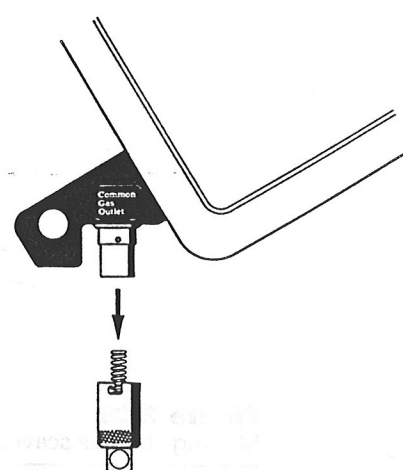
3. Connect the patient circuit to the absorber.
4. Attach a patient breathing bag to the absorber.



Place the inlet adapter all the way (up to the pins) onto the common gas outlet.



Turn the inlet adapter clockwise until completely secured by both (top and bottom) protruding pins.



If the inlet adapter is not secured, the spring ejects the adapter out of the common gas outlet, resulting in no gas flow to the patient circuit.

Figure 2-27

Attaching the inlet adapter to the common gas outlet

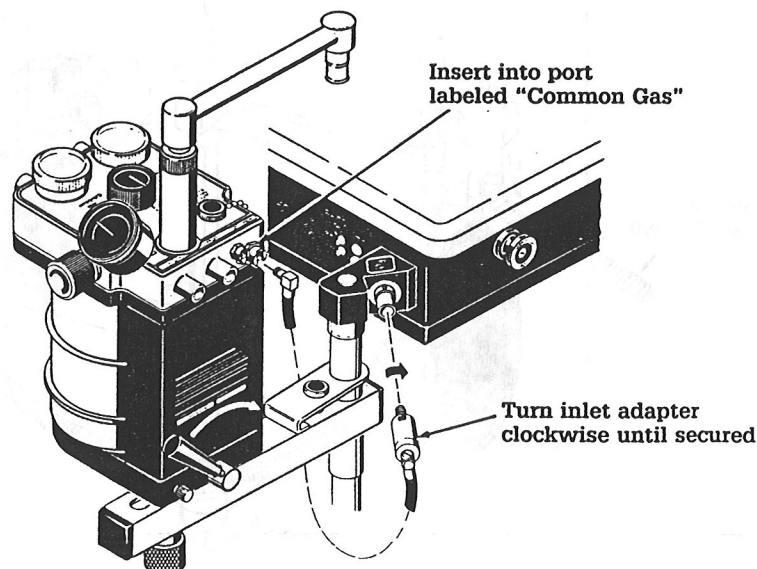


Figure 2-28

Connecting the absorber to the common gas outlet

3/General Information

3.1 System Overview

The Ohmeda Modulus II Plus Anesthesia System includes the anesthesia gas machine with the built-in Ohmeda 7810 Ventilator. Included in the anesthesia gas machine are flow control valves, flowmeters, pressure gauges, a master switch that controls the system's electrical and pneumatic power, a panel that displays the status of the electrical and pneumatic supplies and the built-in backup battery, an oxygen flush button, a waste-gas scavenging system, and a common gas outlet. Up to three vaporizers can be mounted on a vaporizer interlock manifold located at the right of the machine. To provide storage for additional monitors and accessories, two shelves and three drawers are provided. A tabletop serves both as a work surface and a handle. And a lighting panel illuminates the work area. At the rear of the anesthesia machine are the gas pipeline connections, yokes for gas cylinders, and an electrical pod that includes six AC outlets.

As many as three optional monitors, which can include the Ohmeda 5210 CO₂ Monitor, the Ohmeda 3710 Pulse Oximeter, the Ohmeda 2120 NonInvasive Blood Pressure Monitor, and a manual blood-pressure gauge, are contained in the monitor pod at the left of the machine. A patient interface panel on the machine's left side provides a central location for connecting the sensors from the ventilator's built-in oxygen- and volume-monitoring circuits and from certain optional monitors to the anesthesia machine. From the panel, the cables are routed through the gas machine's stand to the ventilator or optional monitors.

Although no absorber is included in the system, the Ohmeda GMS Absorber is highly recommended; the ventilator's bellows assembly can—through an interface manifold—be mounted securely to this absorber without using additional hoses; and the oxygen- and pressure-sensing devices are designed to easily connect to the Ohmeda GMS Absorber.

The Ohmeda 7810 Ventilator consists of two basic units, the bellows assembly and the control module. Mounted at the upper-left of the anesthesia machine, the ventilator's control module serves three functions: it controls mechanical ventilation; it contains the ventilator's integrated monitors, which provide oxygen, airway pressure, and exhaled volume monitoring; and it supplies the ventilator's alarm system. The bellows assembly can either be mounted to an Ohmeda GMS Absorber on the anesthesia machine's absorber arm, or be remotely located on the machine's left side. In either case a tube carries drive gas between the ventilator's control module and the bellows assembly.

The Ohmeda Waste Gas Scavenging Interface Valve Assembly provides a central manifold for channeling waste gas from the breathing system to a waste gas disposal system. This assembly is usually mounted on the anesthesia machine's left side, but it can also be mounted on the absorber arm.

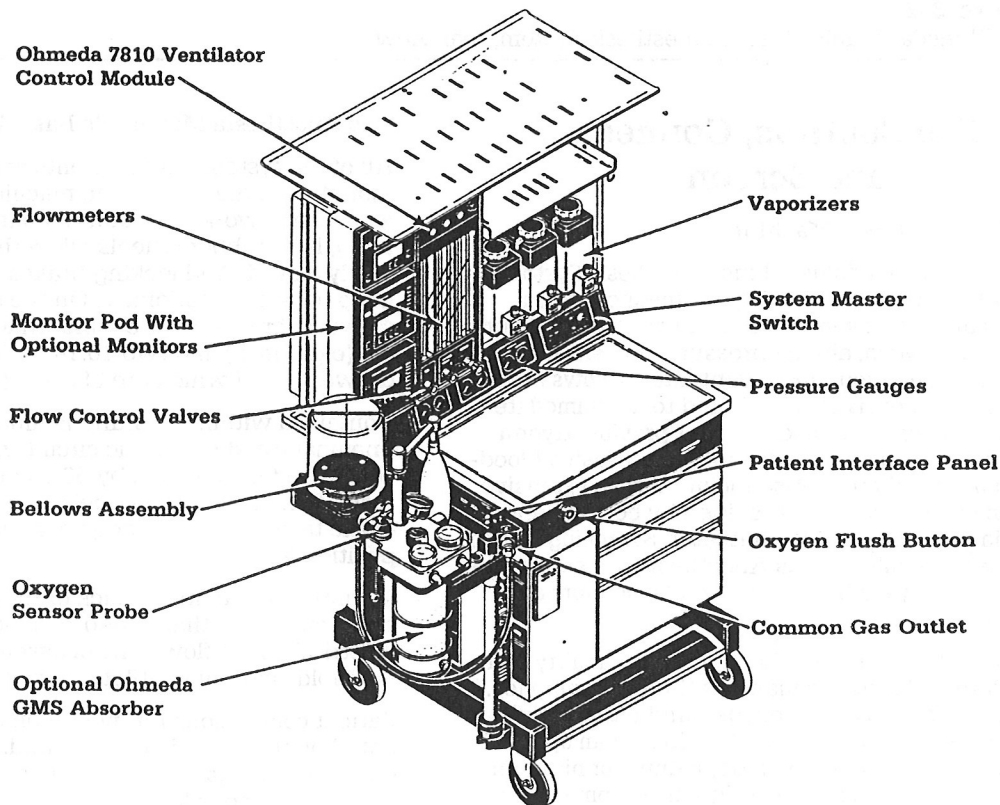


Figure 3-1
The Ohmeda Modulus II Plus Anesthesia System, front view

3/General Information

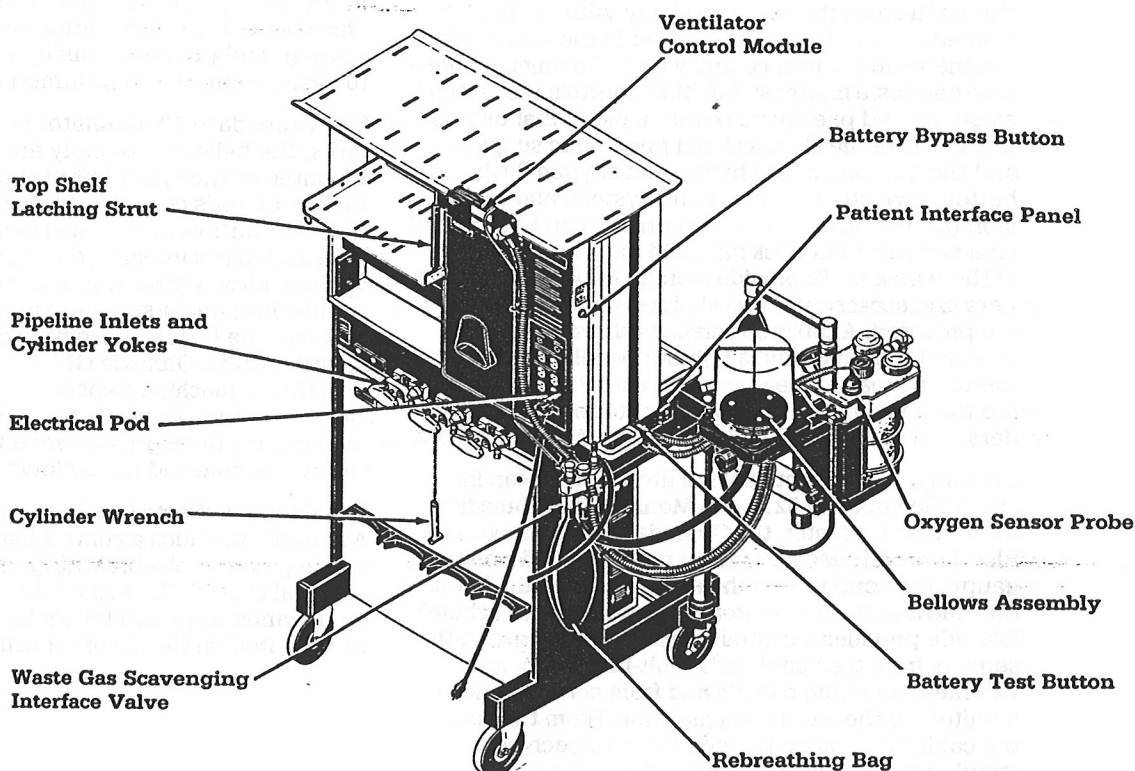


Figure 3-2
The Ohmeda Modulus II Plus Anesthesia System, rear view

3.2 The Controls, Connectors, Devices, and Screen

A. The Anesthesia Machine

The Ohmeda Modulus II Plus Anesthesia System includes pneumatic circuitry for mixing medical gases and agent vapor; a built-in ventilator, which provides oxygen, airway pressure, and exhaled volume monitoring; and a ventilator bellows assembly. The system is also designed to accommodate additional, optional modules that provide oxygen-saturation, carbon-dioxide, and non-invasive-blood-pressure monitoring. Also included is an extensive alarm system, which is provided by both the anesthesia machine and the ventilator. Switching on the Ohmeda Modulus II Plus Anesthesia System's power automatically enables the system's monitors and alarm system.

The anesthesia machine's pneumatic circuitry can regulate and meter as many as three gas supplies. Circuitry for two gases, oxygen and nitrous oxide, is provided with all systems. Circuitry for an optional third gas—air, carbon dioxide, helium, or nitrogen—may be either included as original equipment or installed later by trained service personnel.

The Anesthesia Machine's Basic Framework

All of the system's components and modules are mounted on the anesthesia machine's rigid-steel lower framework—the stand. Four 12.7-cm (five-inch), hard-rubber wheels allow the system to be easily moved. And locking brakes on the front wheels keep the stand stationary. On the stand's lower-right side is a three drawer cabinet that houses one 20.3-cm (eight-inch) and two 10.1-cm (four-inch), sliding drawers, all of which are 35.3 cm (14 inches) deep.

Contained within the stand is much of the system's pneumatic and electronic circuitry, which is concealed under a 35.5-cm by 60.9-cm (14-inch by 24-inch), formed stainless-steel table top. An extension of the table top's front edge serves as a handle for positioning the system.

Mounted on the upper-back of the stand is an aluminum framework that supports a monitor pod, an electrical pod, a flow control assembly, a vaporizer manifold, and the ventilator's control module.

Patient connections for most monitors are consolidated on the left side of the stand. And the gas cylinder yokes and gas supply connections are located at the stand's back plate.

3/General Information

The Ohmeda Anesthesia Record Keeper can also be installed as an optional, integral component of the anesthesia system. When installed this computer-based device, which compiles and prints a record of the anesthesia procedure and surgery, is mounted under, and replaces part of, the table top. Cables routed through the anesthesia machine connect the system's monitors to the Ohmeda Anesthesia Record Keeper.

An adjustable-height bar on the stand's left side supports the absorber. And a specially-designed interface manifold, designed to reduce the chance of making misconnections, attaches the bellows to the Ohmeda GMS Absorber.

To accommodate additional monitors and other equipment, the Ohmeda Modulus II Plus Anesthesia System uses both a vertical mounting track and two horizontal shelves: one, at the system's top, a long, deep shelf, whose angle can be adjusted; and the other, underneath, a smaller, fixed shelf. A set of clips and straps is used to secure equipment to these shelves. And sliding brackets attach equipment to the mounting tracks, which are on the system's upright supports.

The Pressure Gauge Window Panel

Analog gauges for the pipeline pressure and cylinder pressure of the oxygen, nitrous oxide, and—when installed—a third gas are mounted on the anesthesia machine's stand, behind the table top and next to the system master switch. The gauges for each gas are paired in one of three windows, with oxygen to your right, nitrous oxide in the center, and on your left either a blank panel, a pair of gauges for air, or a single cylinder pressure gauge for nitrogen, carbon dioxide, or helium. In the pairs of gauges, cylinder pressure is shown on the gauge to your right; pipeline pressure is shown on the left-most gauge. All of these gauges are connected to gas supply modules, which are contained in the stand, and which extend through the stand to the pipeline inlets and cylinder yokes. The gauges are mounted in the same order as the flowmeters and flow control valves, all of which are just above the gauges.

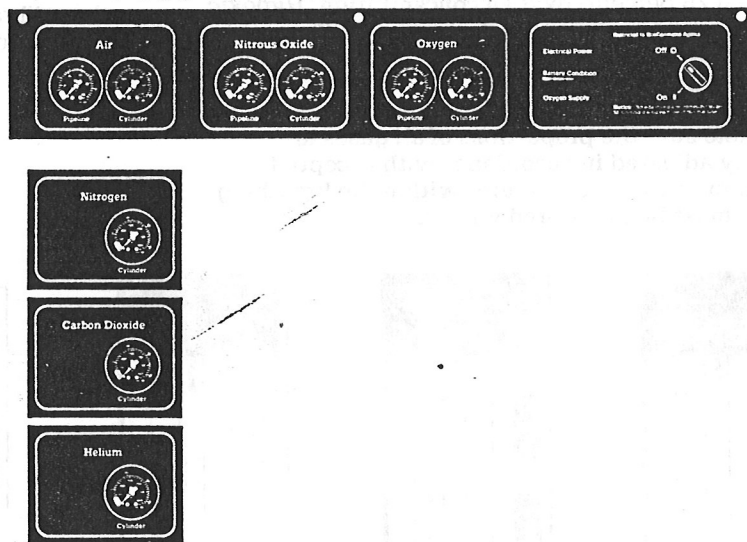


Figure 3-3
The pressure gauge window panel

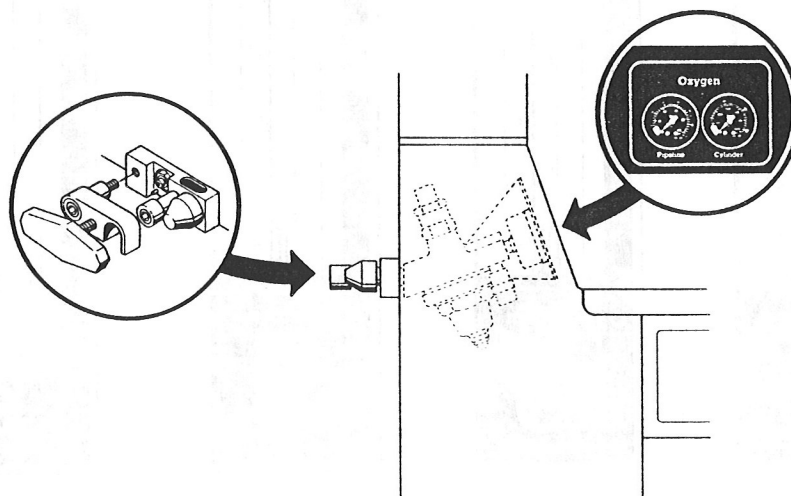


Figure 3-4
The pressure gauges and regulators

3/General Information

The Flow Control Valves

Each gas included on your anesthesia machine is controlled by a single flow control valve. These flow control valves, which are above the pressure gauges and below the flowmeters, are marked with the symbol for the gas they control, and are color coded to match the backgrounds of the corresponding pressure gauges and flowmeters. So you can identify it by touch, the knob for oxygen is fluted. The knobs for nitrous oxide and, when included, a third gas are etched with a finer, cross-hatch pattern.

The Ohmeda Link 25 Proportion Limiting Control System connects the oxygen and nitrous oxide flow control valves. This system is designed both to ensure that any oxygen/nitrous-oxide mixture includes a minimum of about 25 percent oxygen, and to help prevent the oxygen flow from dropping below 200 mL/min (or 50 mL/min when the low-flow option is installed).

WARNING: The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen/nitrous-oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. *Hypoxic mixtures may be delivered if gases other than oxygen, nitrous oxide and/or air are used, or when operating at low oxygen flow rates.* When using carbon dioxide, helium or nitrogen as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

The Flowmeters

Flowmeters for each gas included in your system are mounted directly above the corresponding flow control valves. The backgrounds of these flowmeters are color coded to match the pressure gauges and control valves. When you are using a flowmeter, read across the top of the meter's float, which is inside the flowmeter's tube, to the scale to the immediate right of the float.

Both the oxygen and nitrous oxide flowmeters use pairs of tubes that are connected in series; the left-most tube in each pair is used for flows less than 700 mL/min; the right-most tube indicates flows from 700 mL/min to 12 L/min. For example, if oxygen is set to 500 mL/min, the top of the float in the left tube will line up with 500. If the flow is increased to 2.5 L/min, the top of the float in the right tube will line up with the mark between "2L" and "3L." Unlike the oxygen and nitrous oxide flow-meters, the third-gas flowmeter, when installed, uses a single tube. The flowmeters are factory calibrated to be accurate to ± 2.5 percent at flow rates above 100 mL/min and ± 5 percent at flow rates below 100 mL/min at each point over the calibrated range. A transparent shield protects the flowmeter modules.

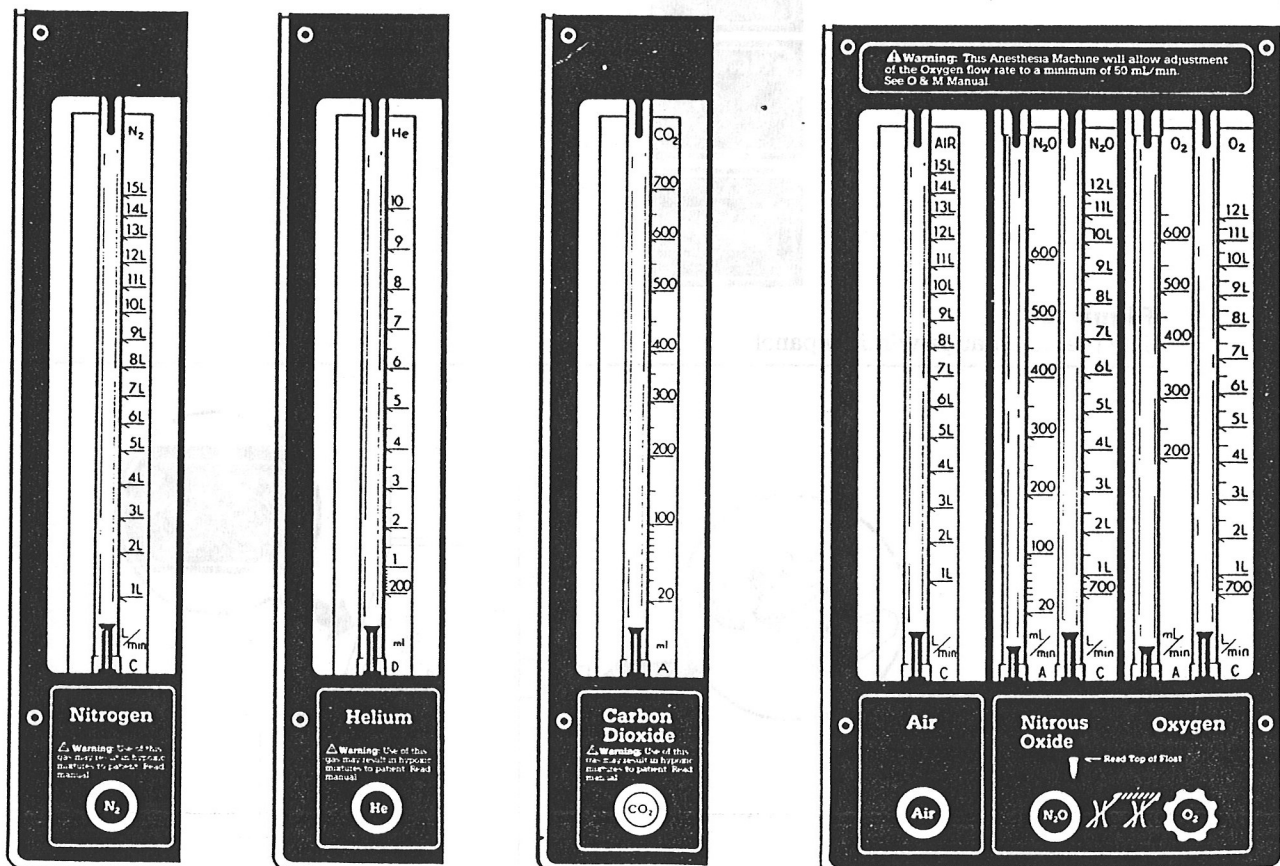


Figure 3-5
The flowmeters and flow control valves

3/General Information

The System Master Switch And Indicator Panel

A two-position switch located to the right of the pressure gauges controls electrical and pneumatic power to the system. When the switch is in its first position, both electrical and pneumatic power are off. In the second position, both electrical and pneumatic power are on.

Just left of the switch is the system's indicator panel, which provides information about the status of the system's electrical supply, battery condition, and oxygen supply.

When the switch is set to "Off": the panel's indicator lights are off; gas is not supplied to the flow control circuits; electrical power is not supplied to the monitors or ventilator; but AC power is provided to the AC outlets on the back of the anesthesia machine.

When the switch is set to "On": the green "Normal" and "Mains" indicators are lighted; gas is supplied to the machine's circuits; and electrical power is provided to the monitors and the AC outlets.

If the switch is set to "On" and the anesthesia machine's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, the "Mains" indicator will go out and the flashing red "Battery" indicator will be lighted. When the "Battery" indicator is on, the system is running on its built-in backup battery, which is designed to temporarily provide power to allow the ventilator and its integrated oxygen, volume, and airway pressure monitors to continue operating.

Beneath the electrical power indicators are the battery-condition indicators. Whenever the battery is powering the system, either a colored bar or "Fail" will be lighted to indicate the backup battery's condition. When the battery is fully charged, the left-most, green-indicator bar will be lighted. As the battery becomes progressively weaker, the lit bar will move from green, to yellow, and then to red. When the battery is almost completely discharged, the system will flash the red "Fail" indicator. If the battery becomes completely discharged, the system will not function without AC power, and will not restart automatically when AC power is restored. You can use the battery *bypass* button to restart the system if the battery fails and AC power is restored during a case. Prior to each case, use the battery *test* button to test the backup battery; do not use the system unless the battery is fully charged.

The system also monitors the condition of the oxygen supply. When the oxygen supply pressure is 34 psig (235 kPa) or greater, the "Normal" indicator is lighted. But if the oxygen supply pressure drops below 28 psig (193 kPa), the system lights the "Fail" indicator, sounds the oxygen supply alarm continuously, and shuts off the nitrous-oxide and optional, third-gas supplies.

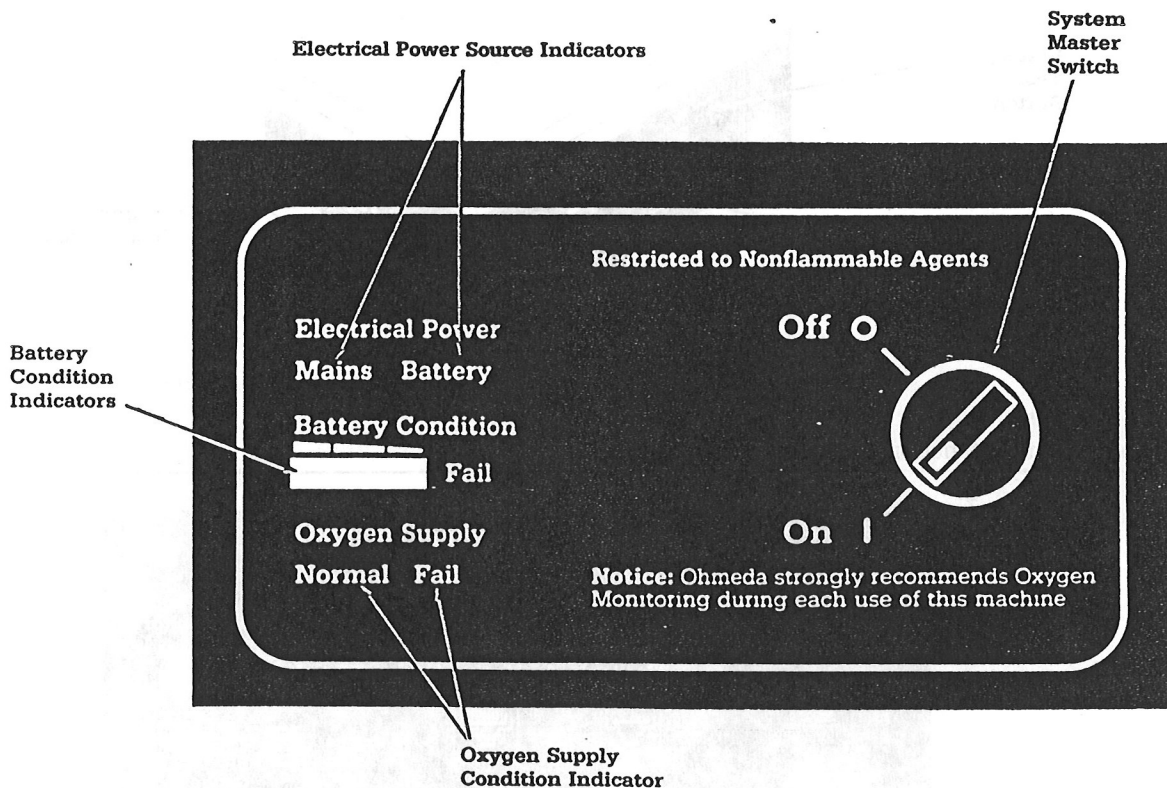


Figure 3-6
The system master switch

3/General Information

The Oxygen Flush Button

The oxygen flush button, when pushed, opens a valve that supplies about 45-75 L/min of oxygen to the common gas outlet. To minimize the chance of accidental engagement, the button, which is on the panel under the table top's front edge, is recessed and self closing. Either the oxygen pipeline or cylinder can provide gas for the oxygen flush; the oxygen flush button is operational whenever an oxygen supply is connected to the oxygen gas supply module.

The Common Gas Outlet

At the common gas outlet the system delivers the combined outputs of the vaporizers, the gas flowmeter modules, and, when enabled, the oxygen flush. The common gas outlet is located on the upper absorber post assembly bracket, next to the patient interface panel. A latching bayonet connection helps prevent accidental disconnections and provides a secure, leak-tight connection. See section 2.7.C for instructions on connecting the common gas outlet.

The Patient Interface Panel

Both the ventilator's oxygen-monitoring circuits and volume-monitoring circuits use external sensors that must connect to the ventilator's control module. The patient interface panel, which is mounted on the stand's left side, provides a central location for these sensors, and sensors for certain optional monitors when installed, to connect to the anesthesia machine. From the panel, the cables are routed through the gas machine's stand to the ventilator or optional monitors. The connectors are labeled and keyed to

help prevent misconnections; and plugs are installed in place of connectors for optional monitors that are not included in your system. The battery test button is also on the patient interface panel.

The Battery Test Button

Pressing the battery test button, which is on the patient interface panel, momentarily connects the system's built-in backup battery to the battery-condition meter on the master switch panel. Before each case—while the system's AC power is switched on—press the battery test button to test the system's backup battery.

When you press the battery test button, either a colored bar or "Fail" will be lighted to indicate the backup battery's condition, unless the battery is completely discharged. When the battery is fully charged, the left-most green-indicator bar will be lighted. As the battery becomes progressively weaker, the lit bar will move from green, to yellow, and then to red. When the battery is almost completely discharged, the system will flash the "Fail" indicator. If the battery is completely discharged, the system will switch itself off. Do not start to use the system unless the battery is completely charged. If, however, the battery fails during an AC power outage, you can use the battery bypass button to restart the system once AC power is restored.

The Battery Bypass Button

Located on the side of the electrical pod, the battery bypass button is included to let you restart the system if the backup battery fails during an AC-power outage. Press this button to restart the system only if the battery fails during a case. Do not begin a case if the backup battery is completely discharged.

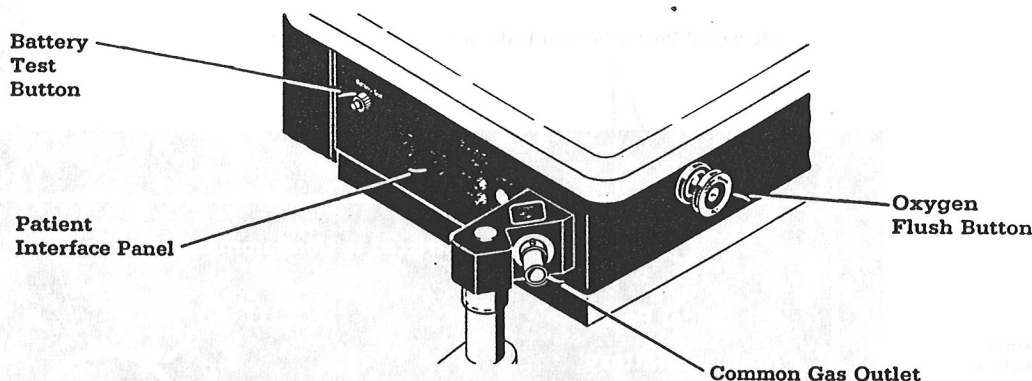


Figure 3-7
The oxygen flush button and common gas outlet

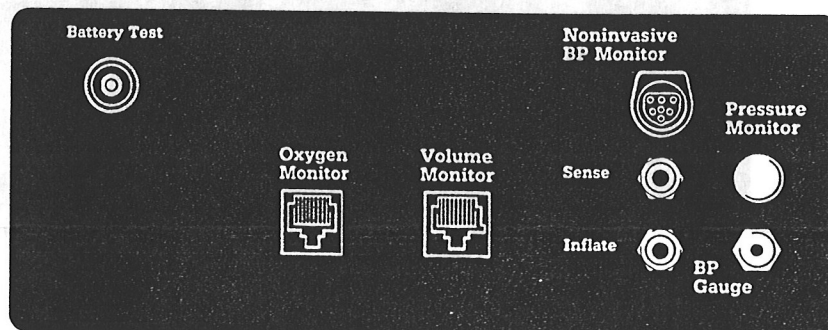


Figure 3-8
The patient interface panel

3/General Information

The Monitor Pod And Optional Monitors

A monitor pod designed to hold up to three optional Ohmeda monitors is mounted to the left of the flow control assembly. This pod, which pivots and can be locked into position, can accommodate any three of these devices: the Ohmeda 5210 CO₂ Monitor, the Ohmeda 3710 Pulse Oximeter, the Ohmeda 2120 NonInvasive Blood Pressure Monitor, and the manual blood-pressure gauge. If fewer than three optional monitors are included in your system, blank panels are installed in the empty slots.

All three of these monitors are divided into two pieces: mounted in the monitor pod, a display module, which contains the monitor's screen and some or all of its controls; and, mounted in the anesthesia machine's stand, an electronics module, which contains the monitor's measurement and processing circuits. Cables routed through the system framework connect the display modules, the electronics modules, system power, and patient connectors. Although the display modules can be easily removed from the monitor pod, they do not function outside the system. Only trained service personnel can install or remove electronics modules.

CAUTION: All Ohmeda monitors, the Ohmeda Anesthesia Record Keeper, the vaporizers, and the Ohmeda GMS Absorber, have their own operation-and-maintenance manuals. Before using the system, read the manuals for all the installed devices.

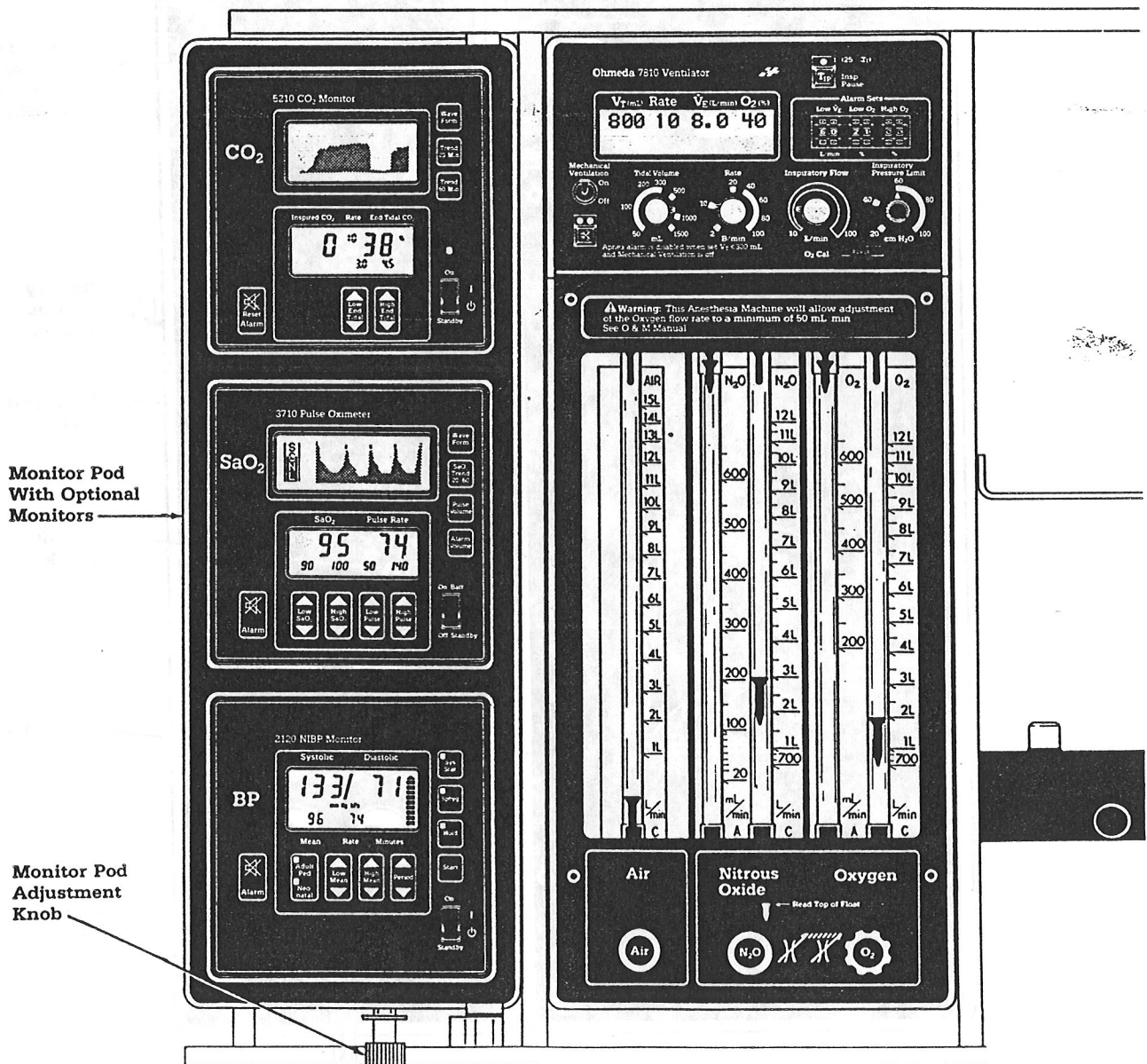


Figure 3-9
The monitor pod

3/General Information

The Optional Blood Pressure Gauge

A manually-operated, analog blood pressure gauge can be installed as an integral system component. When included with your system, this gauge is installed either in the monitor pod or in a "mini-pod" to the left of the monitor pod.

The Electrical Pod

Located directly behind the monitor pod, the electrical pod houses the system's circuit breakers, auxiliary AC power outlets, power cord, battery bypass button, and, when included in the system, power

interrupt switch for the Ohmeda Anesthesia Record Keeper. The seven-ampere circuit breaker helps protect the machine's six 120 volt AC outlets; the five-ampere circuit breaker helps protect the machine's DC power supply.

CAUTION: Make the electrical connection at an appropriate hospital grade receptacle only.

WARNING: Connecting equipment to the auxiliary AC outlets may increase electrical hazards if a protective ground conductor is defective.

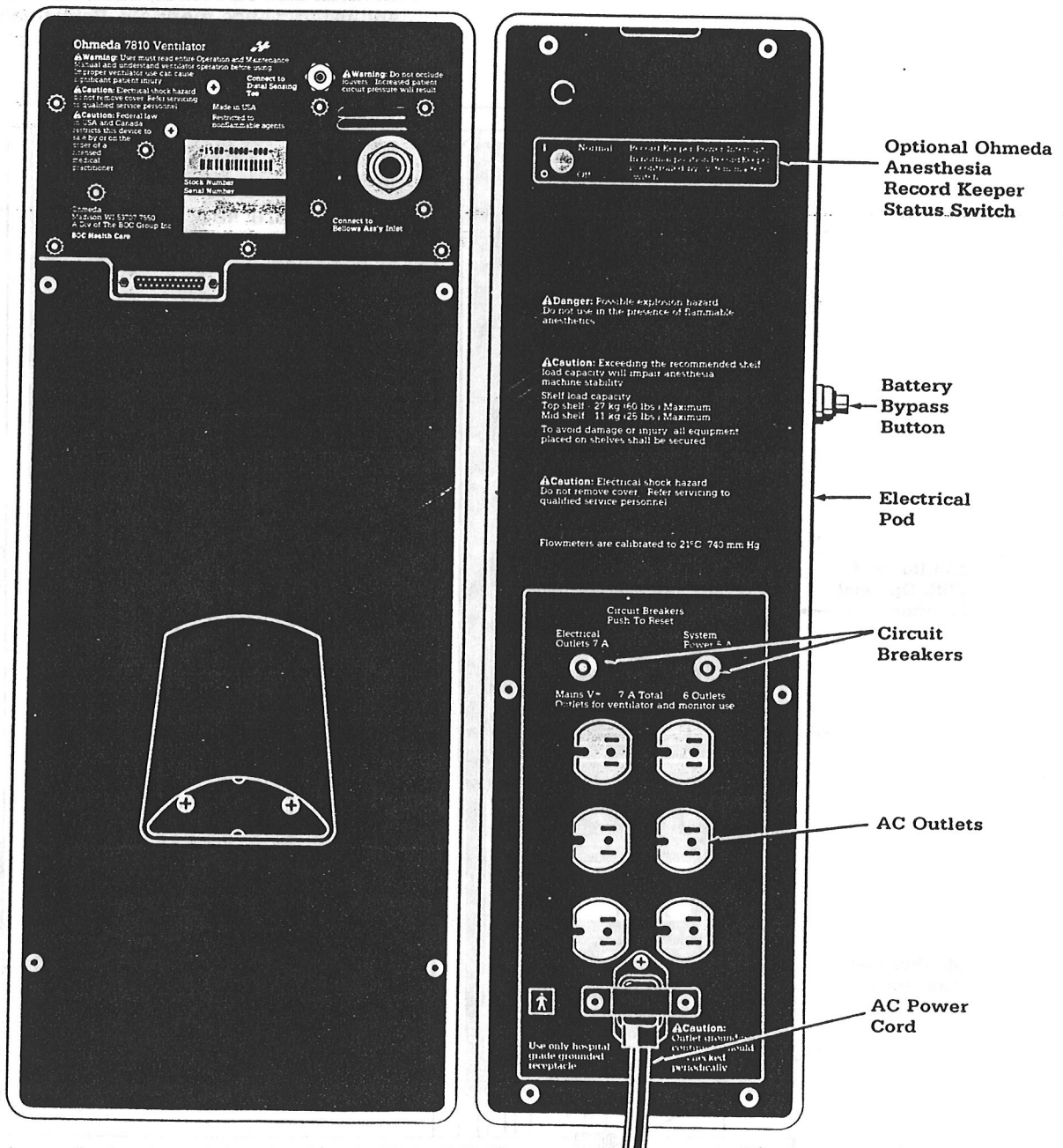


Figure 3-10
The electrical pod

3/General Information

The Cylinder Yokes And Pipeline Inlets

Each of the pipeline gases your system uses connects to the inlets on the machine's rear panel and can be backed up by either "D" or "E" size gas cylinders, which the yokes on the back of the anesthesia machine secure. During normal operation, when your hospital's pipelines are supplying gas, keep the cylinder valves closed. If a pipeline supply fails, use the included wrench to open the appropriate cylinder.

The Vaporizer Manifold And Interlock

The vaporizer manifold, which is located next to the flowmeters, can hold up to three Ohmeda Tec 4 Vaporizers. Mechanisms in the vaporizers and manifold combine to form an interlock system designed to lock vaporizers into the gas circuit, allow no more than one vaporizer to be switched on at a time, allow gas flow to enter only the single vaporizer that is switched on, and minimize unwanted anesthetic trace vapor after the vaporizer is switched off.

The total flow from the gas distribution manifold, which is inside the machine, first enters the vaporizer manifold and then moves through only the vaporizer that is switched on, where it picks up the set concentration of anesthetic vapor. This gas mixture then flows out of the vaporizer manifold to the common gas outlet.

The Lighting Panel

Two levels of illumination are provided by the lighting panel, which is mounted to the bottom of the tilting shelf. A three-position switch controls the lighting panel. This switch is active when the machine's electrical circuits are switched on, but the lighting panel does not function when the system is being powered by its backup battery.

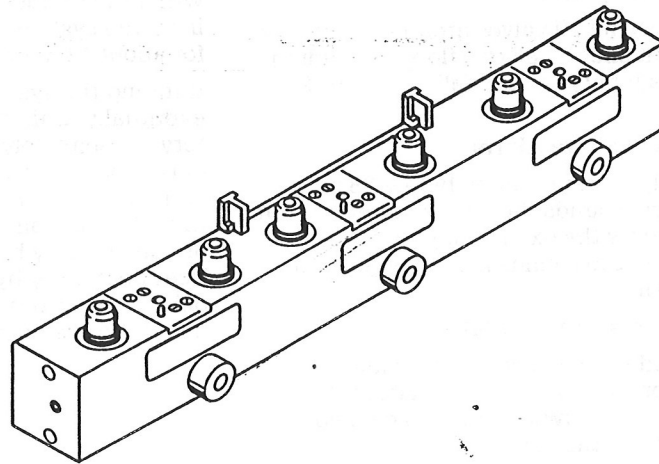


Figure 3-11
The vaporizer manifold

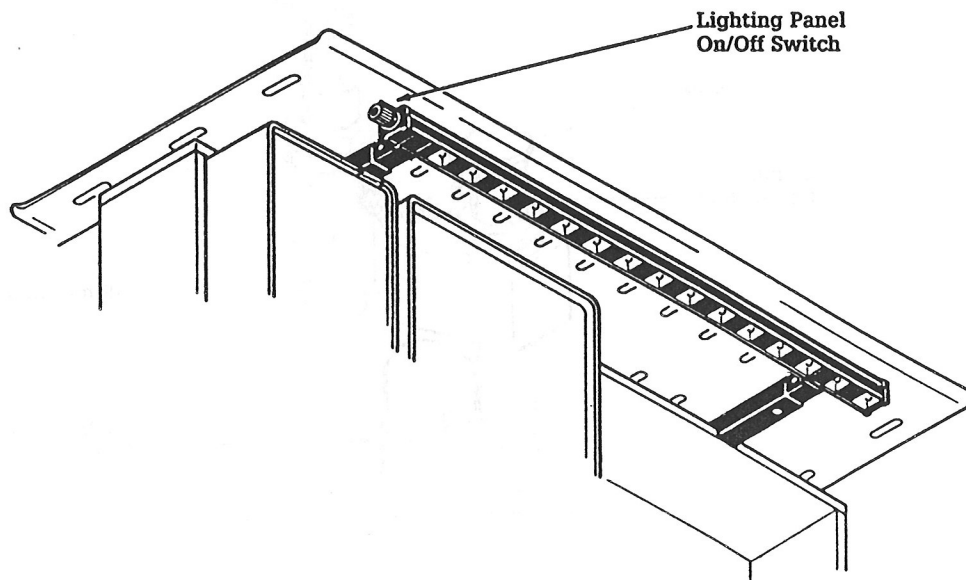


Figure 3-12
The lighting panel

3/General Information

The Waste Gas Scavenging Interface Valve Assembly

The Ohmeda waste gas scavenging interface valve assembly provides a central manifold for channeling waste gas from the breathing system to a waste-gas disposal system. Included in this assembly are three 19-mm male connectors designed to accommodate tubing and a reservoir bag, a pair of gravity-loaded relief valves designed to limit positive and negative pressures, and an adjustable needle valve that controls the suction applied to the manifold.

You can mount this assembly in either of two locations: the left side of the anesthesia machine; or the absorber swivel arm. (See section 2.3.)

B. The Anesthesia Machine's Internal Devices

Many of the Ohmeda Modulus II Plus Anesthesia System devices are contained inside the machine's frame. These devices include the pressure sensor system, the oxygen supply alarm, the second-stage pressure regulators, the gas distribution manifold, and the back-up battery.

The Pressure Sensor System

The pressure sensor shut off valves are pneumatically-operated valves that shut off all gas flow—including air—if the oxygen supply pressure falls to about 20 psig (138 kPa).

The Oxygen Supply Failure Alarm

If the oxygen supply pressure drops below 28 psig (193 kPa), the system sounds the oxygen supply alarm continuously and lights the oxygen supply "Fail" indicator. This alarm also sounds briefly when you switch on the system.

The Second Stage Pressure Regulators

Both the oxygen and nitrous-oxide supply lines are equipped with secondary pressure regulators that minimize bobbing of the flowmeter floats caused by pressure fluctuations in the supply lines.

The Gas Distribution Manifold

Gas, after first being introduced to the machine through the pipeline inlets or the cylinders, passes through a set of secondary circuits to the gas distribution manifold and flowmeters, before it is combined with the total anesthetic gas mixture; the gas distribution manifold is the juncture of the second-stage circuitry and the flow control components.

The Backup Battery

If the anesthesia machine's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, the system's built-in backup battery will provide backup power to the ventilator and its integrated oxygen, volume, and airway pressure monitors. If the ventilator is in the mechanical ventilation mode, the battery—when fully charged as shown on the battery condition indicator—will typically power mechanical ventilation and monitoring for about one hour and for an additional half hour will provide monitoring only. Once the battery is almost completely discharged—as shown when the battery condition "Fail" indicator is flashing—the system must be plugged in and switched on for about 12 hours to recharge the battery.

Running the system using just the backup battery will eventually drain the battery completely. Once the battery is completely discharged—as shown when none of the indicators light, the system's electrical devices will not function, but its gas delivery system will continue to function. Once AC power is restored, you can use the battery bypass button to restart the system. Use the battery bypass button to restart the system only if the battery fails during a case. Do not start using the system unless the battery is fully charged.

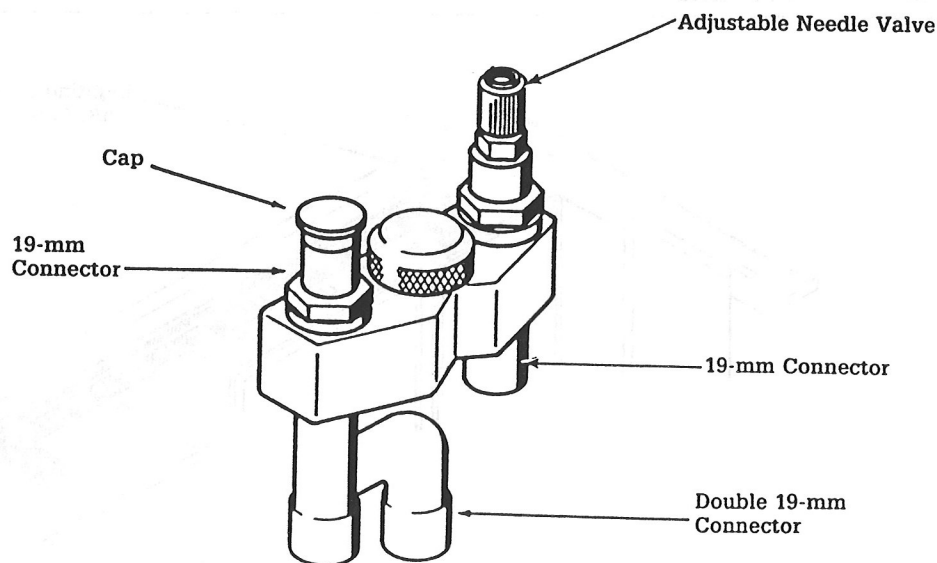


Figure 3-13

The waste gas scavenging interface valve assembly

3/General Information

C. The Absorber

The Ohmeda GMS (Gas Management System) Absorber is the Ohmeda Modulus II Plus Anesthesia System's companion unit and its use, because of compatibility with other system components, is highly recommended. The absorber mounts on the absorber post assembly located at the left front corner of the stand. For more information, see the Ohmeda GMS Absorber Operation and Maintenance Manual, stock number 0178-1742-000.

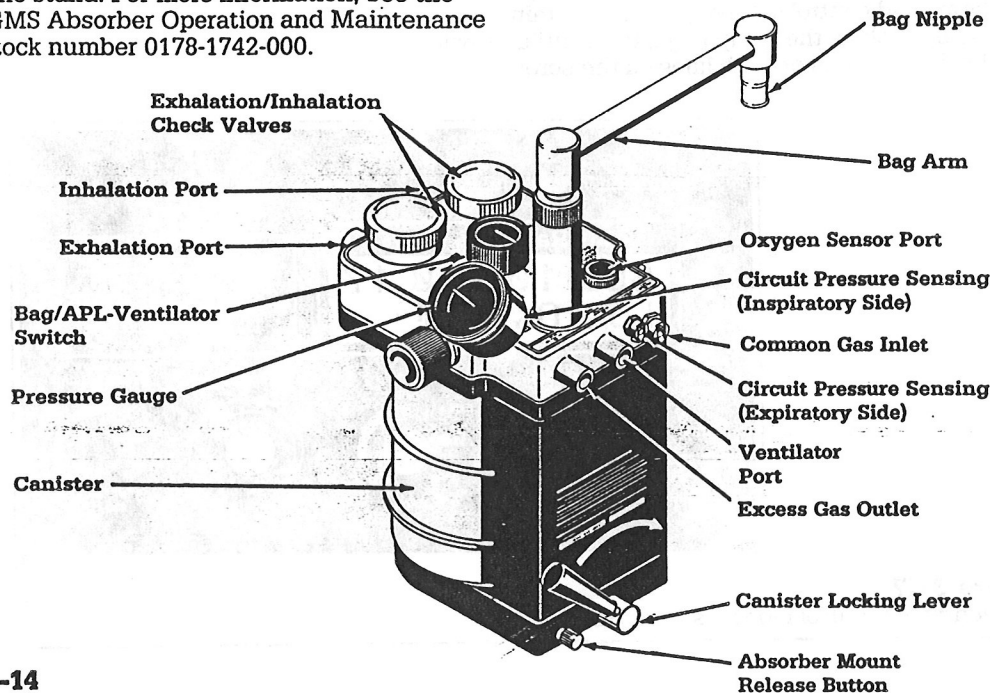


Figure 3-14
The Ohmeda GMS Absorber

D. The Ventilator

The Ohmeda 7810 Ventilator consists of two basic units: the bellows assembly, which contains the bellows and bellows housing, and the control module, which contains the ventilator's control valves, processing circuits, controls, and display screen.

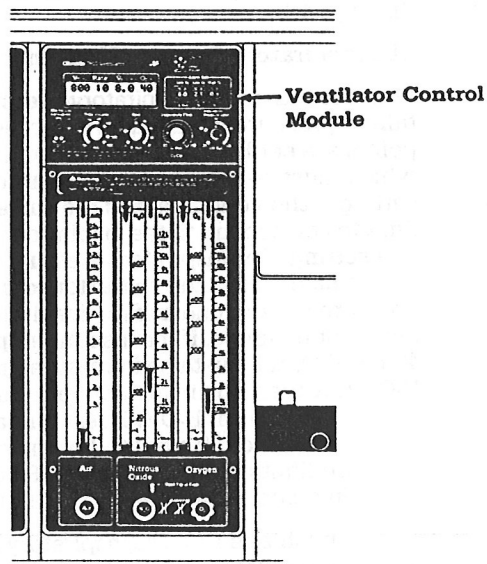


Figure 3-15
The ventilator's control module

The control module serves three functions: it controls mechanical ventilation; it contains the ventilator's integrated monitors, which provide oxygen, airway-pressure, and exhaled-volume monitoring; and it supplies the ventilator's alarm system. By using the control module's front panel dials, pushwheels, and screen, you can set and view the ventilator's operating parameters and alarm limits, view output from the integrated monitors, and initiate mechanical ventilation. Switching on the Ohmeda Modulus II Plus Anesthesia System's power automatically enables the ventilator's monitors and alarm system, even if the ventilator's mechanical ventilation switch is off.

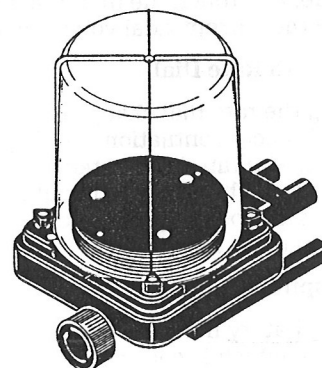


Figure 3-16
The ventilator's bellows assembly

3/General Information

E. The Ventilator's Control Module Front Panel

The Display Screen

The ventilator's liquid crystal display screen serves three functions: on its top line it provides numeric readouts for expired tidal volume, breath rate, expired minute volume and inspired oxygen concentration; on its bottom line it displays messages such as alarms and control settings; and for certain functions, such as the Setup Page, the ventilator will display instructions on both lines on the screen.

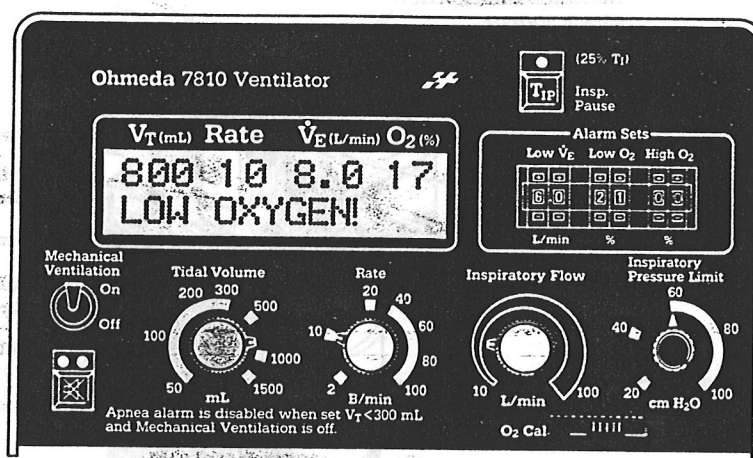


Figure 3-17
The ventilator control module's front panel

The Tidal Volume Dial

The tidal volume dial lets you set the tidal volume at levels from 50 milliliters to 1500 milliliters. As you turn the dial, the ventilator will display the tidal volume setting. The resolution in this setting varies within four ranges, depending on the tidal volume dial's position. In the range from 50 mL to 100 mL, the tidal volume can be set in two-milliliter increments. In the range from 101 mL to 250 mL, the tidal volume can be set in five-milliliter increments. In the range of 251 mL to 1000 mL, the tidal volume can be set in 10-milliliter increments. And in the range of 1001 mL and up, the tidal volume resolution is 10 milliliters or 20 milliliters.

To check the tidal volume setting without changing its value, just touch the dial; the ventilator will then display the current tidal volume setting.

The Breath Rate Dial

Turning the rate dial changes the breath rate used for mechanical ventilation and displays the rate as it changes. The rate is adjustable from two breaths per minute to 100 breaths per minute in whole number increments. Touching the rate dial will display the current rate on the screen.

The Inspiratory Flow Dial

The inspiratory flow dial lets you set the inspiratory flow rate, which is continuously variable from 10 liters per minute to 100 liters per minute. Whenever you adjust or just touch the inspiratory flow dial, the ventilator will display the current I:E ratio, which

it calculates based on the set inspiratory flow, tidal volume, and breath rate. Because the inspiratory flow is continuously variable within its range, the ventilator's actual I:E ratios are continuously variable from 1:0.5 to 1:999. Rather than display I:E ratios in nonstandard increments, such as 1:2.13 or 1:1.97, the ventilator displays the I:E ratio rounded to the nearest 0.5. For example, when the ventilator uses a ratio of 1:2.13, it displays 1:2. And when it uses 1:1.97, it displays 1:2.

The Inspiratory Pressure Limit Dial

Both the maximum-inspiratory-pressure and sustained-pressure alarm limits and pressure release points are set by the inspiratory pressure limit dial, which must be pushed in while turned to change the settings; the ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit dial setting. For inspiratory pressure limits of 20 cm H₂O to 60 cm H₂O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H₂O, the sustained pressure limit will be 21 cm H₂O. However, any inspiratory pressure limit setting higher than 60 cm H₂O will result in a sustained pressure limit of 30 cm H₂O. For example, inspiratory pressure limits of 65 cm H₂O and 80 cm H₂O will both result in a sustained pressure limit of 30 cm H₂O.

As you push and turn the inspiratory pressure limit dial, the ventilator will display both the maximum-pressure-limit and sustained-pressure-limit settings. However, unlike the other three control dials, just touching this dial will not generate a display.

3/General Information

During mechanical ventilation, the maximum inspiratory pressure limit you set is used by the ventilator's electronically-controlled, automatic, high-pressure-relief system to manage excessive airway pressure. If, while the mechanical ventilation switch is on, the ventilator detects airway pressure higher than the limit you set, it will generate a high pressure alarm and terminate the inspiratory cycle.

The ventilator also displays a reminder if you set the inspired pressure limit to more than 60 cm H₂O. If—while the mechanical ventilation switch is off—you set the inspired pressure limit for more than 60 cm H₂O, the ventilator will beep once, light the yellow LED and, instead of blanking the display's lower line in a few seconds, will continuously display the maximum pressure setting. This pressure limit message is displayed in the Monitoring mode only; during mechanical ventilation this reminder is not displayed.

The Inspiratory Pause Button

Pressing the inspiratory pause button adds an inspiratory pause—an inflation hold—to the inspiratory cycle. When the inspiratory pause function is active, the ventilator adds an inspiratory pause equal to 25 percent of the set inspiratory time. The ventilator, to maintain the original breath rate, then decreases the expiratory time by the same amount that the inspiratory time is increased; pressing the inspiratory pause button alters the I:E ratio.

After you press the inspiratory pause button, the ventilator displays the new I:E ratio and lights the green indicator on the button to indicate that the inspiratory pause function is active. To disable the inspiratory pause, press the button again; the ventilator will switch off the indicator light and will display the I:E ratio, which is calculated from the other front-panel control settings.

You can continue to adjust the ventilator's front panel controls even when the inspiratory pause function is active. If, while the function is on, you adjust a front panel control, the instrument takes the inspiratory pause formula into account when it calculates and displays a new I:E ratio.

The Mechanical Ventilation On/Off Switch

The mechanical ventilation switch controls mechanical ventilation only. When the switch is off, the monitors still function and the alarm system is still active, although certain alarms are enabled only during mechanical ventilation. When you want to start mechanical ventilation, move the switch to "On."

Always switch on the Ohmeda Modulus II Plus Anesthesia System and set the ventilator's controls before switching on mechanical ventilation. Switching on mechanical ventilation before setting the controls may result in inappropriate ventilation of the patient and trip alarms that relate to mechanical ventilation.

The Alarm Set Pushwheels

Use the three alarm-set pushwheels to change the low-minute-volume, low-oxygen and high-oxygen alarms' set points. To increase the value of an alarm set point, push the button directly over the digit you

want to change. To decrease the value, push the button under the digit you are changing.

Anytime you change the value of an alarm set point, the ventilator will display, for a few seconds, that alarm's value. However, although all of the digits can be physically set to zero, and the ventilator will accept any low minute-volume limit you select, the ventilator will not accept certain oxygen alarm settings, and will generate warning messages for others.

The system will not accept low oxygen alarm limits of less than 18 percent; if you do set the low oxygen alarm pushwheel to less than 18 percent, the ventilator will continue to use 18 percent for the low oxygen alarm's set point and will display a "LIMIT SET ERROR!" message.

The system also warns you if you set a high oxygen alarm limit below the low oxygen alarm limit. If the high-O₂ pushwheel is set to a level below the level set on the low-O₂ pushwheel, the system will display a "LIMIT SET ERROR!" message. However, unlike the low-O₂ pushwheel, the ventilator will use the limit set on the high-O₂ pushwheel, even when "LIMIT SET ERROR!" is displayed. Setting the high-O₂ pushwheel to zero disables the high oxygen alarm.

The oxygen alarm limits are 18 percent to 99 percent in one percent increments. The low minute volume alarm limits are zero liters per minute to 9.9 liters per minute in 0.1 L/min increments.

The Oxygen Calibration Thumbwheel

The oxygen calibration thumbwheel is used to calibrate the oxygen monitor's sensor. Use this thumbwheel during the oxygen monitor calibration procedure only.

The Alarm Silence Button

To silence an audible alarm, press the alarm silence button. If that alarm condition continues, the alarm will sound again in 30 seconds. If, however, a new alarm condition occurs, its audible alarm will sound immediately. Four types of alarms can be silenced permanently, even if the alarm conditions continue. These permanently silenceable alarms include power failure, oxygen probe failure, low battery, and ventilator failure.

When the mechanical ventilation switch is off—when the ventilator is in its Monitoring mode—pressing the alarm silence button cancels and resets the apnea and low minute volume alarms; the "VOL MON STANDBY!" message will be displayed and these two alarms will not sound again even if these alarm conditions continue. However, if the ventilator senses another breath, the alarm timers and sensor circuits will again be activated and any alarm condition that occurs will trigger an appropriate alarm.

The alarm silence button—combined with the inspiratory pause button—also provides a way to enter and step through the Setup Page mode. To start the Setup Page, move the mechanical ventilation switch to "Off," hold down the alarm silence button, then press the inspiratory pause button. Once the Setup Page is displayed, press the alarm silence button again to move from step to step.

3/General Information

The Alarm Indicator LEDs

The two light emitting diodes (LEDs) embedded in the alarm silence button indicate the status of alarms. When an alarm condition first occurs, a message will appear on the screen, a tone will sound, and an LED will flash. Once the alarm silence button is pressed, the ventilator will light the LED continuously to remind you that the alarm condition still exists. The red LED is lighted during alarm conditions that require immediate operator response. The yellow LED indicates alarm conditions that require prompt operator response or operator awareness.

F. The Ventilator's Control Module Rear Panel

The Drive Oxygen Output

The ventilator bellows' driving oxygen supply is delivered from the connector labeled "Connect to Bellows Ass'y Inlet."

The Pressure Sensing Input

A 1/8-inch tube connects the distal-sensing tee on the absorber to the connector marked "Connect to Distal Sensing Tee" on the control module's rear panel.

Serial Interface Connector

For remote recording, a 25-pin female "D" type connector provides access to the ventilator's RS232C serial port, which conforms to the Ohmeda standard communications protocol (see appendix G).

WARNING: Writing to the ventilator's RS232 port can alter the operation of the ventilator's software, which may result in unpredictable performance. Do not alter the ventilator's hardware or software.

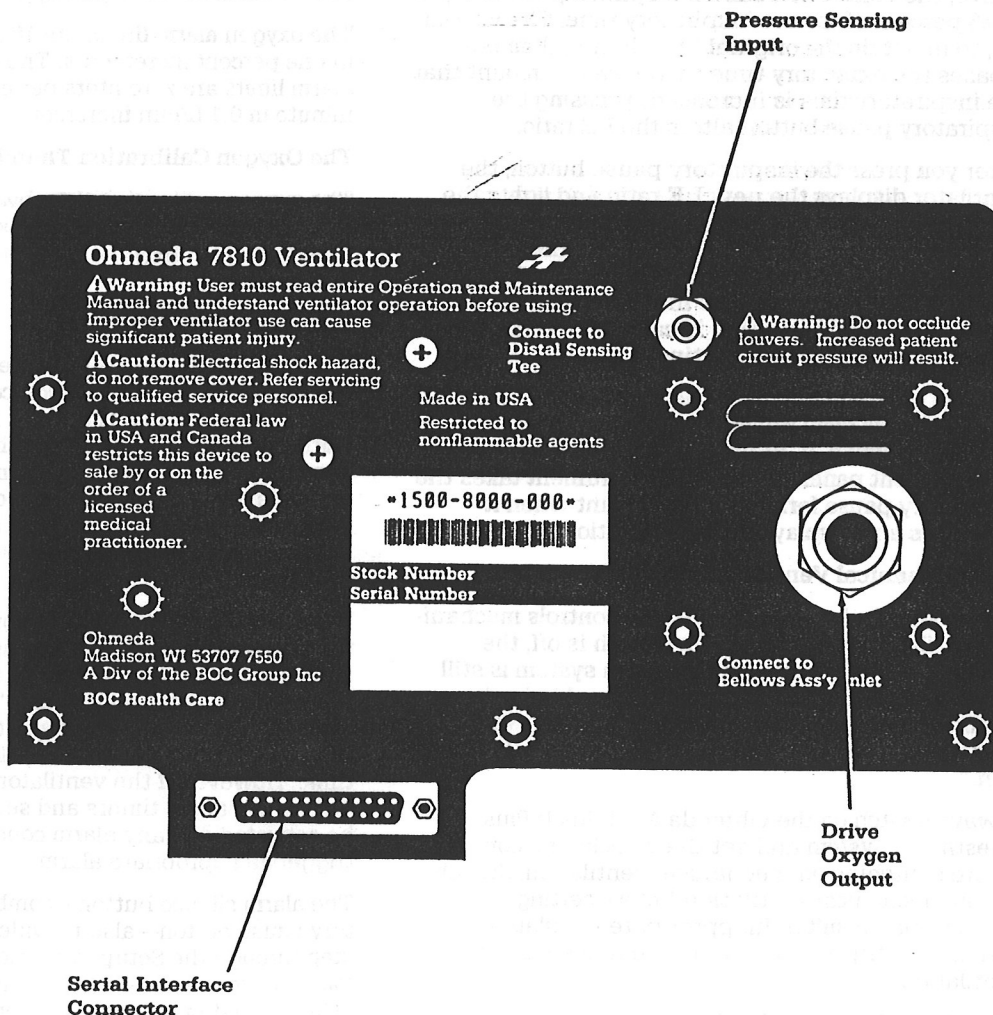


Figure 3-18

The ventilator control module's rear panel

3/General Information

3.3 Theory Of Operation

A. The Ventilation Cycle

The bellows assembly acts as the interface between the control module's driving-gas circuit and the patient breathing system. During inspiration, driving gas from the control module compresses the bellows downward;

during expiration, breathing system gas fills the bellows, forcing it to rise. As the ventilator cycles from inspiration to expiration and back, a set of valves—which includes an exhalation valve in the control module and a pop-off valve in the bellows assembly's base—controls the pressures in the two circuits.

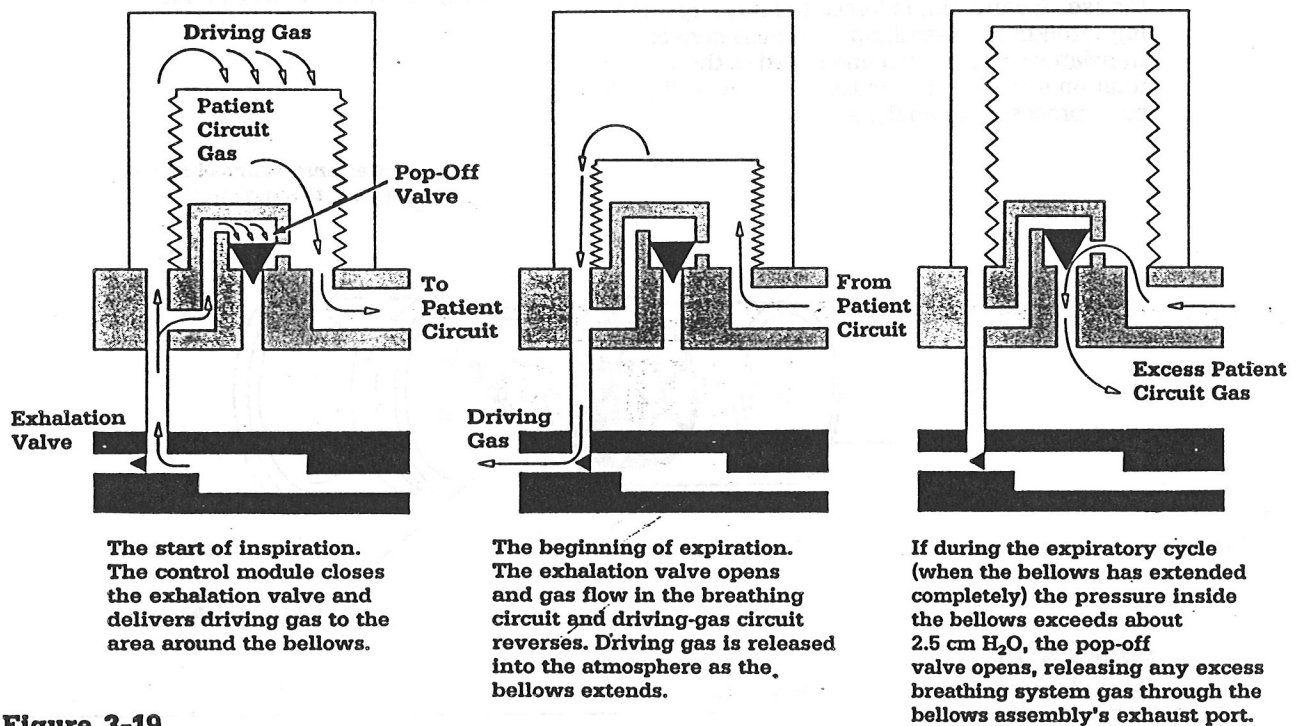


Figure 3-19
The ventilation cycle

Inspiration starts when the ventilator's control module closes the exhalation valve and delivers driving gas to the area surrounding the bellows in the housing. As the driving-gas pressure increases, closing the pop-off valve, the bellows starts to compress downward. This downward pressure forces gas out of the bellows, into the breathing system, and finally into the patient's lungs. The control module, which computes the volume, rate, and timing of driving gas needed based on its front panel settings, delivers driving gas until it reaches the calculated gas volume; then flow stops. If, however, the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit control, the ventilator will generate a high pressure alarm and open the exhalation valve, which releases the driving gas into the atmosphere and ends the inspiratory cycle.

At the start of expiration, the exhalation valve opens and the gas-flow direction in both circuits reverses. The combination of fresh gas from the anesthesia machine and exhaled gases from the breathing system enters the bellows' interior, forcing the bellows to expand; the extending bellows displaces the driving gas, which the exhalation valve releases into the atmosphere.

If the pressure inside the bellows exceeds about 2.5 cm H₂O during the expiratory cycle (when the bellows has extended completely), the pop-off valve opens and releases any excess breathing system gas through the bellows assembly exhaust port.

3/General Information

B. Volume Monitoring

Two volume measurements—tidal volume (VT) and expired minute volume (VE)—and the breath rate (Rate) are displayed on the ventilator's front panel. The ventilator measures all of these displayed values directly, based on the readings of a single volume sensor in the breathing system. Because of compliance losses and fresh gas gains in the breathing system, these measured and displayed values may be different than the values you set using the ventilator's front panel controls.

To measure the exhaled patient volume, the ventilator uses a vane that is forced to rotate by gas traveling through the breathing system. A sensor then translates the direction and speed of the vane's rotation into electrical pulses for the ventilator's microprocessor to analyze.

The rotating vane is one of three vanes located inside a transducer cartridge that is in series with the breathing system, either at the expiratory limb or in the common airway. Two of the vanes, which look like six-spoked wheels, are stationary and positioned before and after the rotating vane. As the circuit gas moves through the cartridge, the first stationary vane's six, angled blades channel the flowing gas into a spiral motion. This motion causes the paddle-shaped, rotating vane to spin. If the gas flow's direction changes, the blades of the other stationary vane create the spiral motion, which forces the rotating vane to switch direction.

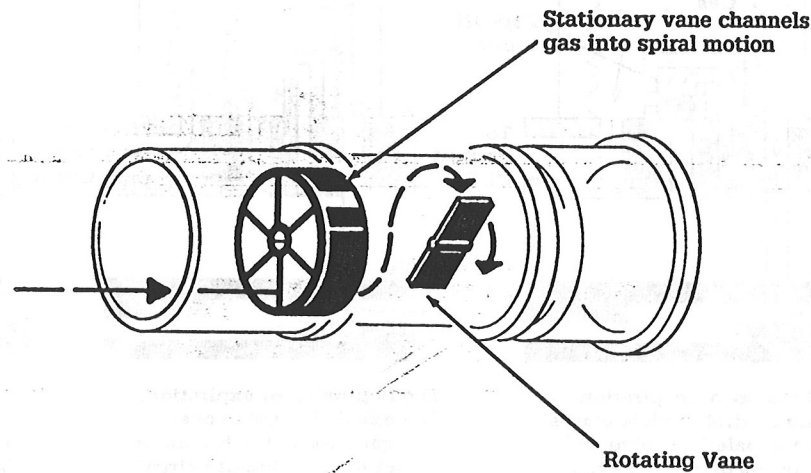


Figure 3-20
Gas entering the volume sensor cartridge

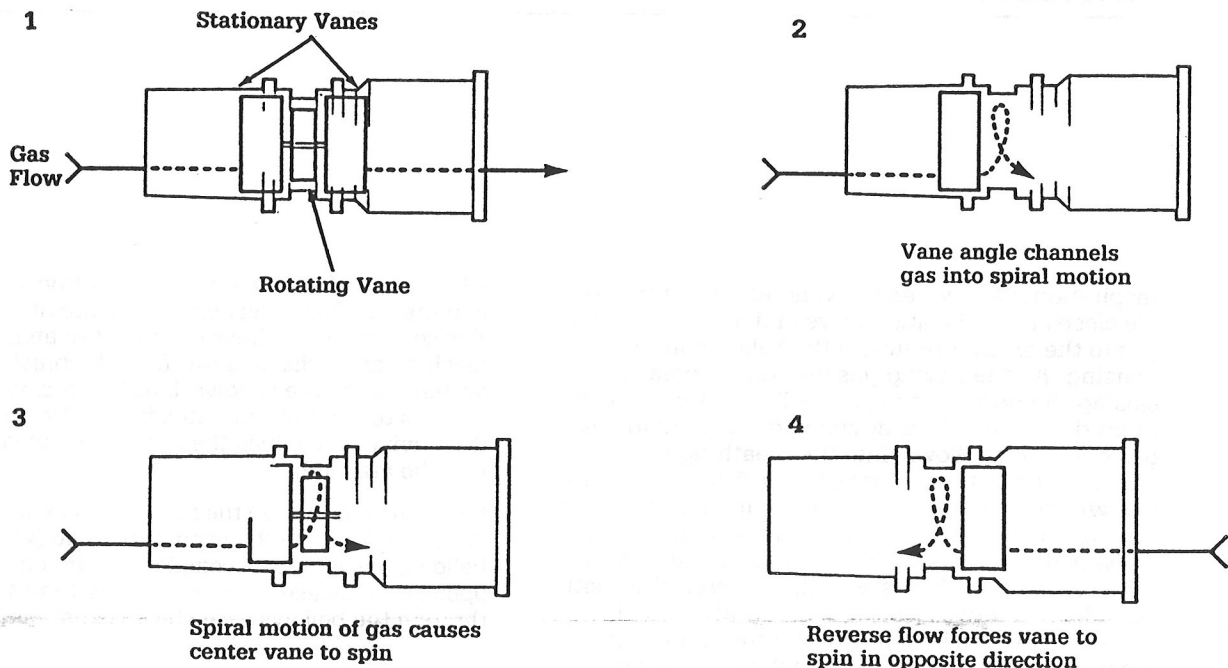


Figure 3-21
The path of gas through the volume sensor cartridge

3/General Information

A pair of optical sensors, each of which consists of an infrared Light Emitting Diode and a photosensitive detector, converts the rotating vane's motion into electrical signals. These optical circuits are located in a clip into which the transducer cartridge fits. As the vane in the transparent cartridge spins, it momentarily blocks the path of the infrared light travelling to the optical detector. Each time the vane passes an optical detector, an electrical pulse is sensed by the

ventilator's microprocessor. The microprocessor counts the pulses to determine the gas volume; and by noting which detector the vane passes first, the microprocessor determines the gas flow direction in the breathing system.

The sensor clip also contains a heater, which is used to help prevent condensation in the transducer cartridge. Anytime the system is on, the heater is also on.

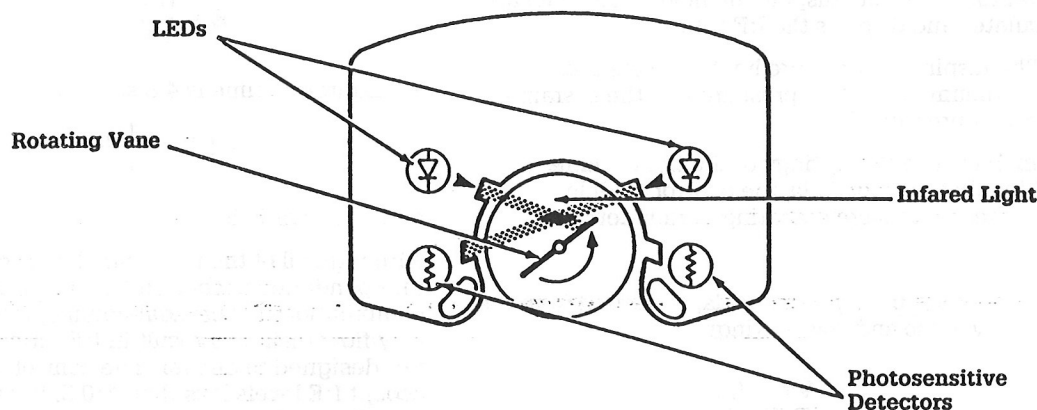


Figure 3-22

The volume sensor clip's optical transducers and detectors

C. Airway Pressure Monitoring

The Ohmeda 7810 Ventilator continuously monitors airway pressures in the patient breathing system, and then uses this information to generate alarms and manage airway pressure. However, this airway pressure monitoring information is used only internally by the ventilator; the ventilator does not display this information directly.

Unlike the volume and oxygen monitoring, the ventilator's airway pressure monitoring doesn't use a transducer connected directly in the patient breathing system. Instead a flexible tube fastened to a sensing port in the breathing system connects to a transducer in the control module. Inside the transducer is a thin, silicon diaphragm that is used as a resistor in a DC amplifier. When the pressure from the breathing system increases, the silicon diaphragm stretches, increasing the diaphragm's resistance to electrical current. The transducer's built-in circuits convert this change in resistance into an electrical DC voltage that is directly proportional to pressure changes in the breathing system. Then, to allow the microprocessor to use the DC signal the transducer provides, the ventilator converts this DC voltage into digital information. The ventilator uses this converted information to assess the airway's pressure status and then generates any necessary alarms.

D. Oxygen Monitoring

When the ventilator's oxygen-monitoring probe is correctly connected, the Ohmeda 7810 Ventilator measures and displays on its front panel the concentration of inspired oxygen. In addition to displaying the oxygen concentration, the ventilator uses this information to generate high-oxygen and low-oxygen alarms based on the levels you set using the front panel pushwheels.

To measure the inspired concentration of oxygen, the ventilator uses a sensor that converts the partial pressure of oxygen into electrical current. This sensor, which is mounted on the absorber, is an electrochemical device that allows oxygen to diffuse through a membrane to reach a base-metal electrode inside the sensor. The oxygen then oxidizes the electrode, which produces a DC current that is directly proportional to the percentage of oxygen in the sensor's gas sample. Because oxidation also gradually consumes the electrode, the oxygen sensor must be calibrated periodically and occasionally replaced.

The gas sample temperature also affects the electrode's electrical output. To compensate for temperature changes, the ventilator uses a temperature-sensitive electrical device called a thermistor. This thermistor is housed inside the sensor. The sensor connects to the control module, which converts the analog electrical signal into digital information used by the ventilator's microprocessor.

3/General Information

E. Control Range Computation

The control module establishes four operating parameters based directly on the settings of the four front panel dials:

- The tidal-volume dial sets (V_T), the volume of each breath in milliliters.
- The rate dial sets (R), the number of breaths per minute.
- The inspiratory flow dial sets (F), the instantaneous gas flow in liters per minute. However, the ventilator doesn't display the flow; instead it calculates and displays the I:E ratio.
- The inspiratory pressure limit dial sets both the maximum inspiratory pressure and the sustained circuit pressure limit.

Then, based on the settings of the tidal volume, rate, and inspiratory flow dials, the control module calculates three more operating parameters:

- Inspiratory time (I), in seconds, is derived from the tidal-volume and flow settings.

$$I = \frac{V_T \times 60}{F \times 1000}$$

- Expiratory time (E), in seconds, is derived from the inspiratory time and the rate setting.

$$E = \frac{60}{R} - I$$

- I:E ratio (I:E), is the ratio of the inspiratory time to the expiratory time. The inspiratory side of the ratio is always expressed as "1." Whenever the inspiratory flow dial is touched, the control module displays the approximate I:E ratio. Because the inspiratory flow is continuously variable within its range, the ventilator's actual I:E ratios are continuously variable from 1:0.5 to 1:999. However, the ventilator displays the I:E ratio rounded to the nearest 0.5.

$$I:E = \frac{I}{E}$$

If, for example, the tidal volume dial is set to 600 mL, the rate dial is set to 10 breaths per minute, and the inspiratory flow dial is set to 30 liters per minute:

$$I = \frac{600 \times 60}{30 \times 1000}, \text{so:}$$

- Inspiratory time is 1.2 seconds.

$$E = \frac{60}{10} - 1.2, \text{so:}$$

- Expiratory time is 4.8 seconds.

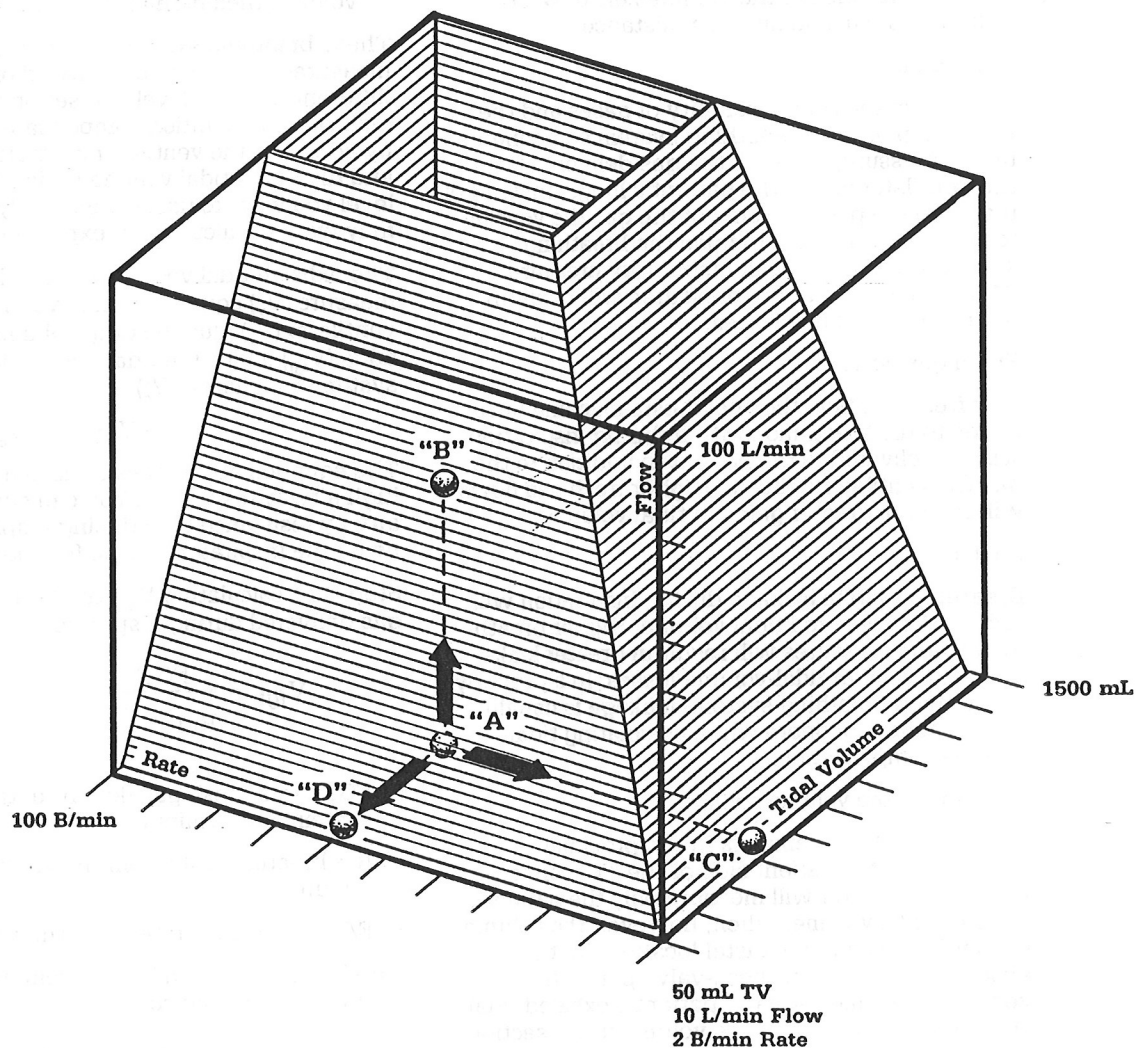
$$I:E = \frac{1.2}{4.8}, \text{so:}$$

- The I:E ratio is 1:4

Although all of the front panel dials can be set independently to their full-scale limits, certain combinations of the tidal-volume, rate, and inspiratory-flow dials will result in I:E ratios the ventilator is not designed to deliver. The control module will not accept I:E levels less than 1:0.5. Instead, the ventilator will continue to use the most recent acceptable settings, and will display the ventilator setting error message until the I:E ratio is corrected.

For example, if the tidal volume is set to 130 mL, the rate is set to 60 BPM, and the flow is set to 10 L/min, the I:E ratio will be only 1:0.28. To increase the I:E ratio to 1:0.5 or more, you must either decrease the tidal volume, decrease the rate, or increase the inspiratory flow. Once the ventilator senses an acceptable control combination, it will remove the "VENT SET ERROR!" message and implement the new settings.

3/General Information



This diagram illustrates the ranges of front-panel control combinations the ventilator is designed to deliver. Control combinations that result in I:E ratios the ventilator can deliver are represented as the unshaded areas in the cube; the shaded areas represent I:E ratios that are out of the ventilator's range. A control combination—as in the example above—of 130 mL tidal volume, 60 BPM rate, and 10 L/min flow sets the I:E ratio at point "A," which is in the shaded area. Increasing the flow moves the point up, along the Z axis, and out of the shaded area to point "B." Decreasing the rate moves the point along the Y axis, toward the lower right corner, and out of the shaded area to point "C." And, decreasing the tidal volume moves the point along the X axis, toward the left corner, and out of the shaded area to point "D."

Figure 3-23

Diagram of the ventilator's range

3/General Information

F. Tidal Volume Compensation

You may notice that the exhaled tidal volume (V_T) the ventilator measures and displays usually does not match the setting on the tidal volume dial. In most cases this is normal: the ventilator measures the patient's actual exhaled volume, which—because of a number of factors—will usually be different than the set tidal volume; use the measured volume as a guide when setting tidal volume. Factors contributing to differences between the set tidal volume and the measured tidal volume include breathing system compliance, fresh gas flow, breathing system leakage, the location of the volume sensor within the breathing system, and airway resistance.

- Compliance:

Because of the compressibility of gases and the expansion of some breathing system components under pressure, not all of the gas delivered from the ventilator enters the patient's lungs. Instead of reaching the patient, some of the gas the ventilator delivers is needed to raise the breathing system pressure to peak inspiratory pressure. Higher peak inspiratory pressures will result in greater tidal-volume losses.

- Fresh gas flow:

Any fresh gas flow the anesthesia machine introduces to the breathing system during inspiration will be delivered to the patient in addition to the gas the ventilator delivers. Higher fresh gas flows will result in greater gains in tidal volume.

- Leakage:

Breathing system leakage during inspiration will reduce the delivered tidal volume. Higher breathing system pressures will result in greater leakages and greater tidal-volume losses. In a properly maintained breathing system, leakage is usually small enough to ignore when calculating tidal volume compensation.

- Location of the volume sensor:

When the volume sensor is in the proximal location—on the patient side of the "Y" connector—the ventilator will measure only the patient's exhaled tidal volume. When, however, the volume sensor is placed in the distal location—at the absorber's exhalation check-valve port—the ventilator will measure the patient's exhaled tidal volume plus the compliance volume in the section of the patient circuit that is between the absorber's inhalation and exhalation check valves and the patient; this compliance volume is not delivered to the patient.

Although tidal volumes measured distally will always be artificially higher than those measured proximally, the difference between the measurements will usually be small (about 2 to 3 mL cm H_2O) when just standard, 30-to-40-inch-long, patient-circuit tubing is between the absorber and the patient. Adding volume to the circuit, for example by connecting a humidifier in the inspiratory limb, will increase the differences between distally-measured tidal volumes and proximally-measured tidal volumes.

- Airway resistance:

High airway resistance, such as caused by a small endotracheal tube or other airway obstruction, may reduce the tidal volume the ventilator delivers to the patient. A tidal volume delivered at a high inspiratory flow may be partially restricted from reaching the lungs, causing a larger than normal portion of that tidal volume to remain in the breathing system. You can determine if airway resistance is a factor in your system: if reducing the inspiratory flow or enabling the inspiratory pause function increases the measured tidal volume, then high airway resistance is a factor.

These breathing system factors may cause the measured tidal volume indicated on the screen to be different than the level you set on the tidal volume dial. During operation compensate for these factors by adjusting the ventilator controls so the measured and displayed tidal volume indicates the ventilation level you want to use. Occasionally, however, you may want to calculate an expected tidal volume.

The exhaled tidal volume you would expect to measure (V_T) equals the tidal volume set on the ventilator (V_s) plus the tidal volume fresh gas flow adds (V_{fgf}) minus the tidal volume lost to breathing system compliance (V_c).

$$V_T = V_s + V_{fgf} - V_c$$

The equation above doesn't account for leakage or high airway resistance. You can compensate for high airway resistance by reducing inspiratory flow or using the inspiratory pause function.

Step One, calculating V_{fgf} , the total volume of fresh gas delivered during inspiration.

$$V_{fgf} = \frac{FGF}{R(1 + \frac{E}{I})}$$

- FGF= total fresh gas flow from the anesthesia system, in mL/minute.
- R = breathing rate from the ventilator, in breaths/minute
- E/I = inverse I:E ratio from the ventilator

Step Two, calculating V_c , the volume lost to breathing system compliance.

$$V_c = C \times PIP$$

3/General Information

- C = compliance factor in mL/cm H₂O.

When the volume sensor is in the distal position, the compliance factor (C) for the Ohmeda GMS Absorber is about 8 mL/cm H₂O with adult bellows and about 6 mL/cm H₂O with pediatric bellows; because the volume sensor is located distally, however, actual patient volume will be somewhat less than the tidal volume the ventilator measures and displays. When the volume sensor is in the proximal position, the compliance factor is about 10 mL/cm H₂O for the Ohmeda GMS Absorber with adult bellows, 60 inch long, disposable, patient-circuit tubes, and no humidifier. If your system includes components different from these, see step three to calculate your system's compliance factor.

- PIP = peak inspiratory pressure, as shown on the breathing system's pressure gauge, in cm H₂O.

For example, to verify the volume reading of a system connected to either a patient or a test lung: assume that the ventilator settings are V_s = 750 mL (on the tidal volume dial), R = 10/min (on the rate dial), and the inspiratory flow is set so that I:E = 1:3. Assume also that fresh gas flows total 3 L/min (3000 mL/min), that PIP = 30 cm H₂O (peak inspiratory pressure as shown on the breathing system's pressure gauge), and that the volume sensor is located in the distal position.

$$V_{fgf} = \frac{FGF}{R(1 + \frac{E}{I})}, \text{ so}$$

$$V_{fgf} = \frac{3000 \text{ mL/min}}{10/\text{min} (1 + \frac{3}{1})} = 75 \text{ mL}$$

- V_c = C x PIP, so
V_c = (8 mL/cm H₂O) x (30 cm H₂O) = 240 mL
- V_T = V_s + V_{fgf} - V_c, so
V_T = 750 mL + 75 mL - 240 mL = 585 mL

The expected tidal volume (V_T) is 585 mL. Because of the number of variables in the equations above, measured tidal volumes within about 15 percent of the calculated value represent a reasonable correlation to the set tidal volume of 750 mL. Leakage will further reduce the measured value.

Step Three, determining the compliance factor. The calculations above use an approximate compliance factor. Occasionally, you may want to determine the compliance for a specific breathing system.

Determining the breathing system compliance factor when the volume sensor is in the proximal position:

1. Connect the ventilator's control module and bellows assembly to the breathing system as if ready for use.

2. Ensure that the absorber is full of absorbent as if ready for use.
3. Ensure that the absorber's Bag/APL-Ventilator switch is in the "Ventilator" position.
4. Connect all of the breathing system components—such as a humidifier, if included in the system, and patient-circuit tubing—as if ready to use.
5. Occlude the patient end—at the "Y" connector—of the patient circuit.

WARNING: When occluding the breathing system for test purposes, do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

6. Move the ventilator's mechanical ventilation switch to "Off."
7. Turn all of the fresh gas flow controls fully clockwise.
8. Move the system master switch to "On."
9. Set the tidal volume to 200 mL.
10. Set the rate to 10 B/min.
11. Turn the inspiratory flow knob completely counterclockwise to 10 L/min.
12. Activate the inspiratory pause function.
13. Move the ventilator's mechanical ventilation switch to "On."
14. Adjust the tidal volume dial until the peak inspiratory pressure—shown on the system's pressure gauge—reads exactly 30 cm H₂O.
15. Move the ventilator's mechanical ventilation switch to "Off."
16. Touch the tidal volume dial to display the tidal volume that was required to achieve a peak inspiratory pressure of 30 cm H₂O. Note the displayed value.
17. C = V_s ÷ PIP. Divide the tidal volume value you noted by 30 cm H₂O to calculate the compliance of your system.
18. Move the system master switch to "Off."
19. Remove the occlusion from the patient circuit.

3/General Information

3.4 The Ventilator Modes

The Ohmeda 7810 Ventilator uses three basic modes: the Setup Page mode, the Mechanical Ventilation mode, and the Monitoring mode. The Setup Page groups parameters not normally adjusted during a case, such as the screen contrast and the alarm volume. In the Mechanical Ventilation mode—when the mechanical ventilation switch is on—patient monitoring and alarms are active, and the control module is driving the bellows assembly. And in the Monitoring mode—when the mechanical ventilation switch is off—mechanical ventilation is off but all patient monitors still function and the alarm system is still active, although certain alarms are enabled only during mechanical ventilation.

When you first enter the Setup Page, the ventilator displays the selected language, the selected drive gas, and version number of the software it is using. The ventilator then lets you enable or disable the reverse flow alarm, and adjust the screen contrast, audio alarm volume, and altitude setting. The last three parameter settings are stored in the ventilator's memory even when the system's power is disconnected; if you are satisfied with these parameter settings, you can skip past the Setup Page. The first parameter, the reverse flow alarm status, is automatically enabled anytime the ventilator is powered on. If you want to disable the reverse flow alarm—usually because you have placed the volume-sensor cartridge at the proximal end of the "Y" connector, you must enter the Setup Page mode and change the alarm's status each time you power on the ventilator.

To adjust the setup parameters, turn the flow dial. The ventilator will display the parameter's current setting. To move from one parameter to the next, press the alarm silence button.

In both the Monitoring mode and the Mechanical Ventilation mode, the patient monitoring and the alarms systems are active. The ventilator measures inspired-oxygen concentration, airway pressure, breath rate and patient volume, regardless of whether the patient is breathing spontaneously, or mechanical ventilation is being used.

3.5 The Alarm System

A. The Anesthesia Machine Alarms

Electrical Disconnect/Failure Alarm—If the anesthesia machine's AC power supply fails or is disconnected, the system will sound a warbling, intermittent alarm and will flash the "Battery" indicator to the left of the master switch. If AC power is lost, the system's built-in backup battery will temporarily provide backup power to the ventilator and its integrated oxygen, volume, and circuit-pressure monitors. The battery, however, will not power any equipment plugged into the electrical pod outlets, the Record Keeper (if installed), or optional monitors.

Oxygen Supply Failure Alarm—If the oxygen supply pressure drops below 28 psig (193 kPa), the system will sound the oxygen supply alarm continuously and light the oxygen supply "Fail" indicator. If oxygen pressure then drops below 20 psig (138 kPa), the system will shut off the nitrous-oxide and optional, third-gas supplies. The oxygen supply failure alarm also will sound briefly when you switch on the system.

Monitor Alarms—Each of the monitors installed in the monitor pod has one or more alarm conditions. Read each monitor's Operation and Maintenance manual for detailed information on the monitor alarms.

B. The Ventilator Alarms

All of the ventilator alarms conditions will sound an alarm, will light either the red or yellow alarm LED, and will display a message on the screen. As soon as the ventilator senses an alarm condition, it will display an appropriate message, which will be updated every one-and-a-half seconds until the condition is resolved (apnea alarms are updated at one-second intervals). If a second alarm condition occurs before the first is resolved, the ventilator will alternate the messages for each condition. The ventilator will alternate, at one-and-a-half-second intervals, the alarm messages for as many alarm conditions as exist at one time. The ventilator will sound the audible alarm for the first alarm condition that occurs. However, any alarm condition that results in a warble tone will always have its audible alarm sounded, overriding any other tones. If that condition is resolved, the ventilator will then sound the alarm for the next condition that occurred.

The two light emitting diodes (LEDs) embedded in the alarm silence button indicate the status of alarms. When an alarm condition first occurs, a message will appear on the screen, a tone will sound, and an LED will flash. Once the alarm silence button is pressed, the ventilator will light the LED continuously to remind you that the alarm condition still exists. The red LED is lighted during alarm conditions that require immediate operator response. The yellow LED indicates alarm conditions that require prompt operator response or operator awareness.

To silence an audible alarm, press the alarm silence button. If that alarm condition continues, the alarm will sound again in 30 seconds. If, however, a new alarm condition occurs, its audible alarm will sound immediately. Four types of alarms can be silenced permanently, even if the alarm conditions continue. These permanently silenceable alarms include power failure, oxygen probe failure, low battery, and ventilator failure.

The ventilator's built-in computer must be functioning correctly for the alarm system to work correctly. If the ventilator's computer fails, the screen may flash erratically and an intermittent tone will sound; the alarm silence button will not terminate the alarm if the ventilator's computer fails. Do not attempt to continue using the ventilator if this failure occurs.

3/General Information

| Alarm Message | Alarm Condition | LED | Tone |
|---|--|------------------|---|
| APNEA ** | Insufficient tidal volume measured in greater than 120-second period | Red, flashing | Continuous warble |
| APNEA xxx SEC. | Insufficient tidal volume measured in a greater than 30-second period | Yellow, flashing | Staged: 30 seconds—one warble; 60 seconds—two warbles; 90 seconds—three warbles |
| LOW OXYGEN! | Oxygen concentration below set limit | Red, flashing | Continuous warble |
| HIGH PRESSURE! | Circuit pressure above set limit | Red, flashing | One warble per occurrence |
| LOW PRESSURE! (Active during mechanical ventilation only) | Pressure change less than threshold for at least 20 seconds | Red, flashing | One warble per breath |
| SUSTAINED PRES! | Pressure exceeds set limit for 15 seconds or more | Red, flashing | Continuous warble |
| SUB-ATMOS. PRES! | Pressure less than -10 cm H ₂ O | Red, flashing | Continuous warble |
| LOW MINUTE VOL! | Minute volume below set limit | Yellow, flashing | Intermittent beep |
| HIGH OXYGEN! | Oxygen concentration greater than or equal to set limit | Yellow, flashing | Intermittent beep |
| LOW BATTERY! | Battery voltage less than 4.7 VDC | Yellow, flashing | Continuous, permanently silenceable |
| POWER FAIL! | Battery voltage less than 4.6 VDC | Yellow, flashing | Continuous, permanently silenceable |
| LIMIT SET ERROR! | High oxygen alarm limit below or same as Low O ₂ alarm limit. Or Low O ₂ alarm limit less than 18 percent | Yellow, flashing | Continuous |
| VENT. SET ERROR! | Combination of settings of ventilator controls out of range | Yellow, flashing | Continuous |
| CHECK O ₂ PROBE! alternating with CHECK GAS SUPPLY | Oxygen sensor output equals zero | Yellow flashing | Continuous, permanently silenceable |
| REVERSE FLOW! | More than 100 mL or 20 mL (when tidal volume dial set below 300 mL) flow in the wrong direction | Yellow | Continuous |

3/General Information

| Alarm Message | Alarm Condition | LED | Tone |
|---|---|--------------------|-------------------------------------|
| LOW SUPPLY PRES! | Supply gas pressure less than 22 psig | Yellow, flashing | Intermittent beep |
| VENT. FAIL xx! | Ventilator hardware failure | Yellow, flashing | Continuous, permanently silenceable |
| DRIVE CKT. OPEN! | Incorrect exhalation valve feedback or pressure switch engaged | Yellow, flashing | Continuous, permanently silenceable |
| MAX. PRES=xxx CM (Active only in the Monitoring mode.) | Pressure limit set to more than 60 cm H ₂ O | Yellow, continuous | One beep, silences automatically |
| APNEA ALARM OFF! (Active only in the Monitoring mode.) | Tidal volume set to less than 300 mL and mechanical ventilation switch set to "Off" | Yellow, continuous | One beep, silences automatically |
| VOL MON STANDBY! | System waiting for first breath to activate volume monitoring and apnea timer | Yellow, continuous | One beep, silences automatically |
| CHECK SETTINGS! | Displayed when Setup Page is exited | Yellow | One beep, silences automatically |

Additional Displays

Alarm Message

????

| Condition | LED | Tone |
|---|------|------|
| Volume sensor probe disconnected or defective | None | None |
| Ventilator out of volume monitor's range | None | None |

3/General Information

Alarm Definitions:

Apnea—If for 30 seconds the ventilator doesn't detect a sufficient breath, an apnea alarm will be generated. The alarm message will indicate the number of seconds that have passed since the last sufficient breath was detected. The tone will warble once at 30 seconds, twice at 60 seconds, and three times at 90 seconds. At 120 seconds the tone will warble continuously and the alarm message will be "APNEA **" only.

The ventilator uses the volume-sensing circuits to activate the apnea alarm. When the ventilator is first switched on it displays the "VOL MON STANDBY!" message to indicate that a set threshold of flow is not being sensed and the apnea alarm is not activated. Then, once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY!" message and starts a timer that controls the apnea alarm. Each time the ventilator senses sufficient volume, it resets this apnea timer.

The actual volume threshold required to start or reset the apnea timer varies depending on the level you set on the tidal volume dial. For tidal volume settings between 180 mL and 400 mL, the threshold varies linearly from 20 mL to 100 mL. For tidal volume settings below 180 mL, the threshold is always 20 mL. And for tidal volume settings above 400 mL, the threshold is always 100 mL. In the Manual Mode, however, once the apnea time starts, the volume threshold required to reset the timer is 20 mL.

For example, if the tidal volume dial is set to 250 mL, and mechanical ventilation is switched on, the timer starts and is reset when the ventilator senses a breath of at least 46 mL. If you then increase the tidal volume dial to 320 mL, the ventilator will increase the threshold to 71 mL. In either case, if the timer reaches 30 seconds (because the ventilator didn't sense enough volume to indicate a breath), the first in the series of four apnea alarms will sound.

Because very low flow levels that are not sufficient to trigger the volume-sensing circuits may occur in spontaneously breathing patients, the ventilator disables the apnea alarm when the tidal volume dial is set to less than 300 mL and mechanical ventilation is switched off. Whenever tidal volume is set to less than 300 mL and the ventilator switch is off, the ventilator, once it has detected a breath, will display "APNEA ALARM OFF!" To enable the apnea alarm while the patient is breathing spontaneously, increase the tidal volume dial to 300 mL or more. Although you should always carefully set the low minute volume pushwheel to enable the low minute volume alarm at an appropriate level, the low minute volume alarm is especially important when the tidal volume dial is set to less than 300 mL, disabling the apnea alarm.

Low Oxygen—If the ventilator detects an oxygen concentration lower than the one you set using the low-O₂ pushwheel, the ventilator will generate a low oxygen alarm.

High Pressure—If, during mechanical ventilation or while in the Monitoring mode, the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit control, the ventilator

will generate a high pressure alarm. In addition, during mechanical ventilation only, the ventilator uses electronically-controlled, adjustable, automatic, high-pressure relief to manage excessive airway pressure. If, while the mechanical ventilation switch is on, the airway pressure rises to a level that causes a high pressure alarm, the ventilator will release the remaining drive gas into the atmosphere and end the inspiratory cycle.

Low Pressure—The ventilator generates a low pressure alarm if, for at least 20 seconds, the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow dial. The amount of airway-pressure change required to prevent an alarm from triggering will vary between 4 cm H₂O to 9 cm H₂O to correspond to the inspiratory-flow range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 L/min, the low pressure alarm will activate if the airway pressure doesn't change by at least 5.1 cm H₂O. But if the inspiratory flow is set to 80 L/min, the airway pressure must change by at least 7.9 cm H₂O to keep the alarm from activating.

Unlike the other alarms, the low pressure alarm is active only when mechanical ventilation is switched on.

Sustained Pressure—The ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit dial's setting. For maximum inspiratory pressure limits of 20 cm H₂O to 60 cm H₂O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H₂O, the sustained pressure limit will be 21 cm H₂O. However, any inspiratory pressure limit setting of more than 60 cm H₂O will result in a sustained pressure limit of 30 cm H₂O. For example, inspiratory pressure limits of 65 cm H₂O and 80 cm H₂O will both result in a sustained pressure limit of 30 cm H₂O.

Anytime the sustained airway pressure exceeds—for 15 seconds or more—the sustained pressure limit set by the inspiratory pressure limit dial, the ventilator will generate a sustained pressure alarm.

Subatmospheric Pressure—If the ventilator detects airway pressure of less than -10 cm H₂O, it will generate a subatmospheric pressure alarm. For example, airway pressure of -12 cm H₂O will cause an alarm.

Low Minute Volume—If the ventilator detects that the minute volume is less than the level you set using the low minute volume pushwheel, the ventilator will generate an alarm. However, to reduce nuisance alarms that can be generated when control settings are changed, whenever you adjust the tidal volume dial, the rate dial, move the mechanical ventilation switch to "On," or exit the volume monitor standby condition, the ventilator will disable the low minute volume alarm for 40 seconds.

WARNING: Always correctly set the low minute volume alarm and use CO₂ monitoring to aid in the detection of breathing system disconnections.

3/General Information

High Oxygen—If the ventilator detects an oxygen concentration equal to or higher than the one you set using the high-O₂ pushwheel, the ventilator will generate a high oxygen alarm.

Low Battery—Two sources can power the control module: the Ohmeda Modulus II Plus Anesthesia System's DC power supply, and the system's backup battery. If the anesthesia machine's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, then its backup battery takes over. The battery supplies 12 volts, which a device in the anesthesia machine converts to five volts for the ventilator to use.

If the voltage from the anesthesia machine drops to 4.7 VDC or less, the ventilator will generate a "LOW BATTERY!" alarm. Pressing the alarm silence button will permanently silence the alarm tone; however, the LED will remain lighted and the alarm message will still appear.

If the voltage then drops to 4.6 VDC or less, the system will generate a "POWER FAIL!" alarm, which will alternate with the low battery alarm. And if the voltage stays at or below 4.6 VDC, within a minute the ventilator will generate the "VENT. FAIL 5!" alarm. While this ventilator failure 5 message is displayed, the ventilator's oxygen, airway-pressure, and volume monitors will continue to operate. But mechanical ventilation is disabled whenever ventilator failure messages are displayed.

If the voltage then drops below 4.35 volts, the ventilator will blank the screen, switch off all monitoring, light the yellow alarm LED, and sound an intermittent alarm tone.

Power Failure—If the voltage from the anesthesia system drops below 4.6 VDC, the ventilator will generate a power failure alarm. See the "Low Battery" description above for the sequence of alarms generated when the voltage from the anesthesia system drops.

Limit Setting Error—If you attempt to set the high oxygen alarm limit for a level below or equal to the low oxygen limit, the ventilator will generate a limit setting error alarm. This alarm will also be generated if you attempt to set the low oxygen alarm limit for less than 18 percent.

Ventilator Setting Error—If you attempt to set a combination of the inspiratory-flow, tidal-volume and rate controls that results in a level the ventilator is not designed to deliver, the ventilator will continue to use the most recent acceptable settings, and will generate a "VENT. SET ERROR!" alarm until the control combination is corrected. For example, a tidal volume of 500 mL, combined with a rate of 20 B/min, and an inspiratory flow of 10 L/min will trigger a ventilator setting error. To remove the error, either decrease the tidal volume setting, or decrease the rate setting, or increase the flow setting.

Check O₂ Probe/Check Gas Supply—If the ventilator doesn't detect any oxygen, it assumes that either the oxygen probe has failed, or that no oxygen is in the breathing system, and it generates an alarm.

A check O₂ probe/gas supply alarm will also be generated if the probe isn't connected correctly, if the probe is broken, or if no oxygen is in the area of the probe.

Reverse Flow—If the ventilator senses an unacceptable level of reverse flow, it generates an alarm. The level of reverse flow that will trigger a reverse flow alarm depends on the tidal volume you set. If you set the tidal volume dial for less than 300 mL, then 20 mL or more reverse flow will trigger an alarm. However, if you set the tidal volume dial for 300 mL or more, the ventilator will allow up to 100 mL of reverse flow before triggering an alarm. Once an alarm has been triggered, two forward breaths must be sensed before the ventilator will automatically switch off the alarm.

The reverse flow alarm is intended to warn you of inadvertent reverse flow conditions, such as those caused by a defective or sticking exhalation check valve. These kinds of conditions will be detected only when the volume sensor is correctly placed at the distal position of the expiratory limb of the breathing system. If you place the volume sensor at the proximal end of the "Y" connector, volume monitoring will still function. However, when the volume sensor is located at the proximal position, a reverse flow condition will exist each time the patient inhales and the reverse flow alarm will activate for each breath. To disable the reverse flow alarm, select "REVERSE ALARM: OFF" from the Setup Page (see section 5.3).

WARNING: The reverse flow alarm will function correctly only if the volume sensor cartridge is working correctly and is properly placed in the distal position of the expiratory limb of the breathing system.

WARNING: When the volume sensor is in the distal position of the breathing system, check the ventilator's Setup Page to confirm that the reverse flow alarm is enabled. Do not use the system with the reverse flow alarm disabled if the volume sensor is in the distal position.

Low Supply Pressure—If the ventilator's supply gas pressure is less than 22 psig, the ventilator will generate a low supply pressure alarm.

Ventilator Failure—Both mechanical and electrical failures can generate an alarm, such as "VENT. FAIL 8!". The number in the alarm message will correspond to the specific type of failure that has occurred, in this case a gas inlet valve failure. If a ventilator failure alarm does occur, pressing the alarm silence button will permanently silence the alarm tone, although the yellow LED and alarm message will remain on, and the ventilator will not function. During some ventilator failure alarms the ventilator's built-in monitors will continue to function. Mechanical ventilation, however, will be disabled whenever any ventilator failure message—except the messages for ventilator failures 6, 8, and drive gas circuit open—is displayed.

3/General Information

Some ventilator failure alarm conditions may be caused by transitory electrical interference that devices such as electrocautery instruments can generate. Although the ventilator will disable mechanical ventilation during most ventilator failure alarms, during certain of these alarms, whose causes may be transitory, the ventilator will continuously attempt to reset its circuits for correct operation. If the ventilator successfully resets its circuits, it will remove the alarm message and resume normal operation.

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

Pressure Limit—Anytime you adjust the inspiratory pressure limit dial, the ventilator will briefly display the pressure limit in centimeters of water. However, if the ventilator is in the Monitoring mode and the inspiratory pressure limit is set to more than 60 cm H₂O, the ventilator will also light the yellow alarm LED and will continuously display the "MAX. PRESS=xxx CM" reminder. The pressure limit reminder is displayed in the Monitoring mode only; during mechanical ventilation this reminder is disabled.

Apnea Alarm Off—Because very low flow levels that are not sufficient to trigger the volume-sensing circuits may occur in spontaneously breathing patients, the ventilator disables the apnea alarm when the tidal volume dial is set to less than 300 mL and mechanical ventilation is switched off. Whenever tidal volume is set to less than 300 mL and the mechanical ventilation switch is off, the ventilator, once it has detected a breath, will display "APNEA ALARM OFF!". To enable the apnea alarm while the patient is breathing spontaneously, increase the tidal volume dial to 300 mL or more. Although you should always carefully set the low minute volume push-wheel to enable the low minute volume alarm at an appropriate level, the low minute volume alarm is especially important when the tidal volume dial is set to less than 300 mL, disabling the apnea alarm.

Volume Monitor Standby—When the ventilator is first switched on, when the ventilator is switched from mechanical ventilation to the monitoring mode, or when—while the ventilator is in the monitoring mode—the alarm silence button is pressed, the ventilator displays the "VOL MON STANDBY!" message to indicate that the alarm system is waiting for a sufficient breath. Once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY!" message and starts the timers that control the apnea alarm and low minute volume alarms.

Check Settings—In the Setup Page the front panel controls are used to set parameters not normally adjusted during a case, such as the screen contrast and the alarm volume. Before you use the ventilator on a patient, you must readjust any controls you used in the Setup Page. To remind you to check your control settings, when you exit the Setup Page the ventilator displays the "CHECK SETTINGS!" message.

Dashes Displayed In Place Of Readings—If during mechanical ventilation the system does not sense any volume for two consecutive breaths, the system assumes the volume sensor is disconnected or damaged. However, the system does not send a volume sensor failure message. Instead it displays dashes in place of the usual tidal volume reading.

Question Marks Displayed In Place Of Readings—Certain combinations of ventilator front panel control settings can result in ventilation conditions the ventilator can deliver but the volume sensor cannot measure. If you attempt to set a combination of the controls that results in a level the ventilator is not designed to deliver, the ventilator will generate a ventilator setting error alarm. If you set a control combination the ventilator can deliver, but the volume monitor cannot measure, or if—in the monitoring mode—breathing occurs that the monitor cannot measure, the ventilator will display question marks in place of the VT, VE, and rate readings.

Notes

1. The first part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

2. The second part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

3. The third part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

4. The fourth part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

5. The fifth part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

6. The sixth part of the document is a list of names and dates. The names are: John Doe, Jane Smith, and Bob Johnson. The dates are: 1/1/1980, 2/1/1980, and 3/1/1980.

4/Preoperative Checkout Procedures

Always complete the following checkout procedures before using the Ohmeda Modulus II Plus Anesthesia System on a patient. Perform these checkout procedures before each case, and use the actual room, pipeline supply, and electrical supply that will be used during the case. If the system does not pass all of the steps in these procedures, consult the troubleshooting guide, section 7.2. Do not use the system if it does not function correctly, as described in the preoperative checkout procedures; instead call a qualified service representative.

In addition to the procedures listed here, individual preoperative checklists for this system and its options and accessories are included in the system's binder, at the front. Before each case review these checklists, which are intended only to serve as reminders of the complete checkout procedures listed in the operation-and-maintenance manuals for the devices. Always complete the checkout procedures for all the devices in the system.

Before starting the preoperative checkout procedures, visually check the system.

1. Check for damage:
 - Cylinder yokes
 - Pipeline inlets
 - Flowmeters and flow control valves
 - Pressure gauges
 - Vaporizers
 - Monitors and cables
 - All hoses and tubing
2. Check that the cylinders are properly installed.
3. Check that the vaporizers are properly installed.
4. Check that the cylinder wrench is available.

4.1 Checking The Pipeline And Reserve Cylinder Supply

1. Make sure a gas cylinder or cylinder yoke plug is properly and securely mounted in each cylinder hanger yoke.
2. Disconnect the pipeline supply hose from the wall outlet.
3. Move the system master switch to "Off."
4. Open the flow control valves by turning their knobs fully counterclockwise.

CAUTION: Open the cylinder valves s-l-o-w-l-y to avoid damaging the regulators.

5. Open each cylinder valve and check the cylinder pressure gauges to verify that the cylinder supplies are adequate. Make a note of all the cylinder pressures.
6. If you are using a second oxygen or nitrous oxide yoke:
 - a. Close the first cylinder.
 - b. Press the oxygen flush button to release the pressure from the first cylinder.

- c. Open the second cylinder and check its pressure.

7. Check that none of the flowmeters indicate gas flow.
8. Close all of the cylinder valves and note the value on each cylinder pressure gauge. The gauges must show less than a 100 psig (690 kPa) pressure drop in a five minute period. If the pressure drops more than 100 psig in less than five minutes, the high-pressure circuit has an unacceptable leak.

If the circuit is leaking excessively:

- a. Defective cylinder gaskets or loose tee handles can cause such leaks. Replace the gasket and tighten the tee handle.
 - b. Repeat the leak check. If the circuit still leaks, do not use the system for clinical applications. Call a qualified service representative for repairs.
9. Check the anesthesia machine to hospital pipeline connections.
 - a. Turn the system master switch to "On."
 - b. Open all of the flow control valves to return the cylinder pressure gauges to zero.
 - c. Turn the system master switch to "Off."
 - d. Close all of the flow control valves.
 - e. Connect the hospital O₂ pipeline hose to the system's O₂ pipeline inlet. Ensure that the O₂ pipeline supply pressure, which should be about 50 psig (345 kPa), is indicated on the O₂ pipeline pressure gauge only.
 - f. Turn the system master switch to "On."
 - g. Fully open all of the flow control valves.
 - h. Ensure that only the O₂ flowmeter indicates flow.
 - i. Close all of the flow control valves.
 - j. Connect the hospital N₂O pipeline hose to the system's N₂O pipeline inlet. Ensure that the N₂O pipeline supply pressure, which should be about 50 psig (345 kPa), is indicated on the N₂O pipeline pressure gauge only.
 - k. Fully open the N₂O and, if included in your system, the third-gas flow control valves. As you open the N₂O flow control valve, the Ohmeda Link 25 Proportion Limiting Control System will engage, increasing the O₂ flow. Refer to section 4.3 to check the correct O₂ flow when the N₂O flow control valve is opened.
 - l. Ensure that the N₂O flowmeter indicates flow.
 - m. Ensure that the third-gas flowmeter indicates zero flow.
 - n. Close all of the flow control valves.
 - o. Disconnect the N₂O pipeline supply from the system.

4/Preoperative Checkout Procedures

- p. Fully open all of the N₂O flow control valve to return the N₂O pressure gauge to zero.
- q. Close all of the flow control valves.
- r. If your system includes pipeline air, connect the hospital air pipeline supply to the system's air pipeline inlet. Ensure that the air pipeline supply pressure, which should be about 50 psig (345 kPa), is indicated on the air pipeline pressure gauge only.
- s. Fully open the N₂O and Air flow control valves: As you open the N₂O flow control valve, the Ohmeda Link 25 Proportion Limiting Control System will engage, increasing the O₂ flow.
- t. Ensure that the N₂O flowmeter indicates zero flow.
- u. Close all of the flow control valves.

4.2 Checking The Low Pressure Gas Circuitry

Before performing this test, check the pipeline supply pressure as described in the previous section.

WARNING: Leaking gases and vapors (downstream of the flow control valves and Oxygen Flush valve) may deprive the patient of metabolic gases and anesthetic agent and may pollute the atmosphere. Tests that detect such leaks must be performed frequently. If detected, leakage must be reduced to an acceptable level.

A low-pressure leak-testing device is included with all Ohmeda Modulus II Plus Anesthesia Systems. Store this device, which should always be kept with the system, in one of the drawers. Perform the low-pressure leak test with the cylinders installed.

The leak-testing device must be in good condition to reliably perform the low-pressure circuit leak test. At least once every six months test the device's ability to produce a partial vacuum of 65-mm hg or greater.

To check the leak-testing device's vacuum production:

1. Connect the device to a suitable vacuum gauge.
2. Squeeze and release the bulb to obtain progressively greater displacements. Replace the leak testing device if—while the bulb is still deformed—the device produces a partial vacuum less than 65-mm hg.

To check the low pressure gas circuitry:

1. Check the condition of the low pressure leak-testing device.
 - a. Seal the device's inlet connector and squeeze the bulb until it collapses.
 - b. Release the bulb and check the time it takes to reinflate.
 - c. Replace the leak testing device if reinflation occurs in less than a minute.
2. Turn the system master switch to "Off," if it is not off already.
3. Switch off the vaporizers.
4. Open each gas supply either by slowly opening the cylinder valves or by connecting the pipeline hoses.
5. Fully open all of the flow control valves.
6. Disconnect the gas supply tubing from the common gas outlet.
7. Attach the leak testing device to the common gas outlet.
8. Repeatedly squeeze and release the hand bulb until it collapses and remains collapsed. Once the bulb stays closed, check how long it takes to reinflate. If the hand bulb reinflates in less than 30 seconds, the low-pressure circuit has an unacceptable leak.

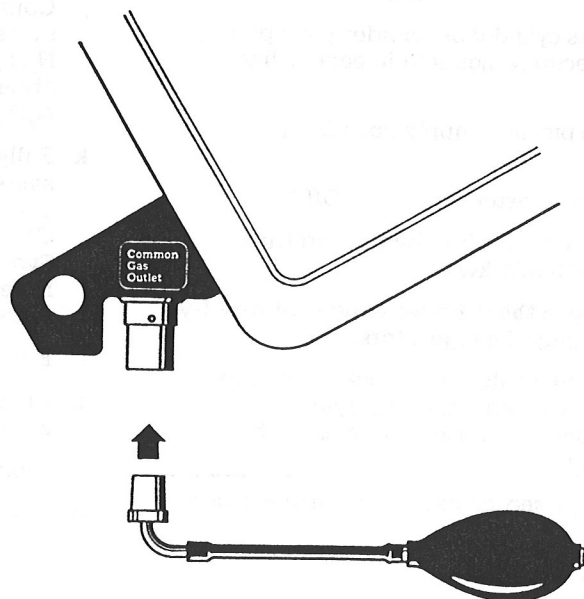


Figure 4-1

The low-pressure leak-testing device

4/Preoperative Checkout Procedures

9. For each mounted vaporizer:
 - a. Make sure the vaporizer is properly mounted and that the filler and drain valves are closed tightly.
 - b. Turn the vaporizer concentration control dial to one percent.
 - c. Repeat step eight. If the circuit does not pass the test, the leak is in the vaporizer. Remove leaking vaporizers from service.
 - d. Switch off the vaporizer.
10. Remove the low pressure leak testing device from the common gas outlet.
11. With all vaporizers switched off, purge the circuit with a flow of 1 L/min oxygen flow for one minute.

WARNING: Do not use the anesthesia system after performing the low-pressure leak test until the vaporizer circuits have been purged with oxygen. Using a system that has not been purged with oxygen may result in incorrect gas mixtures, and injury to the patient.

4.3 Checking The Gas Flow Controls

1. Turn all of the flow control valve knobs completely clockwise to close the flow control valves. Do not over tighten the valves.
2. Either connect the pipeline supplies or slowly open the cylinder valves.
3. Turn the system master switch to "On."
The oxygen flowmeter should show about 200 mL/min (50 mL/min). The other flowmeters should show no gas flow.
4. This step tests the function of the Ohmeda Link 25 Proportion Limiting Control System when the nitrous oxide knob is adjusted. During these tests use only the nitrous-oxide flow-control valve; perform the checks from low to high flows; and do not overshoot any setting. If you do overshoot a setting, repeat this section starting at step one.

Set the N₂O flow control valve so that flow reads: The O₂ flow must then read:

| (mL/min) | Minimum (mL/min) | Maximum (mL/min) |
|----------|------------------|------------------|
| 300 | 79 | Not Applicable |
| 600 | 158 | Not Applicable |
| 900 | 236 | 366 |
| 1500 | 394 | 611 |
| 3000 | 788 | 1222 |
| 6000 | 1577 | 2445 |
| 9000 | 2365 | 3669 |
| 12,000 | 3153 | 4891 |

5. This step tests the function of the Ohmeda Link 25 Proportion Limiting Control System when the oxygen flow knob is adjusted. During these tests use only the oxygen flow control valve. Be careful not to overshoot any setting. If you do overshoot a setting, repeat this step starting at "a." Perform these checks from high to low flows.

- a. Increase the oxygen flow to 6000 mL/min.
- b. Reduce the oxygen flow to 3000 mL/min.

Set the O₂ flow control valve so that flow reads:

The N₂O flow must then read:

| (mL/min) | Minimum (mL/min) | Maximum (mL/min) |
|----------|------------------|------------------|
| 3000 | 7358 | 11,414 |
| 1000 | 2453 | 3804 |
| 500 | 1226 | 1902 |
| 300 | 736 | 1141 |

WARNING: Do not use the anesthesia system if the Ohmeda Link 25 Proportion Limiting Control System does not operate within permitted ranges. Using an incorrectly operating control system may result in incorrect gas mixtures, and injury to the patient.

6. Adjust all of the gas flows to midscale. While you are turning the flowmeter knobs, the flowmeter floats must move smoothly.
7. Shut off the oxygen supply either by closing the oxygen cylinder valve, or by disconnecting the oxygen pipeline supply. As pressure bleeds off:
 - The oxygen-supply failure alarm must continuously sound.
 - The green, oxygen-supply indicator labeled "Normal" must extinguish.
 - The red, oxygen-supply indicator labeled "Fail" must flash.
 - All gas flow must fall to zero, with oxygen being the last gas to stop flowing.
8. Turn all of the flow control valve knobs completely clockwise to close the flow control valves. Do not over tighten the valves.
9. Either reconnect the oxygen pipeline supply or slowly open the oxygen cylinder valve. Once the oxygen supply is restored:
 - The oxygen supply alarm must be silenced.
 - The red, oxygen supply indicator labeled "Fail" must extinguish.
 - The green, oxygen supply indicator labeled "Normal" must light.

4/Preoperative Checkout Procedures

4.4 Testing The Anesthesia Machine Electrical Alarms

1. Move the system master switch to "On."
2. Unplug the power cord.

The electrical disconnect/failure alarm must activate, the green "Mains" indicator must go out, a battery indicator bar must light, and the red "Battery" electrical power indicator must flash.

3. Plug in the power cord and observe that: the "Battery" indicator stops flashing and the tone is silenced; the battery indicator bar is extinguished; and the "Mains" electrical power indicator is lit.
4. Check that:
 - All system monitors are powered on.
 - No monitor is in its battery mode.
 - The Record Keeper, if installed, is on.

5. Check the alarms of any installed monitors as described in their individual operation-and-maintenance manuals.

4.5 Testing The Breathing System

Before each case, test the breathing system, which, as throughout this manual, includes the ventilator's bellows assembly and the Ohmeda GMS Absorber. If your system includes other components, consult the literature for those devices and consider their effect on the performance of the entire breathing system. Although this section does mention the Ohmeda GMS Absorber, you should refer to the absorber's operation-and-maintenance manual for a detailed description of using, maintaining, and checking the Ohmeda GMS Absorber.

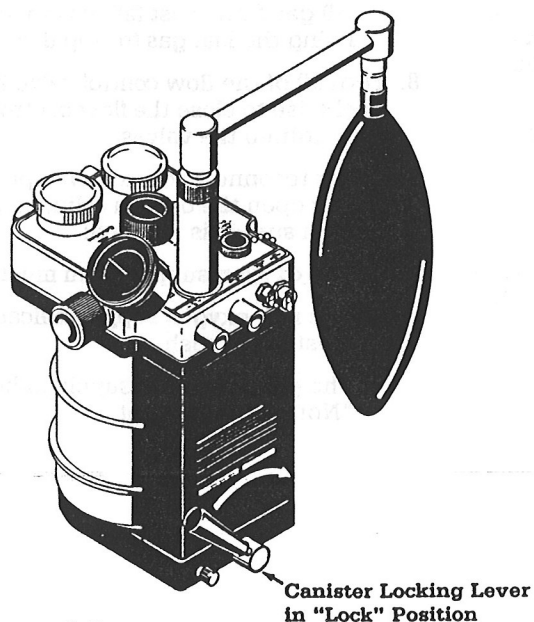


Figure 4-2
The Ohmeda GMS Absorber

A. General Breathing System Checks

1. Verify that any absorber condensate has been drained and that the drain is completely closed.
2. Verify that the capacity of the absorbent is adequate for the case.
3. Verify that the canisters are properly seated and that the canister locking lever is in the "Lock" position. (See figure 4-2.)
4. Verify that the Ohmeda GMS Absorber's pressure gauge is zeroed when the system is open to atmosphere.

B. Testing The Absorber Bag/APL Circuit

1. Turn the Bag/APL-Ventilator switch to the "Bag/APL" position.
2. Perform the absorber leak test:
 - a. Close the APL valve by turning the APL valve knob fully clockwise. Then rotate the knob counterclockwise one-quarter turn to partially open the valve.
 - b. Set the anesthesia machine for a oxygen flow of 200 mL/min delivered to the breathing system.
 - c. Occlude the rebreathing bag nipple and the patient end—at the "Y" connector—of the patient circuit. (See figure 4-3.)

WARNING: When occluding the breathing system for test purposes, do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

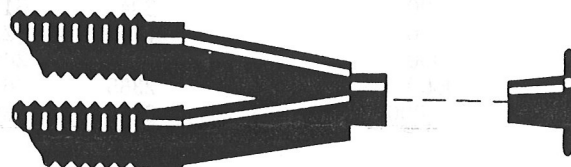


Figure 4-3
Occluding the "Y" Connector

4/Preoperative Checkout Procedures

- d. Watch the absorber's pressure gauge. Press the oxygen flush button briefly to pressurize the breathing system to just under 40 cm H₂O. The bellows must not move. Any movement indicates unacceptable cross-leakage between the bag/APL and ventilator circuits.
 - e. Continue to watch the pressure gauge. The 200 mL/min oxygen flow from the anesthesia machine should raise the breathing system's pressure to at least 40 cm H₂O. The leakage of the bag/APL circuit is then less than or equal to 200 mL/min at 40 cm H₂O.
3. Perform the APL valve tests:
- a. Rotate the APL valve knob fully clockwise.
 - b. Increase the oxygen flow to 3.0 L/min. The pressure on the absorber's pressure gauge should increase to between 65 cm H₂O and 80 cm H₂O. This checks the maximum pressure limit in the bag/APL circuit.
 - c. Slowly turn the APL valve knob counterclockwise in one-quarter-turn increments. The pressure should drop, then stabilize, with each turn of the knob. This checks the adjustable pressure-limiting function of the valve.
 - d. The APL valve knob should now be fully counterclockwise. Remove the occlusion in the absorber bag nipple.
 - e. Connect, to the absorber bag nipple, the breathing bag you are planning to use for the next case. The 3.0 L/min flow should fill the breathing bag to its nominal capacity. The pressure should stabilize between 1.0 cm H₂O and 7.0 cm H₂O. This ensures that the breathing bag will fill for spontaneous breathing with the APL valve completely open, but will limit the positive pressure in the circuit.
4. Reduce the oxygen flow delivered to the breathing system to 200 mL/min.
5. Remove any occlusions you have added to the breathing system.
- C. Testing The Ventilator Circuit
1. Occlude the patient end—at the "Y" connector—of the patient circuit. (See figure 4-4.)
 2. Turn the Bag/APL-Ventilator switch to the "Ventilator" position.

WARNING: When occluding the breathing system for test purposes, do not use any object small enough to slip completely into the system. Objects in the breathing system can interrupt or disrupt the delivery of breathing-system gases, possibly resulting in injury to the patient. Before using the breathing system on a patient, always check the breathing system components for foreign objects.

3. Watch the absorber's pressure gauge. Press the oxygen flush button to fill the bellows. When full the bellows may swell, but it must remain installed on the bellows base. The pressure gauge reading must not exceed 15 cm H₂O.
4. Examine the bellows and confirm that it is undamaged.
5. Release the oxygen flush button.
6. Watch the pressure gauge and adjust the oxygen flow from 200 mL/min to 10 L/min and back. The pressure reading must stay within the range of 1.0 cm H₂O and 5.0 cm H₂O. This tests the bellows assembly's pop-off valve.
7. Switch off the anesthesia machine. The bellows must not drop more than 100 mL per minute. If the bellows drops more than 100 mL per minute, either the bellows is leaking or the pop-off valve is not functioning properly.
8. If any leak cannot be corrected, do not use the ventilator; have a qualified service representative make repairs.
9. Remove any occlusions you have added to the system.

4.6 Testing The Ventilator Alarms

A. Testing The Low And High Oxygen Alarms

1. Set the inspiratory pressure limit to 40 cm H₂O
The ventilator displays: P_{MAX}=40 SUST=20
2. Remove the oxygen sensor probe from the absorber. Let the probe sit in room air at least two minutes before you move to the next step.

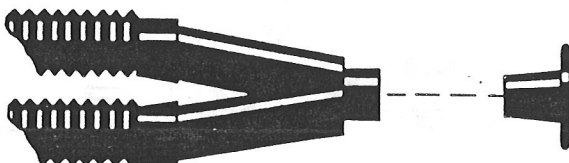


Figure 4-4
Occluding the "Y" Connector

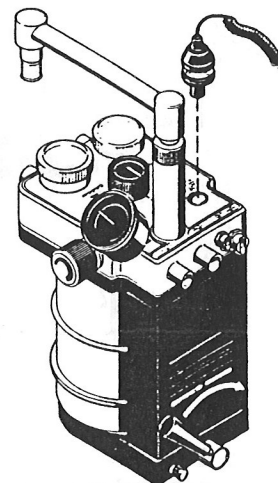


Figure 4-5
Removing the oxygen sensor from the absorber

4/Preoperative Checkout Procedures

3. Set the tidal volume dial to 200 mL.
4. Use the low-O₂ pushwheel to set the low O₂ alarm limit to 18 percent.
The ventilator displays: LOW O₂ LIMIT = 18%
5. Use the high-O₂ pushwheel to set the high O₂ alarm limit to 40 percent.
The ventilator displays: HI O₂ LIMIT = 40%
6. Adjust the O₂ Calibration dial until the O₂(%) display reads 21 percent.
7. Use the low-O₂ pushwheel to readjust the Low O₂ alarm limit to 22 percent.
The ventilator displays: LOW O₂ LIMIT = 22%
Within four seconds the ventilator will sound the warble tone, flash the red LED, and display the "LOW OXYGEN!" message.
The ventilator displays: LOW OXYGEN!
8. Now use the low-O₂ pushwheel to readjust the low O₂ alarm limit to 18 percent.
The ventilator displays: LOW O₂ LIMIT = 18%
Because you have resolved the alarm condition, the ventilator will cancel the low O₂ alarm within four seconds.
9. Use the high-O₂ pushwheel to readjust the high oxygen alarm limit to 20 percent.
The ventilator displays: HI O₂ LIMIT = 20%
Within four seconds the ventilator will sound the intermittent tone, flash the yellow LED, and display the "HIGH OXYGEN!" message.
The ventilator displays: HIGH OXYGEN!

10. Now use the high-O₂ pushwheel to readjust the high oxygen alarm limit to 22 percent.

The ventilator displays: HI O₂ LIMIT = 22%

The ventilator will cancel the high oxygen alarm within four seconds.

11. Use the high-O₂ pushwheel to readjust the high oxygen alarm limit to 40 percent.
The ventilator displays: HI O₂ LIMIT = 40%
12. Return the oxygen sensor probe to the absorber socket.
13. Perform the oxygen sensor calibration, as described in section 6.6, at least once a month. If you don't know when the sensor was last calibrated, do it now.

B. Testing The Low Minute Volume, Reverse Flow, And Apnea Alarms

1. Set the inspiratory pressure limit to 40 cm H₂O.
The ventilator displays: P_{MAX}=40 SUST=20
2. Set the tidal volume to 500 milliliters.
The ventilator displays: SET TV = 500 ML
3. Use the low VE pushwheel to set the Low VE alarm limit to 0.0 L/min.

The ventilator displays: MV LIMIT = 0.0 L

4. Set the anesthesia system's oxygen flow to 8 L/min.
5. Remove the volume sensor assembly, which includes the volume cartridge and sensor clip, from the breathing system.

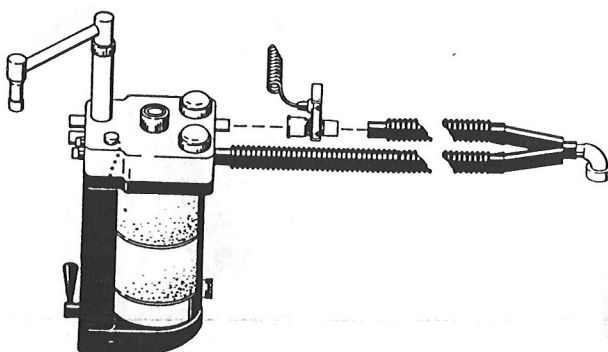


Figure 4-6
Removing the volume sensor cartridge from the expiratory limb of the patient circuit

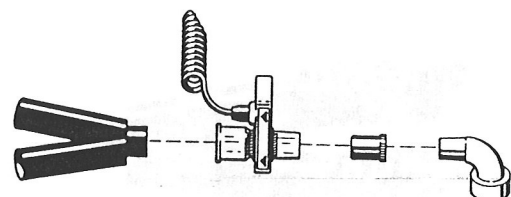


Figure 4-7
Removing the volume sensor cartridge from the distal position of the patient circuit

5/Operating The System

5.1 Preparing The System For Operation

A. Adjusting The Monitor Pod Viewing Angle

To adjust the monitor pod viewing angle:

1. Loosen the knob that is beneath the monitor pod.
2. Adjust the pod to the desired viewing angle.
3. Turn the knob clockwise to secure the pod.

B. Connecting The Optional Manual Blood Pressure Gauge Inflation System

If your system has an optional manual blood pressure gauge installed, insert the blood-pressure cuff connector into the Luer-Lok receptacle labelled "BP Gauge" on the patient interface panel.

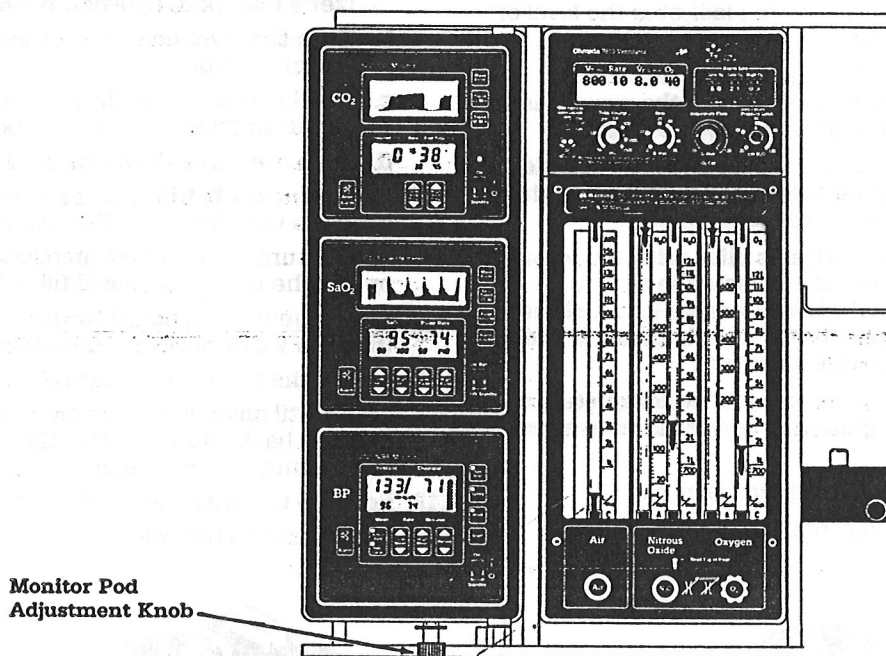


Figure 5-1
Adjusting the monitor pod's viewing angle

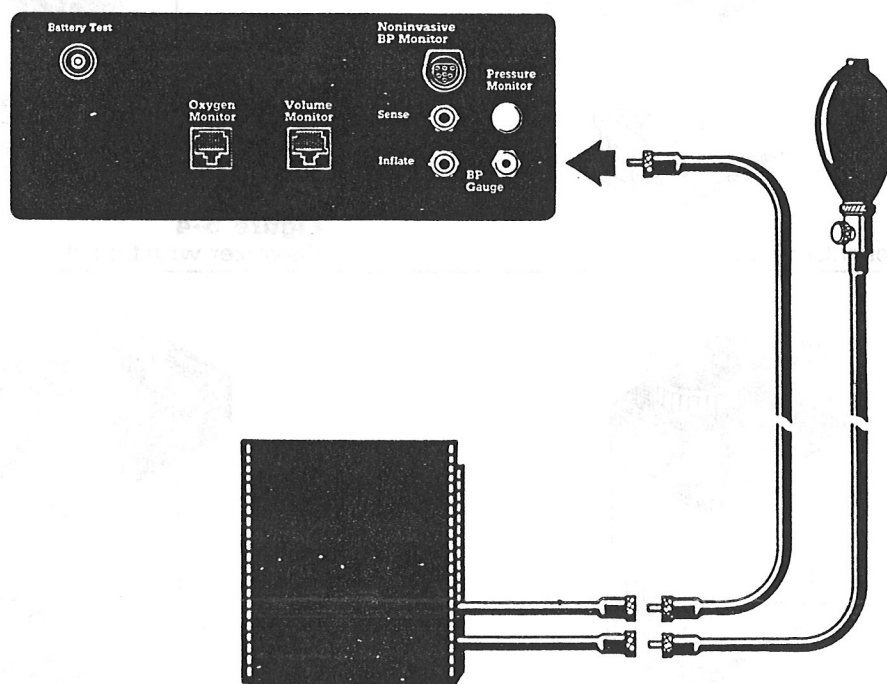


Figure 5-2
The optional manual blood pressure gauge inflation system

5/Operating The System

C. Filling The Vaporizers

Your Ohmeda Tec 4 Continuous Flow Vaporizers were built with one of two optional systems for introducing agent into the vaporizers. You will either use a keyed bottle adapter to inject agent through the vaporizer's keyed filler port, or you will pour agent into the vaporizer's funnel-fill port. Using the keyed port helps assure that the correct agent will be introduced to the vaporizer. For complete instructions on using the vaporizers, refer to the Ohmeda Tec 4 Continuous Flow Vaporizer operators manual.

A sight glass on each vaporizer indicates the level of agent in the vaporizer.

WARNING: Do not use flammable anesthetics. A possibility of explosion will exist if the system is used in the presence of flammable anesthetics.

WARNING: A vaporizer is calibrated and labeled for one agent only. Do not introduce any other than the designated agent into the vaporizer.

WARNING: If a vaporizer is filled with the wrong agent, draining will not eliminate the agent, because the wick will have absorbed some of the agent. The wick must be thoroughly cleaned and dried by trained service personnel.

CAUTION: The vaporizers must be completely upright for the sight glass to properly indicate agent levels.

To add agent through the keyed filler port:

1. Switch off the vaporizer.

2. A lever is on the left side of the vaporizer's filler port, which is on the front of the vaporizer. Turn this lever counterclockwise as far as it will go, but do not try to remove the lever. (See figure 5-5.)
3. Remove the cap of the agent bottle.
4. Insert a keyed bottle adapter into the bottle.
5. Turn the adapter clockwise until it is secure.
6. While you keep the agent bottle below the level of the filler port:
 - a. Insert the bottle's adapter tube into the vaporizer's filler port. (See figure 5-6.)
 - b. Turn the lever on the port's side until the adapter is locked in place.
 - c. A valve is on top of the filler port. Turn this valve counterclockwise until it is open.
 - d. Turn the valve clockwise until it is sealed.
7. Lift the agent bottle until it is tilted downward and is above the filler port. Wait five seconds.
8. Slowly turn the valve counterclockwise until it is open. The vaporizer should fill in less than a minute.
9. Once agent has reached the line on the sight glass, turn the valve clockwise until it is closed.
10. Lower the bottle below the filler port.
11. Wait until any agent remaining in the tube has drained back into the bottle, then turn the port's lever counterclockwise to release the adapter.
12. Remove the adapter tube from the port.
13. Retighten the port's lever.

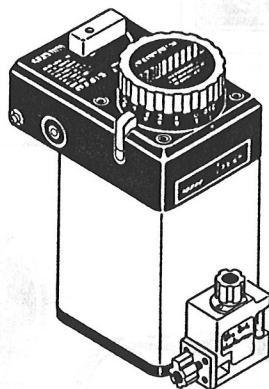


Figure 5-3
Vaporizer with keyed filler port

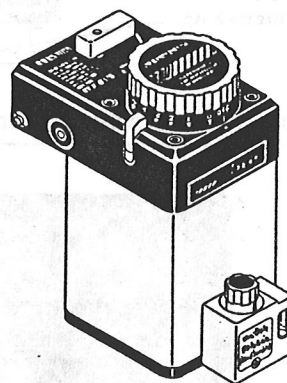


Figure 5-4
Vaporizer with funnel filler port

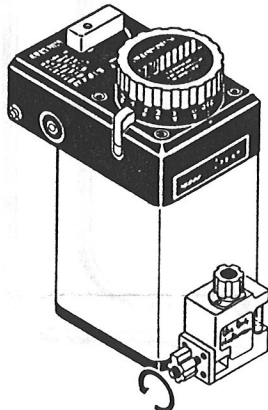


Figure 5-5
Opening a vaporizer's keyed filler port

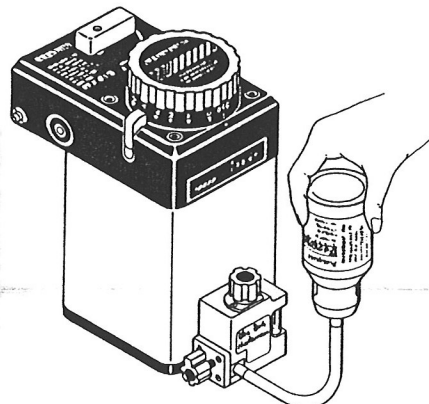


Figure 5-6
Filling a vaporizer through its keyed filler port

5/Operating The System

To add agent through the funnel-fill port:

1. Switch off the vaporizer.
2. A funnel-cap/valve is on top of the filler port. Turn this cap counterclockwise until you can remove it, exposing the built-in funnel in the port. (See figure 5-7.)
3. While touching the valve's stem with the agent bottle's lip, gradually pour the correct agent directly into the port until agent has almost reached the line on the sight glass. You must pour slowly to allow time for the vaporizer's wick to absorb agent.
4. Replace and tighten the funnel cap.

WARNING: Incomplete sealing of the vaporizer's funnel cap will result in loss of gases. To help prevent such loss, make sure the cap-sealing O-ring is in good condition and the funnel cap is securely tightened before using the vaporizer.

5.2 Powering The System On

A two-position system master switch located to the right of the pressure gauges controls electrical and pneumatic power to the system. When the switch is in its first position, both electrical and pneumatic power are off. In the second position, both electrical and pneumatic power are on.

Just left of the switch is the system's indicator panel, which provides information about the status of the system's electrical supply, battery condition, and oxygen supply.

When the switch is set to "Off": the panel's indicator lights are off; gas is not supplied to the flow-control circuits; electrical power is not supplied to the monitors or ventilator; but AC power is provided to the AC outlets on the back of the anesthesia machine.

When the switch is set to "On": the "Normal" indicator is lighted; gas is supplied to the machine's circuits; and electrical power is provided to the monitors and the AC outlets.

If the switch is set to "On" and the anesthesia machine's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, the "Mains" indicator will go out and the "Battery" indicator will be lighted. When the "Battery" indicator is lighted, the system is powered by its built-in backup battery, which is designed to temporarily provide power to allow the ventilator and its integrated oxygen, volume, and airway-pressure monitors to continue operating.

To power the system on:

1. Perform the preoperative checkout.
2. Turn all the gas flow control knobs completely clockwise.
3. Set the vaporizers to "Off."
4. Move the mechanical ventilation switch to "Off."
5. Move the system master switch to "On."

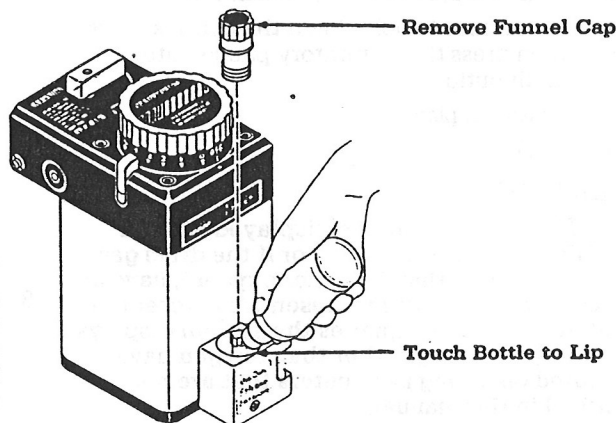


Figure 5-7

Filling a vaporizer through its funnel port

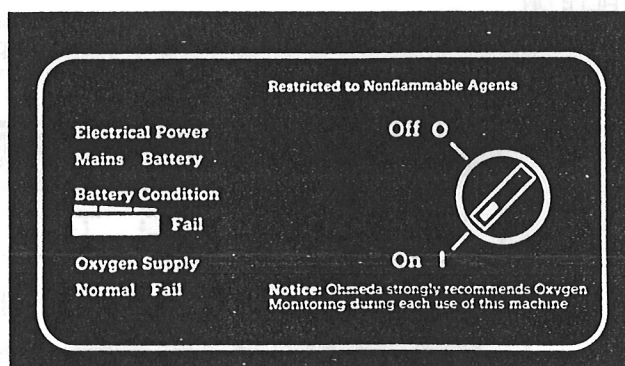


Figure 5-8

The system master switch

5/Operating The System

5.3 Using The Ventilator's Setup Page

In the Setup Page the front panel controls are used to set parameters not normally adjusted during a case, such as the screen contrast and the alarm volume. When you first enter the Setup Page, the ventilator displays the version number of the software it is using and the language selected. The ventilator then lets you adjust the status of the reverse flow alarm, the screen's contrast, the audio alarm volume, and the altitude setting. Except for the reverse flow alarm, which, if you want it disabled, must be manually switched off each time you power on the system, these parameter settings are saved even when the system is off. To adjust the setup parameters, turn the flow dial. To move from one parameter to the next, press the alarm silence button.

To exit the Setup Page, either repeatedly press the alarm silence button to move through all the steps or, before you reach the final Setup Page step, move the mechanical ventilation switch to "On." When the ventilator exits the Setup Page, it will first store any changes you've made, then it will exit the Setup Page and begin normal operation. As the ventilator exits the Setup Page it will beep once, blink the yellow LED, and display "CHECK SETTINGS!". Although you must press the inspiratory pause button to begin using the Setup Page, when the ventilator exits the Setup Page it also resets the inspiratory pause to its original state.

To use the Setup Page:

1. Move the mechanical ventilation switch to "Off."
2. If the anesthesia system is off, switch it on.
3. Press and continue to hold down the alarm silence button, then press the inspiratory pause button. Release both buttons.

The ventilator displays:

REV 2.x /O

ENGLISH STD.

CAUTION: If the language displayed is other than "ENGLISH-STANDARD," or if the drive gas displayed is other than "/O" (for oxygen), have an Ohmeda-trained service representative reset the ventilator. Certain languages the system displays and drive gas settings other than oxygen have associated operating parameters that are not described in this manual.

4. Press: Alarm Silence.

The ventilator displays:

FLOW KNOB TO SET

REVERSE ALM: ON

5. If you are using the volume sensor at the proximal end of the "Y" connector in the patient

breathing system, you may want to disable the reverse flow alarm, which, in that position, can be triggered by normal breathing. Do not disable the reverse flow alarm if the sensor is mounted in the distal position of the expiratory limb; in this position the alarm provides valuable information about possible breathing-system malfunctions. See section 2.5B for information about installing the volume sensor.

To disable the reverse flow alarm, turn the flow knob clockwise until the display changes to "Off." When you are ready to move to the next step,

Press: Alarm Silence.

The ventilator displays:

FLOW KNOB TO

SET CONTRAST: xx

6. If you want to adjust the LCD screen's contrast, turn the flow dial. As you turn the dial, the ventilator will show a one-to-ten scale that indicates the screen contrast that will be used during normal operation. For best results, set the room lighting to the level that will be used while you are operating the ventilator. When you are ready to move to the next step,

Press: Alarm Silence.

The audio alarm sounds continuously and the ventilator displays:

FLOW KNOB TO SET

AUDIO VOLUME: xx

7. If you want to adjust the audio alarm's volume level, turn the flow dial. The displayed number represents, on a scale of one to ten, the current volume level, which is also sounding. As you turn the dial, the ventilator will change the tone's volume and the displayed number to indicate the level that will be used during normal operation. When you are ready to move to the next step,

Press: Alarm Silence.

The ventilator silences the alarm and displays:

FLOW KNOB TO SET

ALTITUDE: xxxx M.

8. If you want to adjust the altitude compensation, turn the flow dial. As you turn the dial, the ventilator will display the altitude compensation that will be used during normal operation. When you are ready to move to the next step,

Press: Alarm Silence.

The ventilator beeps once, blinks the yellow LED, enters the Monitoring mode, and displays:

CHECK SETTINGS!

Any changes you selected are implemented, and the inspiratory pause button returns to the state it was in when you selected the Setup Page.

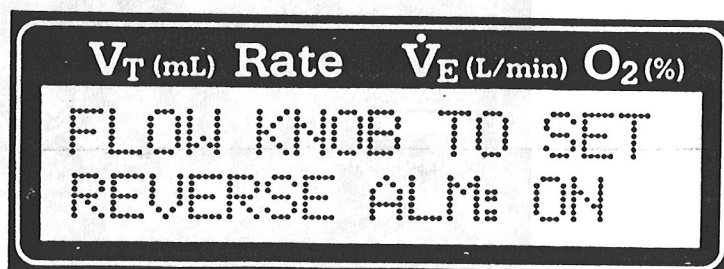


Figure 5-9
The ventilator's setup page

5/Operating The System

5.4 Setting The Alarm Limits

Use the three alarm-set pushwheels to change the low-minute-volume, low-oxygen and high-oxygen alarms' set points. To increase the value of an alarm set point, push the button directly over the digit you want to change. To decrease the value, push the button under the digit you are changing. Use the inspiratory pressure limit dial to set the inspiratory pressure limit and the sustained pressure limit. To adjust these limits, press the inspiratory pressure limit dial as you turn it.

Anytime you change the value of an alarm set point, the ventilator will display that alarm's value on the screen.

To set the alarm limits:

1. If the anesthesia system is off, move the mechanical ventilation switch to "Off" before moving the system master switch to "On."

2. Switch on the anesthesia system, if it is not on already.

The ventilator enters the Monitoring mode. Because the monitoring is active whenever the anesthesia system's power is on, some alarms may sound.

3. Use the low-VE pushwheel to set the low minute volume alarm limit. The low minute volume alarm limits are zero liters per minute to 9.9 liters per minute in 0.1 L/min increments.

WARNING: Always correctly set the low minute volume alarm and use CO₂ monitoring to aid in the detection of breathing system disconnections.

4. Use the low-O₂ pushwheel to set the low oxygen alarm limit. The low oxygen alarm limits are 18 percent to 99 percent in one percent increments.

Although all the digits can be physically set to zero, the ventilator will not accept low oxygen alarm limits of less than 18 percent. If you set the low oxygen alarm pushwheel to less than 18 percent, the ventilator will continue to use 18 percent for the low oxygen alarm's set point; and the ventilator will display a "LIMIT SET ERROR!" message.

5. Use the high-O₂ pushwheel to set the high oxygen alarm's limit. The high oxygen alarm's limits are 18 percent to 99 percent in one percent increments.

If you set the high-O₂ pushwheel to a level below or equal to the limit set by the low-O₂ pushwheel, the ventilator will display a "LIMIT SET ERROR!" message. However, the ventilator will continue to use the level shown on the high-O₂ pushwheel as the high oxygen alarm trigger point.

To disable the high oxygen alarm, set the high-O₂ pushwheel to "00"; setting the high-O₂ pushwheel to "00" will not generate a "LIMIT SET ERROR!" message.

6. Use the inspiratory pressure limit dial to set the inspiratory pressure limit and the sustained pressure limit.

Both the maximum inspiratory pressure and the sustained pressure alarm limits and pressure-release points are set by the inspiratory pressure limit dial, which must be pushed in while turned to change the settings; the ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit dial setting. For inspiratory pressure limits of 20 cm H₂O to 60 cm H₂O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H₂O, the sustained pressure limit will be 21 cm H₂O. However, any inspiratory pressure limit setting higher than 60 cm H₂O will result in a sustained pressure limit of 30 cm H₂O. For example, inspiratory pressure limits of 65 cm H₂O and 80 cm H₂O will both result in a sustained pressure limit of 30 cm H₂O.

As you push and turn the inspiratory pressure limit dial, the ventilator will display both the maximum pressure limit and the sustained pressure limit settings. However, unlike the other three control dials, just touching this dial will not generate a display.

If while the mechanical ventilation switch is off you set the inspired pressure limit for more than 60 cm H₂O, the ventilator will beep, light the yellow LED, and continually display the maximum pressure setting. This pressure limit message is displayed in the Monitoring mode only; during mechanical ventilation this reminder is disabled.

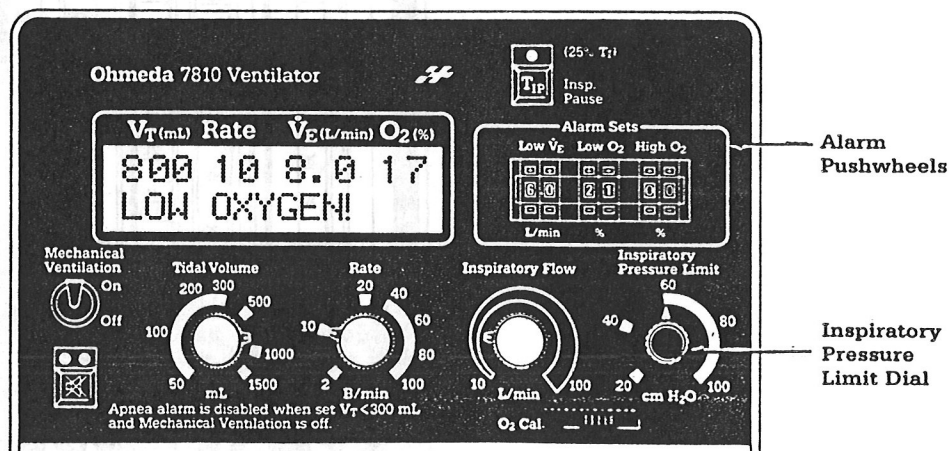


Figure 5-10
The alarm pushwheels and inspiratory pressure limit dial

5/Operating The System

In addition to the three alarms set by the pushwheels and the two alarms set by the inspiratory pressure limit dial, the ventilator also sets trigger points for certain alarms based on the positions of other front panel controls. These alarms include the low pressure alarm, the apnea alarm, and the reverse flow alarm.

The Low Pressure Alarm

The low pressure alarm activates if the airway pressure fails to change by a value the ventilator sets. This level of change depends on the settings of the tidal volume dial and the inspiratory flow dial.

The ventilator generates a low pressure alarm if the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow dial. The amount of pressure change required to prevent an alarm from triggering will vary between 4 cm H₂O to 9 cm H₂O to correspond to the inspiratory range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 L/min, the low pressure alarm will activate if the airway pressure doesn't change by at least 5.1 cm H₂O. But if the inspiratory flow is set to 80 L/min, the airway pressure must change by at least 7.9 cm H₂O to keep the alarm from activating.

Unlike the other alarms, the low pressure alarm is active only when mechanical ventilation is switched on.

The Apnea Alarm

The apnea alarm is keyed to the tidal volume dial's setting and the position of the mechanical ventilation switch. When the tidal volume dial is set to less than 300 mL and the mechanical ventilation switch is off, the apnea alarm is disabled. If you have set the front panel controls to disable the apnea alarm, the ventilator alerts you by constantly displaying the "APNEA

ALARM OFF!" message. To enable the apnea alarm when in the Monitoring mode, set the tidal volume dial to 300 mL or more.

The Reverse Flow Alarm

The reverse flow alarm is tied to the tidal volume level regardless of the mechanical ventilation switch's position. If the tidal volume dial is set to 300 mL or more, an alarm will activate if the ventilator senses 100 mL or more reverse flow. If the tidal volume dial is set to less than 300 mL, 20 mL or more reverse flow will trigger an alarm.

WARNING: The reverse flow alarm will function correctly only if the volume sensor cartridge is working correctly and is properly placed in the distal position of the expiratory limb of the breathing system.

5.5 Setting The Gas Flow

Each gas included on your anesthesia machine is controlled by a single flow control valve. These flow control valves, which are above the pressure gauges and below the flowmeters, are marked with the symbols for the gases they control, and are color coded to match the backgrounds of the corresponding pressure gauges and flowmeters. So that you can identify it by touch, the knob for oxygen is fluted. The knobs for nitrous oxide and, when included, a third gas are etched with a finer, cross-hatch pattern.

The Ohmeda Link 25 Proportion Limiting Control System connects the oxygen and nitrous-oxide flow-control valves. This system is designed both to ensure that any oxygen/nitrous-oxide mixture includes a minimum of about 25-percent oxygen, and to help prevent the oxygen flow from dropping below 200 mL/min (or 50 mL/min when the low-flow option is installed).

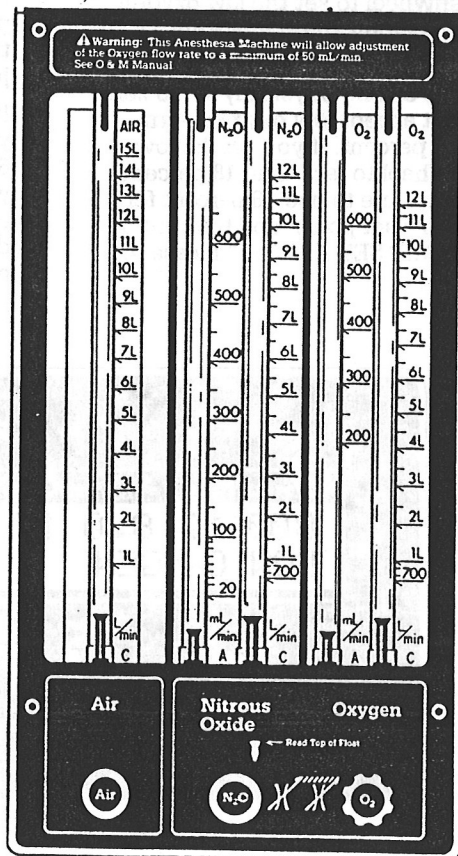


Figure 5-11

The flow control knobs and flowmeters

5/Operating The System

WARNING: The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen/nitrous-oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. *Hypoxic mixtures may be delivered if gases other than oxygen, nitrous oxide and/or air are used, or when operating at low oxygen flow rates.* When using carbon dioxide, helium or nitrogen as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

Flowmeters for each gas included in your system are mounted directly above the corresponding flow control valves. The backgrounds of these flowmeters are color coded to match the pressure gauges and control valves. When you are using a flowmeter, read across the top of the meter's float, which is inside the flowmeter's tube, to the scale to the immediate right of the float.

To set the gas flow:

1. Switch the system on as described in section 5.2. Do not set the gas flow while the system is off.
2. Turn the control knob for the gas whose level you want to set. Read across the top of the flowmeters' floats.

5.6 Setting The Vaporizers

For complete instructions on using the vaporizers, refer to the Ohmeda Tec 4 Continuous Flow Vaporizer Operators Manual.

1. Check that the vaporizers are securely installed, as described in section 2.6.C.
2. Check the agent level shown in the vaporizer's sight glass. If the agent is below the fill line, fill the vaporizer as described in section 5.1.C.
3. Set the carrier gas flow as described in section 5.5.
4. Press the vaporizer's control-release button and turn the dial to the setting you want to use. (See figure 5-12.)

5.7 Setting The Ventilation Parameters, Beginning Ventilation

Set the ventilation parameters before moving the mechanical ventilation switch to "On." Because we recommend that you set the ventilator's controls starting on the left and moving to the right, these instructions describe setting the ventilator's controls from left to right. You can, however, adjust the front panel dials in any order and independently. If you do adjust either the tidal volume dial or rate dial without also adjusting the inspiratory flow dial, touch the inspiratory flow dial to check the new I:E ratio.

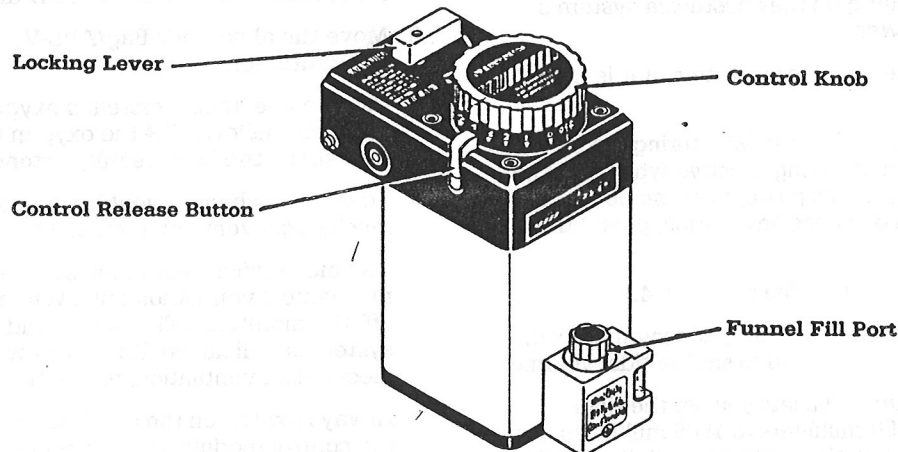


Figure 5-12
Vaporizer controls

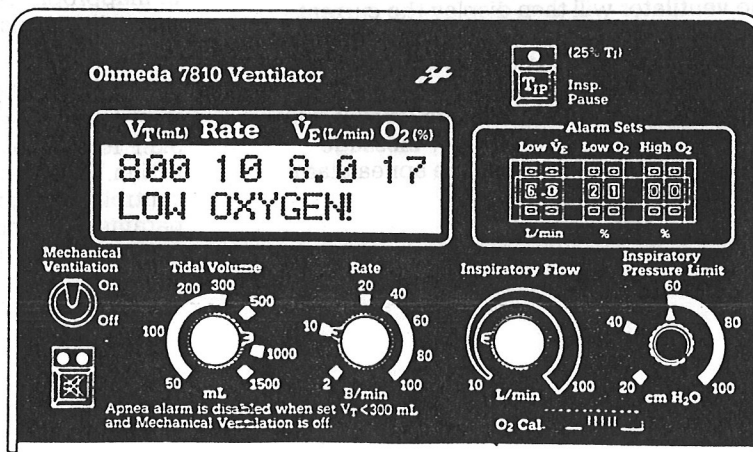


Figure 5-13
The control module's front panel

5/Operating The System

It is possible to adjust the controls for a combination of settings that will result in a level the ventilator cannot deliver. If the combination of settings results in a level the ventilator is not designed to deliver, a "VENT SET ERROR!" alarm will be displayed. See section 3.3.E for a description of the range of control settings.

The measured tidal volume indicated on the screen may be different than the level you set on the tidal volume dial. Under pressure gases compress and certain breathing system components expand, which results in some loss of tidal volume in the breathing system. Also, any fresh gas introduced to the system will be measured by the volume sensor in addition to the gas the bellows assembly delivers. For instructions on calculating these breathing system losses and gains, see section 3.3.F.

You don't, however, have to manually calculate the compliance effect to compensate for compliance losses. With the volume sensor correctly connected in the breathing system, adjust the tidal volume dial until the tidal-volume reading on the ventilator's screen indicates the level you want to use.

To set the ventilation parameters and begin mechanical ventilation:

1. Before connecting the ventilator to a patient, perform the Preoperative Checkout Procedures described in section 4.
2. Move the mechanical ventilation switch to "Off" before switching on the anesthesia system's electrical power.
3. Switch on the anesthesia system, if it is not on already.

The ventilator enters the Monitoring mode. Because the monitoring is active whenever the anesthesia system's power is on, some alarms may sound. To silence any alarms, press Alarm Silence.

4. Set the alarm limits. (See section 5.4.)
5. While the mechanical ventilation switch is off, use the tidal volume dial to set the tidal volume.

The tidal volume dial lets you set the tidal volume from 50 milliliters to 1500 milliliters. As you turn the dial, the ventilator will display the tidal volume setting. To check the tidal volume setting without changing its value, just touch the dial; the ventilator will then display the current tidal volume setting. Until the ventilator senses sufficient volume to indicate a breath, it will display "VOL MON STANDBY!" Once the ventilator senses a sufficient volume level, it will remove the "VOL MON STANDBY!" message and start the timer that controls the apnea alarm.

If, however, while the mechanical ventilation switch is off, you set the tidal volume to less than 300 mL, the ventilator will disable the apnea alarm. Once the ventilator removes the "VOL MON STANDBY!" message—after an activation breath—the ventilator will display the "APNEA ALARM OFF!" message. If you want the apnea alarm enabled when the ventilator is in the Monitoring mode, set the tidal volume dial to 300 mL or higher.

6. Use the rate dial to set the mechanical breath rate.

Turning the rate dial changes the breath rate used for mechanical ventilation and displays the rate. The rate's range is two breaths per minute to 100 breaths per minute in whole number increments. Touching the rate dial will display the current rate on the screen.

7. Use the inspiratory flow dial to set the inspiratory flow rate.

The inspiratory flow dial lets you set the inspiratory flow rate, which is continuously variable from 10 liters per minute to 100 liters per minute. Whenever you adjust or just touch the inspiratory flow dial, the ventilator will display the current I:E ratio, which the ventilator calculates based on the set inspiratory flow, tidal volume, and breath rate. Adjusting any of these parameters will change the I:E ratio; to check the current I:E ratio, touch the inspiratory flow dial.

8. Move the absorber's Bag/APL-Ventilator switch to "Ventilator."
9. Use the anesthesia system's oxygen flush valve to fill the bellows. Set the oxygen flow to a level that keeps the bellows fully extended.
10. To start mechanical ventilation, move the mechanical ventilation switch to "On."

The mechanical ventilation switch controls mechanical ventilation only. When the switch is off, the monitors still function and the alarm system is still active. When you want to start mechanical ventilation, move the switch to "On."

Always switch on the anesthesia system and set the control module's front panel controls before switching on the ventilator. Switching on the ventilator before setting the controls may result in inappropriate ventilation of the patient and may trip alarms that relate to mechanical ventilation.

11. Once the ventilator is mechanically ventilating the patient, check the tidal volume. (See section 3.3.F for information about tidal volume compensation.) If necessary, adjust the front panel controls to modify the ventilator's operating parameters. You can adjust any of the front panel controls while the ventilator is on.

5/Operating The System

5.8 Adjusting The Scavenging Interface Needle Valve

When you are using the Ohmeda waste gas scavenging interface valve assembly with a high-vacuum disposal system, you must adjust the assembly's needle valve to prevent the reservoir bag from filling to capacity.

1. Set the gas flow as described in section 5.5.
2. Adjust the assembly's needle valve so the reservoir bag oscillates between half-full and completely collapsed during each normal breathing cycle. (See figure 5-14.)
3. If the vacuum level for your scavenging system changes, readjust the assembly's needle valve.

5.9 Responding To Alarms

These sections describe the alarms and alarm messages the system may display. Although we have provided recommendations on how to resolve messages directly related to the system's operation, only the clinician can determine what to do when an alarm relates to the patient's condition. The first step when any alarm sounds is to check the patient. Then, to resolve the alarm, follow the steps listed below.

WARNING: If an alarm condition cannot be resolved, do not continue to use the system.

A. Responding To Anesthesia Machine Alarms

Responding to an electrical disconnect/failure alarm

If the anesthesia machine's AC power supply fails or is disconnected, the system will sound a warbling intermittent alarm and will flash the "Battery" indicator to the left of the master switch. If AC power is lost, the system's built-in backup battery will temporarily provide power to provide backup power to the ventilator and its integrated oxygen, volume, and circuit-pressure monitors. The battery, however, will not power any equipment plugged into the electrical pod outlets, the light panel, the Record Keeper (if installed), or optional monitors.

If the Electrical Disconnect/Failure Alarm activates:

1. Continue normal operation; the backup battery will allow you to continue for about one hour with mechanical ventilation. To extend the operating time, discontinue mechanical ventilation.
2. Make sure the system power cord has not been disconnected.
3. Resolve the cause of the power failure.

Responding to an oxygen supply failure alarm

If the oxygen supply pressure drops below 28 psig (193 kPa), the system will sound the oxygen supply alarm continuously and light the oxygen supply "Fail" indicator. If oxygen pressure then drops below 20 psig (138 kPa), the system will shut off the nitrous-oxide and optional, third-gas supplies. The oxygen supply failure alarm also will sound briefly when you switch on the system.

If the oxygen supply failure alarm sounds:

1. Open the reserve oxygen cylinder.
2. Switch off mechanical ventilation until the oxygen supply is restored.
3. Switch to the Bag/APL mode and use manual ventilation.
4. Check the oxygen pipeline gauge.
5. Check the oxygen pipeline for disconnections.

B. Responding To Ventilator Alarms

Responding To An APNEA xxx SEC. Message

If for 30 seconds the ventilator doesn't detect enough volume in the breathing system, an apnea alarm will be generated. The alarm message will indicate the number of seconds that have passed since flow was last detected. The tone will warble once at 30 seconds, twice at 60 seconds, and three times at 90 seconds. At 120 seconds the tone will warble continuously and the screen will display "APNEA ***" only.

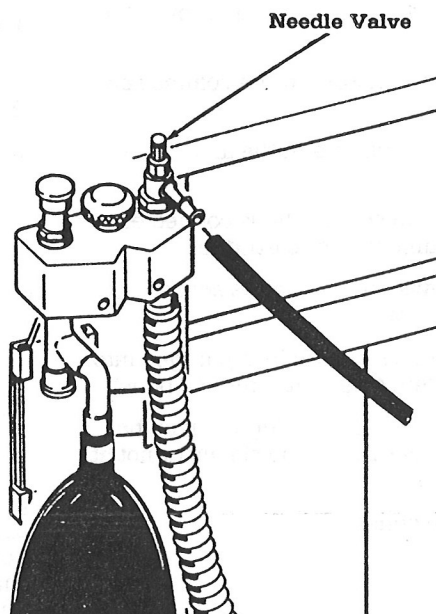


Figure 5-14
Adjusting the scavenging interface valve

5/Operating The System

The ventilator uses the volume-sensing circuits to activate the apnea alarm. When the ventilator is first switched on it displays the "VOL MON STANDBY!" message to indicate that the apnea and low minute volume alarms are not enabled. Then, once the ventilator senses a sufficient volume level, it removes the "VOL MON STANDBY!" message and starts a timer that controls the apnea alarm. Each time the ventilator senses sufficient volume, it resets this apnea timer.

The actual volume threshold required to start or reset the apnea timer varies depending on the level you set on the tidal volume dial. For tidal volume settings between 180 mL and 400 mL, the threshold varies linearly from 20 mL to 100 mL. For tidal volume settings below 180 mL, the threshold is always 20 mL. And for tidal volume settings above 400 mL, the threshold is always 100 mL.

For example, if the tidal volume dial is set to 250 mL, and mechanical ventilation is switched on, the timer starts and is reset when the ventilator senses a breath of at least 46 mL. If you then increase the tidal volume dial to 320 mL, the ventilator will increase the threshold to 71 mL. In either case, if the timer reaches 30 seconds (because the ventilator didn't sense enough volume to indicate a breath), the first in the series of four apnea alarms will sound.

Since the ventilator uses the volume-sensing circuits to determine if an apnea condition exists, problems with the volume sensor cartridge or clip can trigger an apnea alarm, as can disconnections in the breathing system.

WARNING: If you remove the sensor clip from the volume sensor cartridge before switching on the anesthesia system, the apnea alarms will be inoperative. Do not use the ventilator without the sensor clip properly attached to the volume sensor cartridge.

If the apnea alarm activates:

1. Check the patient.
2. Check for disconnections in the patient breathing system.
3. Check for excessive moisture in the volume sensor cartridge.
4. Check for excessive moisture in the absorber's check valves.
5. Make sure the volume sensor clip is connected securely to the volume sensor cartridge.
6. Make sure the arrows on the volume sensor clip point toward the absorber.
7. Make sure the volume sensor clip is plugged into the anesthesia system's patient interface panel.
8. Replace the volume sensor cartridge. It may be worn out if its rotor is turning too slowly or not at all. (See section 6.3.)
9. Replace the volume sensor clip.

Responding To A LOW OXYGEN! Message

If the ventilator detects an oxygen concentration lower than the one you set using the low-O₂ pushwheel, the ventilator will generate a low oxygen alarm.

If a low oxygen alarm activates:

1. Check the patient.
2. Check the anesthesia system's flowmeter settings. Are they set correctly?
3. Check the anesthesia system's pressure gauges.
4. Check the low-O₂ alarm limit. Is it set correctly?
5. Check the oxygen supply.
6. Check the oxygen sensor assembly for damage.
7. Make sure the oxygen sensor is inserted securely into the absorber oxygen port.
8. Make sure the oxygen sensor is plugged into the anesthesia system's patient interface panel.
9. Check the oxygen-sensor cartridge's surface for excessive moisture.
10. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, an oxide coating may have built up on the sensor's surface. Connecting the sensor through the patient interface panel to the control module will eventually remove this coating. However, up to 12 hours may be required to free the sensor's surface of oxide build-up.
11. Replace the oxygen-sensor cartridge. It may be worn out. (See section 6.5.)

Responding To A HIGH OXYGEN! Message

If the ventilator detects an oxygen concentration equal to or higher than the one you set using the high-O₂ pushwheel, the ventilator will generate a high oxygen alarm.

If the high oxygen alarm activates:

1. Check the high-O₂ alarm limit. Is it set correctly?
2. Check the anesthesia system settings.
3. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, an oxide coating may have built up on the sensor's surface. Connecting the sensor through the patient interface panel to the control module will eventually remove this coating. However, up to 12 hours may be required to free the sensor's surface of oxide build-up.

Responding To A HIGH PRESSURE! Message

If, during mechanical ventilation or while in the Monitoring mode, the ventilator detects airway pressure higher than the limit you set using the inspiratory pressure limit dial, the ventilator will generate a high pressure alarm. And, during mechanical ventilation only, the ventilator will also terminate the inspiratory cycle.

5/Operating The System

If the high pressure alarm activates:

1. Check the patient.
2. Check for a blockage in the patient breathing system.
3. Check the inspiratory pressure limit dial. Is it set correctly?
4. Check for moisture in the sensing line that connects the absorber to the ventilator's control module.

5. Check for kinks in the pressure sensing line.

Responding To A LOW PRESSURE! Message

The ventilator generates a low pressure alarm if, for at least 20 seconds, the airway pressure fails to change by a value that varies proportionally to the setting of the inspiratory flow dial. The amount of airway-pressure change required to prevent an alarm from triggering will vary between 4 cm H₂O to 9 cm H₂O to correspond to the inspiratory flow range of 10 liters per minute to 100 liters per minute. For example, if the inspiratory flow is set to 30 L/min, the low pressure alarm will activate if the airway pressure doesn't change by at least 5.1 cm H₂O. But if the inspiratory flow is set to 80 L/min, the airway pressure must change by at least 7.9 cm H₂O to keep the alarm from activating.

Unlike the other alarms, the low pressure alarm is active only when mechanical ventilation is switched on.

If the low pressure alarm activates:

1. Check the patient.
2. Check the breathing system for leaks or disconnections.
3. Check for leaks or disconnections in the sensing tube that connects the absorber to the barbed connector on the control module's rear panel.
4. Check for kinks in the pressure-sensing line.
5. Is the patient breathing spontaneously? During mechanical ventilation spontaneous breathing may trip this alarm.

Responding To A SUSTAINED PRES! Message

The ventilator sets the sustained pressure limit to correspond to the inspiratory pressure limit dial setting. For inspiratory pressure limits of 20 cm H₂O to 60 cm H₂O, the ventilator sets the sustained pressure limit to one half the inspiratory pressure limit. For example, if the inspiratory pressure limit is 42 cm H₂O, the sustained pressure limit will be 21 cm H₂O. However, any inspiratory pressure limit setting of more than 60 cm H₂O will result in a sustained pressure limit of 30 cm H₂O. For example, inspiratory pressure limits of 65 cm H₂O and 80 cm H₂O will both result in a sustained pressure limit of 30 cm H₂O.

Anytime the sustained airway pressure exceeds—for 15 seconds or more—the sustained pressure limit set by the inspiratory pressure limit dial, the ventilator will generate a sustained pressure alarm.

If the Sustained Pressure alarm activates:

1. Check the patient.
2. Check for kinks or blockages in the breathing tubes.
3. Check to make sure the absorber's Bag/APL-Ventilator Valve is in the correct position.

Responding To A SUB-ATMOS. PRES! Message

If the ventilator detects airway pressure of less than -10 cm H₂O, it will generate a subatmospheric pressure alarm. For example, airway pressure of -12 cm H₂O will cause an alarm.

If the Subatmospheric Pressure alarm activates:

1. Check for inadvertent vacuum hook-ups to the patient breathing system.
2. Check for kinks or occlusions in the breathing system.
3. The inspiratory check valve in the absorber may be stuck. Check the inspiratory check valve.
4. Is the patient breathing spontaneously? During mechanical ventilation spontaneous breathing may trip this alarm.
5. Check the gas-scavenging system for excessive vacuum.

Responding To A LOW MINUTE VOL! Message

If the ventilator senses that the minute volume is less than the level you set using the low-MV pushwheel, the ventilator will generate an alarm. However, whenever you adjust the tidal volume dial, the rate dial, or the mechanical ventilation switch, or when you exit volume monitor standby, the ventilator will disable the low minute volume alarm for 40 seconds.

If the low minute volume alarm activates:

1. Check the patient.
2. Check the low-VE alarm limit. Is it set correctly?
3. Check for breathing tube disconnections.
4. Check for excessive moisture in the volume sensor cartridge.
5. Check for excessive moisture in the absorber's check valves.
6. Make sure the volume sensor clip is connected securely to the volume sensor cartridge.
7. Make sure the arrows on the volume sensor clip point toward the absorber.
8. Make sure the volume sensor clip is plugged into the anesthesia system's patient interface panel.
9. Replace the volume sensor cartridge. It may be worn out if its rotor is turning too slowly or not at all. (See section 6.3.)
10. Replace the volume sensor clip.

5/Operating The System

Responding To A LOW BATTERY! Or POWER FAIL! Message

Two sources can power the control module: the Ohmeda Modulus II Plus Anesthesia System's DC power supply, and the system's backup battery. If the anesthesia system's DC power supply fails, either because of an electronic failure or because the anesthesia system's AC power is lost, then its backup battery takes over. The battery supplies 12 volts, which a device in the anesthesia system converts to five volts for the ventilator to use.

If the voltage from the anesthesia system drops to 4.7 VDC or less, the ventilator will generate a "LOW BATTERY!" alarm. Pressing the alarm silence button will permanently silence the alarm tone; however, the LED will remain lighted and the alarm message will still appear.

If the voltage then drops to 4.6 VDC or less, the system will generate a "POWER FAIL!" alarm, which will alternate with the low battery alarm. And, within a minute, the ventilator will generate the "VENT FAIL. 5!" alarm, which indicates the voltage supplied is insufficient for mechanical ventilation. While this ventilator failure 5 message is displayed, the ventilator's oxygen, airway-pressure, and volume monitors will continue to operate. But mechanical ventilation is disabled whenever this ventilator failure message is displayed.

If the low-battery or power-failure alarm activates:

1. Begin manual ventilation.
2. Switch to an alternative ventilator.
3. After the case, leave the anesthesia system plugged in with the system master switch set to "On" for at least 12 hours to recharge the battery; then test the battery as described in section 4.10.

Responding To A LIMIT SET ERROR! Message

If you attempt to set the high oxygen alarm limit for a level below or equal to the low oxygen limit, the ventilator will generate a limit setting error alarm. This alarm will also be generated if you attempt to set the low oxygen alarm limit for less than 18 percent.

If the limit setting error alarm activates:

1. Reset the alarm limits to acceptable values.

Responding To A VENT SET ERROR! Message

If you attempt to set a combination of the inspiratory-flow, tidal-volume and rate controls that results in a level the ventilator is not designed to deliver, the ventilator will continue to use the most recent acceptable settings, and will generate a ventilator setting error alarm until the control combination is corrected. For example, a tidal volume of 500 mL, combined with a rate of 20 B/min, and an inspiratory flow of 10 L/min will trigger a ventilator setting error. To remove the error, either decrease the tidal volume setting, or decrease the rate setting, or increase the flow setting.

If the ventilator setting error alarm activates:

1. Readjust the ventilator's controls within the ventilator's operating limits.

Responding To A CHECK O₂ PROBE! CHECK GAS SUPPLY Message

If the ventilator doesn't detect any oxygen, it assumes the oxygen probe has failed, and it generates an alarm. An alarm will also be generated if the probe isn't connected correctly, if the probe is broken, or if no oxygen is in the area of the probe.

If the Check O₂ Probe/Check Gas Supply Message is displayed:

1. Check the oxygen supply.
2. Make sure the oxygen sensor is plugged into the anesthesia system's patient interface panel.
3. Check the oxygen-sensor cartridge's surface for excessive moisture.
4. Has the oxygen sensor been left unplugged from the patient interface panel? If it has, or if the control module has been left disconnected from the panel, an oxide coating may have built up on the sensor's surface. Connecting the sensor to the patient interface panel will eventually remove this coating. However, up to 12 hours may be required to free the sensor's surface of oxide build-up.
5. Replace the oxygen-sensor cartridge. It may be worn out. (See section 6.5.)

Responding To A REVERSE FLOW! Message

If the ventilator senses an unacceptable level of reverse flow in the patient breathing system, it generates an alarm. The level of reverse flow that will trigger a reverse flow alarm depends on the tidal volume you set. If you set the tidal volume control for less than 300 mL, then 20 mL or more reverse flow will trigger an alarm. However, if you set the tidal volume control for 300 mL or more, the ventilator will allow up to 100 mL of reverse flow before triggering an alarm.

The reverse flow alarm is intended to warn you of inadvertent reverse flow conditions, such as those caused by a defective or sticking exhalation check valve. These kinds of conditions will be detected only when the volume sensor is correctly placed at the distal position of the expiratory limb of the breathing system. If you place the volume sensor at the proximal end of the "Y" connector, volume monitoring will still function. However, when the volume sensor is located at the proximal position, a reverse-flow condition will occur each time the patient inhales and the reverse flow alarm will activate for each breath. To disable the reverse flow alarm, select "REVERSE ALARM: OFF" from the Setup Page (See section 5.3).

5/Operating The System

If the Reverse Flow Alarm activates:

1. Make sure the volume sensor assembly is in the expiratory limb of the patient breathing system. If the sensor is in the expiratory limb, check the exhalation valve; its disk may be sticking.
2. Make sure the arrows on the volume sensor clip point toward the absorber.

Responding To A LOW SUPPLY PRES! Message

If the ventilator supply gas pressure is less than 22 psig, the ventilator generates a low supply pressure alarm.

If the low supply pressure alarm activates:

1. Check the oxygen-supply pressure.
2. Switch to oxygen cylinder use, if necessary.

Responding To A VENT. FAIL x! or DRIVE CKT. OPEN! Message

The number in the ventilator failure message—such as “VENT. FAIL 8!”—will correspond to the specific type of failure that has occurred, in this case a gas inlet valve failure. If a ventilator failure alarm does occur, pressing the alarm silence button will permanently silence the alarm tone, although the yellow LED and alarm message will remain on, and the ventilator will not function. During some ventilator failure alarms the ventilator’s built-in monitors will continue to function. Mechanical ventilation, however, will be disabled whenever any ventilator failure message—except the messages for ventilator failures 6, 8, and drive gas circuit open—is displayed.

Ventilator failure messages can indicate anything from a defective IC chip to excessive pressure in the ventilator’s driving gas supply. Although the ventilator’s monitors may continue to operate, mechanical ventilation is disabled when ventilator failure messages are displayed; do not attempt to use the ventilator while a ventilator failure message is displayed. One type of ventilator failure—exhalation valve failure—does not display a numbered message; instead “DRIVE CKT. OPEN!” is displayed. This message will also appear if, during mechanical ventilation, the absorber’s Bag/APL-Ventilation switch is in the “Bag/APL” position.

Some ventilator failure alarm conditions may be caused by transitory electrical interference that devices such as electrocautery instruments can generate. Although the ventilator will disable mechanical ventilation during most ventilator failure alarms, during certain of these alarms, whose causes may be transitory, the ventilator will continuously attempt to reset its circuits for correct operation. If the ventilator successfully resets its circuits, it will remove the alarm message and resume normal operation.

WARNING: The use of electrosurgical units or other devices that radiate high-intensity electrical fields can affect the operation of the ventilator and monitors attached to the patient. Maintain as much distance as possible between the electrosurgical leads and the cables to the flow and oxygen sensors. Do not drape the electrosurgical leads across the absorber or the anesthesia machine.

Do not let the electrosurgical leads rest on any surface of the anesthesia system. Constant surveillance of all monitoring and life support equipment is mandatory whenever electrosurgical devices are in operation, on, or in the vicinity of the patient.

WARNING: Ventilator failure messages indicate that a problem exists in the ventilator. Do not attempt to use the ventilator while a ventilator failure message is displayed.

If the ventilator failure 4 (supply gas pressure more than 30 psig) alarm activates:

1. Have the ventilator supply gas regulator checked.

If the ventilator failure 5 (anesthesia system power failure and battery less than 4.7 VDC) alarm activates:

1. Check the anesthesia system’s power cord.
2. Check the anesthesia system’s circuit breaker.
3. Check the power connections between the control module and the anesthesia system.
4. After the case, leave the anesthesia system plugged in with the system master switch set to “On” for at least 12 hours to recharge the battery; then test the battery as described in section 4.10.

Refer to the Troubleshooting Guide, section 7.2, for more information about ventilator failure messages.

Responding To An APNEA ALARM OFF! Message

Because very low flow levels that are not sufficient to trigger the volume-sensing circuits may occur in spontaneously breathing patients, the ventilator disables the apnea alarm when the tidal volume dial is set to less than 300 mL and mechanical ventilation is switched off. Whenever tidal volume is set to less than 300 mL and the ventilator switch is off, the ventilator, once it has detected a breath, will display “APNEA ALARM OFF!” To enable the apnea alarm system while the patient is breathing spontaneously, increase the tidal volume dial to 300 mL or more. Although you should always carefully set the low minute volume alarm limit to enable the low minute volume alarm at an appropriate level, the low minute volume alarm is especially important when the tidal volume dial is set to less than 300 mL, disabling the apnea alarm.

If the “APNEA ALARM OFF!” message is displayed:

1. This is normal if the tidal volume dial is set below 300 mL and the mechanical ventilation switch is set to “Off.”

Responding To A MAX. PRESS=xxx CM Message

Anytime you adjust the inspiratory pressure limit dial, the ventilator will briefly display the pressure limit in centimeters of water. However, if the ventilator is in the Monitoring mode and the inspiratory pressure limit is set to 60 or more, the ventilator will also light the yellow alarm LED and will continually display the “MAX. PRESS=xxx CM” message. This pressure limit reminder is displayed in the Monitoring mode only; during mechanical ventilation the reminder is disabled.

5/Operating The System

Responding When ----- Is Displayed For The Tidal Volume Reading

If during mechanical ventilation the system does not sense any volume for two consecutive breaths, the system assumes the volume sensor is disconnected or damaged. However, the system does not send a volume sensor failure message. Instead it displays, on the top line, dashes in place of the tidal volume reading.

If the ventilator indicates a volume sensor failure:

1. Check the connections between the volume sensor cartridge and the sensor clip.
2. Make sure the sensor clip is plugged into the anesthesia system's patient interface panel.
3. Check for obstructions in the volume-sensor cartridge that may be preventing the cartridge vanes from spinning.

Responding When The Alarm Silence Button Will Not Silence The Alarm

Certain electronic failures may be so significant as to cause the system to lose the ability to generate ventilator failure messages even though the ventilator has failed. If such a serious failure occurs, the alarm silence button will not silence the alarm. Do not attempt to use the ventilator if this type of failure occurs.

WARNING: Do not attempt to use the ventilator if the alarm silence button will not silence alarms.

If the alarm won't silence:

1. Ventilate the patient manually.
2. Switch to a functioning system.

Responding When VOL MON STANDBY! Is Displayed

When the mechanical ventilation switch is off—when the ventilator is in its Monitoring mode—pressing the alarm silence button cancels and resets the apnea and low minute volume alarms; the "VOL MON STANDBY!" message will be displayed and these two alarms will not sound again even if these alarm conditions continue. However, if the ventilator senses another breath, the alarm timers and sensor circuits will again be activated and any alarm condition that occurs will trigger an appropriate alarm.

Responding When ??? Is Displayed In Place Of VE, VT, Or Rate Readings

Certain combinations of ventilator front panel control settings can result in ventilation conditions the ventilator can deliver but the volume sensor cannot measure. If you attempt to set a combination of the controls that results in a level the ventilator is not designed to deliver, the ventilator will generate a ventilator setting error alarm. If you set a control combination the ventilator can deliver, but the volume monitor cannot measure, or if—in the monitoring mode—breathing occurs that the monitor cannot measure, the ventilator will display question marks in place of the VT, VE, and rate readings.

5.10 Shutting Down The System

After using the Ohmeda Modulus II Plus Anesthesia System:

1. Move the system master switch to "On."
2. Make sure all vaporizers are switched off.
3. Remove the patient circuit from the absorber.
4. Close all of the flow controls.
5. Disconnect all of the pipeline supplies.
6. Open the cylinder valves.
7. Fully open the flow control valve for air or the third gas, if installed.
8. Fully open the flow control valve for nitrous oxide.
9. Fully open the flow control valve for oxygen.
10. Close the third gas's cylinder valve. Before moving to the next step, wait until the float in the flowmeter for the third gas drops to the bottom of its tube.
11. Close the nitrous-oxide cylinder valve. Before moving to the next step, wait until the float in the nitrous-oxide flowmeter drops to the bottom of its tube.
12. Close the oxygen cylinder valve. The low pressure alarm will sound. Before moving to the next step, wait until the float in the oxygen flowmeter drops to the bottom of its tube.
13. Move the system master switch to "Off."
14. Close all of the flow control valves.
15. Make sure the system's monitors are not in the battery mode.
16. Unplug the system's electrical power cord from the hospital-grade outlet.

6/Maintaining The System

6.1 Maintenance Schedule

Cleaning:

| | |
|--|-------|
| Painted Areas | Daily |
| Stainless Steel and Chrome | Daily |
| Anodized Aluminum | Daily |
| Clear Plastic Areas | Daily |
| Rubber and Plastic Components of the Frame | Daily |

Lubrication:

| | |
|-----------------------|-------------|
| Yoke tee Handle | As required |
|-----------------------|-------------|

Replacement:

| | |
|-----------------------|-----------------|
| Strainer Nipple | Yearly |
| Battery | Every two years |

6.2 Cleaning And Sterilizing

This chart is provided for quick reference once you are familiar with the cleaning and sterilization of the system. Refer to the following sections for cleaning-and-sterilization details. Use a cleaning and sterilization schedule that conforms to your institution's sterilization and risk-management policies.

| ITEM | TO CLEAN | TO STERILIZE |
|--|-----------------------------------|---|
| Ventilator Control Module | mild detergent | n/a |
| Bellows Assembly | mild detergent | ethylene oxide |
| Volume Sensor Assembly | damp cloth | disinfectant |
| Volume Sensor Cartridge | damp cloth | ethylene oxide |
| Oxygen Sensor Probe Housing | damp cloth | ethylene oxide |
| Oxygen Sensor Cartridge | white vinegar, isopropyl alcohol | ethylene oxide |
| Painted Areas | damp cloth, soap | n/a |
| Stainless Steel, Chrome | damp cloth, Bon Ami™ | n/a |
| Anodized Aluminum | damp cloth, Bon Ami | n/a |
| Clear Plastic Areas | damp cloth | n/a |
| Rubber, Plastic | damp cloth, mild alkali detergent | cold germicidal detergent, ethylene oxide |
| Scavenging Interface Relief Valve Manifold | soap and water | ethylene oxide |

A. Cleaning The Control Module

Clean the exterior surfaces of the control module with a soft, lint-free cloth lightly moistened in a solution of mild liquid detergent.

CAUTION: Use cleaning solution sparingly. Do not saturate system components. Excessive solution can damage internal devices.

CAUTION: Do not cover the system with any type of fabric or plastic covering. These types of coverings can generate static charges that may damage the equipment.

B. Cleaning And Sterilizing The Bellows Assembly

Because of the temperature difference between exhaled patient gases and the room environment, water droplets may form in the breathing system. This droplet formation, which is normal, will be particularly noticeable in the bellows and bellows base. Periodically clean and sterilize the bellows assembly to reduce the risk of cross-infection and to help keep the ventilator working properly. The bellows is an expendable item; replace the bellows periodically or when it shows any sign of damage.

CAUTION: The bases for the adult and pediatric bellows assemblies use different seals and are not interchangeable. Do not mix parts for these two assemblies. Interchanging parts for these assemblies may cause the bellows assembly to malfunction.

WARNING: Sterilize the bellows assembly periodically to minimize the risk of cross-infecting patients. Use a sterilization schedule that complies with your institution's infection-control and risk-management policies. Use Ohmeda-approved sterilization methods.

CAUTION: Perform the Preoperative Checkout Procedure after cleaning and sterilizing the bellows assembly.

To disassemble the bellows assembly:

1. Remove all hose connections from the bellows assembly.

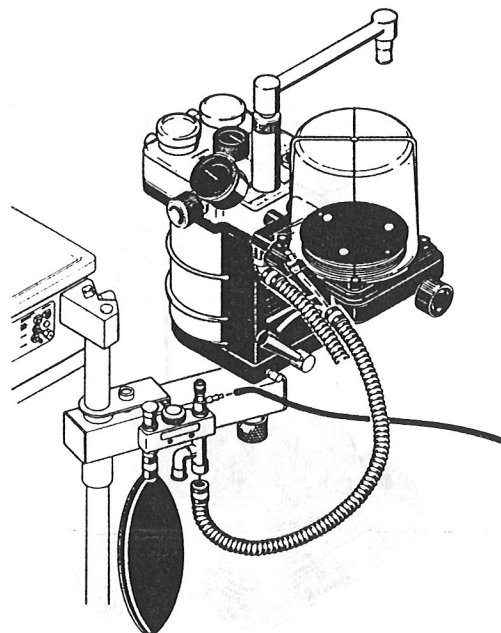


Figure 6-1

Disconnecting hoses from the bellows assembly

6/Maintaining The System

2. Detach the bellows assembly from the Ohmeda GMS Absorber:
 - a. Turn the locking knob counterclockwise until the locking rod releases.
 - b. Hold the entire assembly firmly and slide the support guides off the support pins.
3. To remove the adult bellows housing, grasp it and rotate the housing counterclockwise, then lift the housing off the bellows assembly's base.

To remove the pediatric bellows housing, remove the four thumbscrews that attach the bellows

assembly to the base. Then lift the housing off the bellows assembly's base.

4. Use figure 6-5 (adult bellows) or figure 6-6 (pediatric bellows) as a guide if you need to disassemble the bellows assembly further for cleaning or sterilization.

Before reassembling the bellows assembly, check all of the rubber parts—including the bellows—for swelling, tackiness, holes, cracking, or any other signs of damage. Rubber devices, which deteriorate, are expendable items and must be replaced periodically.

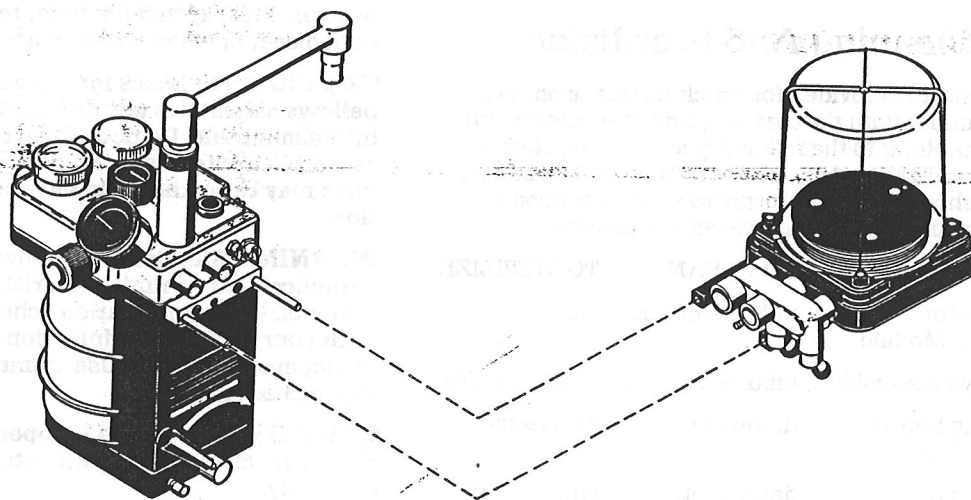


Figure 6-2

Detaching the bellows assembly from the absorber

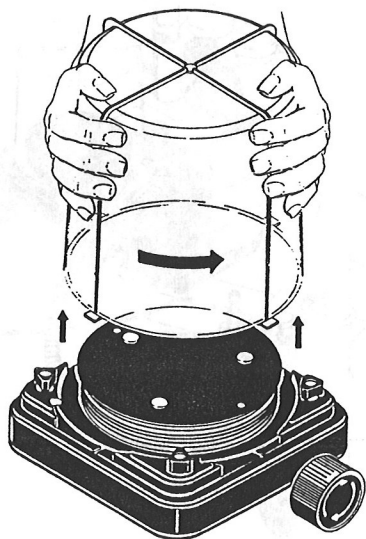


Figure 6-3

Removing the adult bellows housing

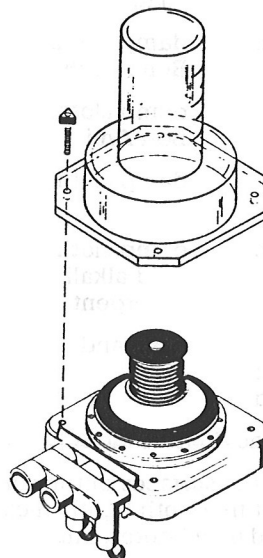


Figure 6-4

Removing the pediatric bellows housing

6/Maintaining The System

To clean the bellows housing, bellows, pressure-sensing tube, pop-off valve, bellows base, and interface manifold:

1. Wash the bellows housing in a mild soap-and-water solution. Use cold water to thoroughly rinse the housing of all soap. Dry the housing with a soft, lint-free cloth.
2. Wash the bellows (and—in the pediatric bellows only—the base and ring (see figure 6-6)) in a mild soap-and-water solution. Use cold water to thoroughly rinse the bellows of all soap. Remove excess water from the bellows, then hang the bellows, suspended by its top disk, to dry for at least 12 hours.

The bellows must be allowed to dry completely; moisture remaining in the folds of the bellows may make the bellows tacky, which will cause the bellows to operate improperly.

3. Wash the pressure-sensing tube with a mild soap-and-water solution. Use cold water to thoroughly rinse the tube of all soap. Remove all soap and water from inside the tube. Dry the tube thoroughly.
4. Do not immerse the pop-off valve in liquid. Immersion can trap liquids in the valve, which will impair the valve's performance. Clean the valve's exterior surfaces with a soft cloth dampened with a solution of warm water and mild, liquid detergent. Do not allow liquid to enter the drive-gas port (see figure 6-5). Dampen a clean, soft cloth in cold water and use the cloth to wipe the valve clean. Let the valve dry completely before either use or sterilization.

WARNING: Liquids or any foreign materials trapped in the driving-gas circuit of the pop-off valve or the bellows base can impair the valve's operation. Do not use the bellows assembly if you suspect that materials are trapped. Have the assembly repaired by trained service personnel.

5. Do not immerse the bellows base in liquid. Immersion can trap liquids in the driving gas circuit of the base, which will impair the bellows assembly's performance. Clean the base's exterior surfaces with a soft cloth dampened by a solution of warm water and mild, liquid detergent. Do not allow liquid to enter the drive-gas ports (see figure 6-5). A bottle brush may be used to clean the ports labeled "To Anesthesia Machine" and "Exhaust." The 17-mm "Inlet" port is normally exposed to only oxygen and shouldn't need cleaning. Use a clean cloth or bottle brush dampened in cold water to remove all traces of soap from the bellows base. Let the base dry completely before either use or sterilization.

WARNING: Liquids or any foreign materials trapped in the driving-gas circuit of the pop-off valve or the bellows base can impair the valve's operation. Do not use the pop-off valve or bellows base if you suspect that materials are trapped. Have the assembly repaired by trained service personnel.

6. Wash the interface manifold with a mild soap-and-water solution. Use cold water to thoroughly rinse the manifold of all soap. Dry the interface manifold thoroughly.
7. Before reassembling the bellows assembly, check all of the rubber parts—including the bellows—for swelling, tackiness, holes, cracking, or any other signs of damage. Rubber devices, which deteriorate, are expendable items and must be replaced periodically.

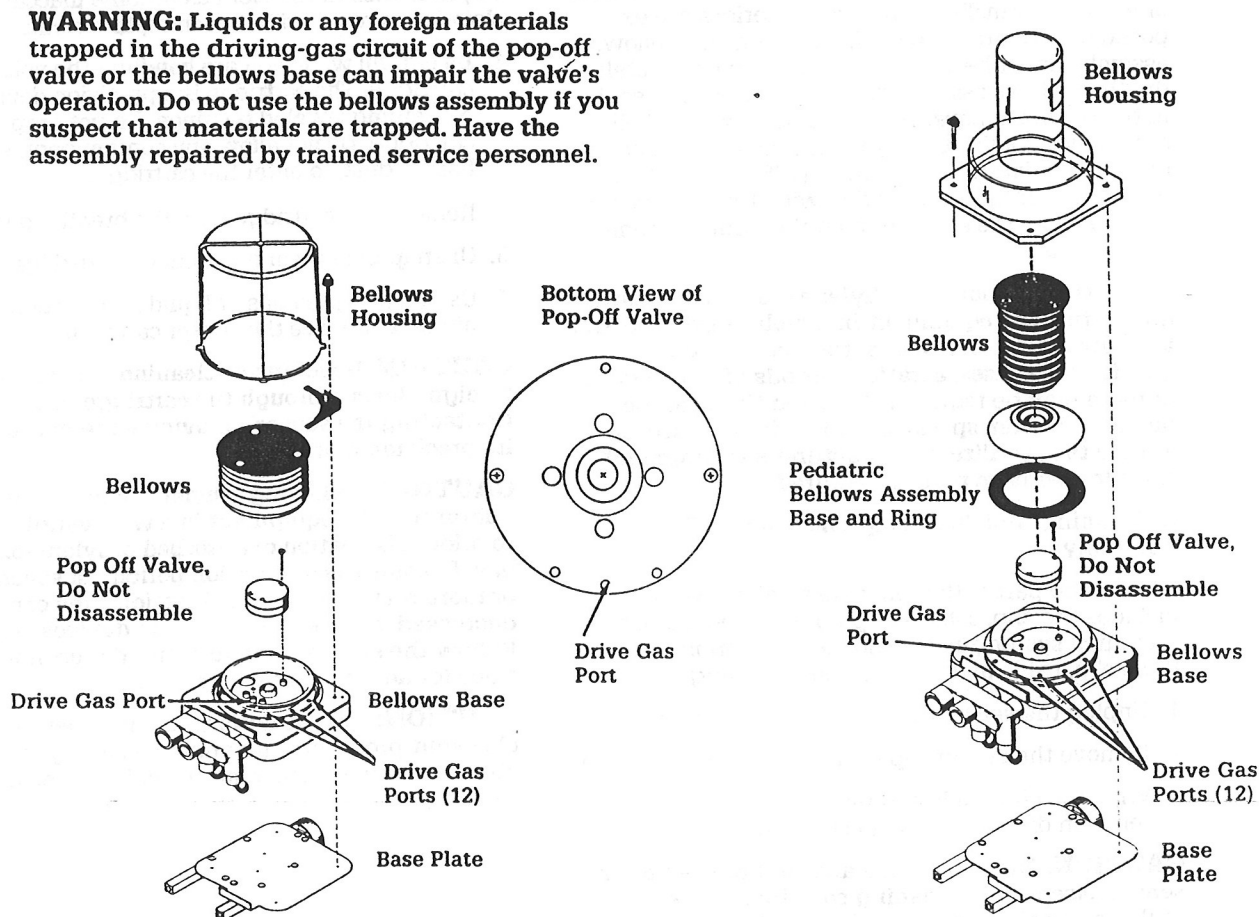


Figure 6-5

Adult and pediatric bellows assemblies, exploded view

6/Maintaining The System

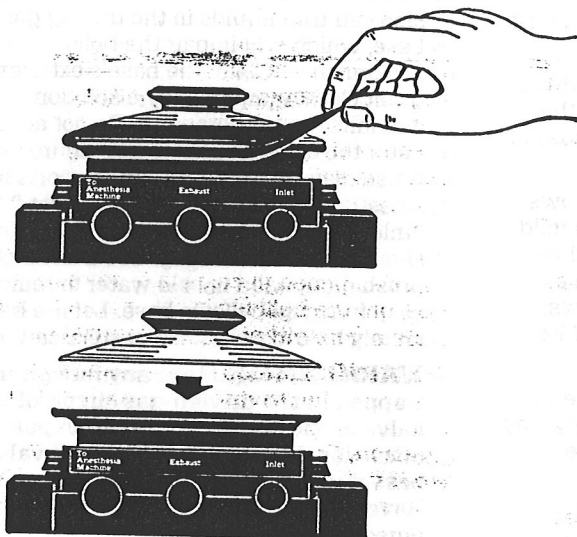


Figure 6-6

Removing the pediatric bellows assembly's base ring

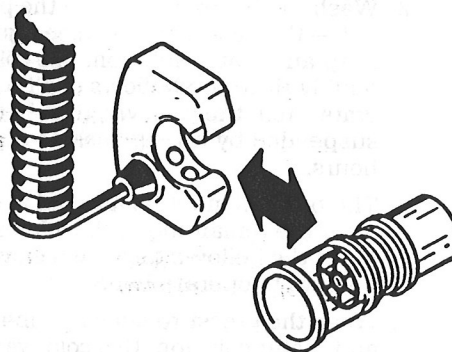


Figure 6-7

Disconnecting the volume sensor cartridge from its clip

To sterilize the bellows housing, bellows, pop-off valve, pressure-sensing tube, bellows base, and interface manifold:

The adult and pediatric clear-plastic bellows housings require sterilization only if the bellows has torn or leaked. Normally the bellows exteriors are exposed only to driving gas. If, however, the bellows assembly must be sterilized, wash and completely dry the bellows assembly's components as described in the previous steps. To further sterilize the bellows assembly's components, you may also use an ethylene oxide mixture at 52 to 57°C (125 to 135°F), or room temperature sterilization with 100% ethylene oxide. Follow the sterilizer manufacturer's recommendations.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

C. Cleaning And Sterilizing The Volume Sensor Clip Assembly

Because no part of the sensor assembly—which includes the clip, cable and plug—is exposed to the breathing system, usually no sterilization is required. If the clip, cable and plug do need cleaning:

1. Unplug the sensor from the control module.
2. Remove the sensor clip from the volume cartridge.
3. Wipe the clip, cable and plug with a cloth moistened in disinfectant (cold sterilizing agent).

CAUTION: Never immerse any part of the volume sensor assembly in cleaning solution. Immersion will destroy the clip's electrical contacts.

D. Cleaning And Sterilizing The Volume Sensor Cartridge

Replace the sensor cartridge at least every thirty days, or when the volume sensor checkout (section 6.3) indicates the sensor has become inaccurate. If cleaning is required between replacements:

1. Be careful while you are handling the volume cartridge. The cartridge is a precision device containing jeweled bearings. Do not drop the cartridge. Do not allow any contaminant, such as hair or dust, to enter the cartridge.
2. Remove the cartridge from the breathing system.
3. Unsnap the sensor clip from the cartridge.
4. Use an accepted gas or liquid sterilization technique to sterilize the sensor cartridge.

CAUTION: Never insert cleaning brushes or other foreign objects through the cartridge vanes. Contacting the sensor's moving vane may damage its precision movement.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

CAUTION: Always perform the preoperative checkout procedures for volume sensing functions after cleaning or replacing the volume sensor cartridge.

6/Maintaining The System

E. Cleaning And Sterilizing The Oxygen Sensor Assembly

Because the probe section of the probe housing is the only part of the sensor assembly exposed to the breathing system, it is normally the only section of the assembly that must be sterilized. However, it is possible, though unlikely, that a defective cartridge will leak potassium hydroxide, which is used as an electrolyte, into the sensor housing. Discard any leaking cartridge immediately, then, before installing a new cartridge, clean or replace the sensor housing, as described in the next section.

WARNING: Defective oxygen-sensor cartridges may leak potassium hydroxide, which is caustic. Use care when handling oxygen-sensor cartridges. Do not use any oxygen-sensor cartridge that shows signs of leaking. If you get the potassium hydroxide solution in your eyes, immediately flush with water, then seek medical attention.

1. Disconnect the oxygen sensor probe's plug from the anesthesia system's patient interface panel.
2. Remove the sensor probe from the absorber.

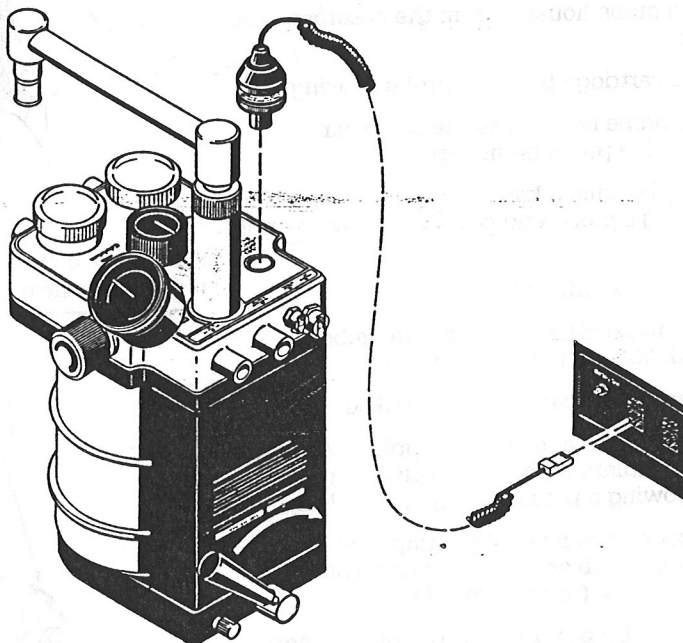


Figure 6-8

Disconnecting the oxygen sensor from the absorber and patient interface panel

3. If the probe housing, cable and plug need cleaning, wipe them with a cloth moistened in disinfectant (cold sterilizing agent).
4. Use only room-temperature, ethylene-oxide sterilization to sterilize the probe section.
5. Place the probe in a well-ventilated area to let any absorbed ethylene oxide dissipate.
6. If you want to clean or sterilize the sensor cartridge, refer to the next section.
7. Reinsert the sensor into the absorber.
8. Reconnect the sensor probe to the anesthesia machine's patient interface panel.

9. Calibrate the oxygen sensor as described in section 6.6.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

CAUTION: Never immerse any part of the oxygen sensor assembly in cleaning solution. Immersion will destroy the sensor cartridge's electrical contacts.

6/Maintaining The System

F. Cleaning And Sterilizing The Oxygen Sensor Cartridge

The sensor cartridge should be replaced at regular intervals as explained in section 6.4. If cleaning is required between replacements, first remove the cartridge from the probe housing, then carefully clean and sterilize the cartridge.

It is possible, though unlikely, that a defective cartridge will leak potassium hydroxide, which is used as an electrolyte, into the sensor housing. Discard any leaking cartridge immediately, then, before installing a new cartridge, clean or replace the sensor housing, as described in the next section.

1. Disconnect the oxygen-sensor probe's plug from the anesthesia machine's patient interface panel.
 2. Remove the probe housing from the absorber. (See figure 6-8.)
 3. Remove the cartridge from the probe housing:
 - a. Hold the probe housing so the cable hangs down and the probe points up.
 - b. Grasp the housing's knurled surfaces and turn the housing's probe end counterclockwise until it is free.
 - c. Set the probe section aside.
 - d. Lift the sensor cartridge out of the probe's cable end. (See figures 6-9 and 6-10.)
 4. If the oxygen-sensor cartridge has leaked:
 - a. Wear latex gloves and safety goggles, and work in a well-ventilated area, when cleaning the probe following a potassium hydroxide leak.
 - b. Using a cotton swab slightly dampened in white vinegar, rub accumulated oxide off the circular contacts. (See figure 6-11.)
- WARNING:** Do not inhale any fumes generated by the oxygen-sensor cleaning procedure. Such fumes can cause respiratory system or skin damage. This material is caustic.
- c. Use a clean cotton swab, liquid soap, and water to clean all of the surfaces inside the probe housing.
 - d. Thoroughly clean and dry the entire probe.
 - e. Remove the two O-rings from the probe housing. Both of these O-rings are located in the section of the probe that contacts the absorber.
 - f. Inspect the probe housing for damage. If necessary, replace the housing.
 - g. Install a new internal O-ring, part #0210-0499-300, into the probe housing.
 - h. Install a new external O-ring, part #0210-0503-300.
 - i. Open a new cartridge, then move to step 8.
5. To clean the cartridge use a cloth moistened in distilled water or isopropyl alcohol to remove salt deposits and dirt accumulation.
 6. To sterilize the sensor cartridge, use room-temperature ethylene oxide.

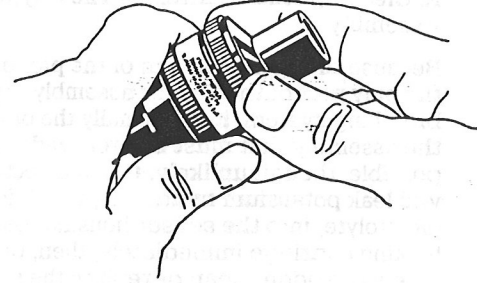


Figure 6-9
Opening the oxygen sensor

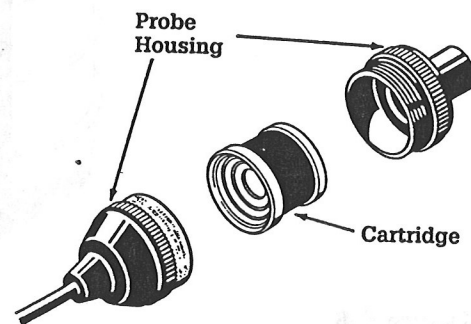


Figure 6-10
Oxygen sensor, exploded view

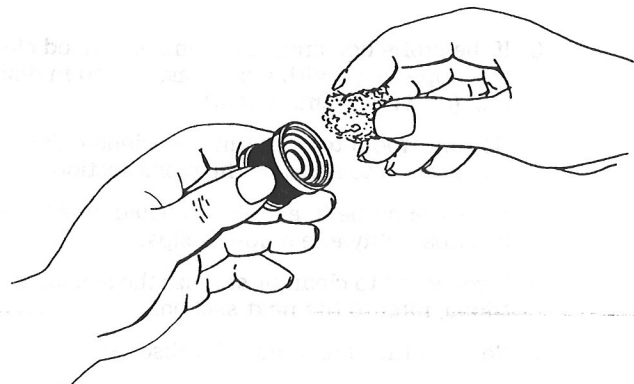


Figure 6-11
Cleaning the oxygen-sensor cartridge

6/Maintaining The System

7. Place the cartridge in a well-ventilated area to let any absorbed ethylene oxide dissipate.
8. Reinsert the cartridge:
 - a. Hold the probe housing so the cable hangs down and the probe points up.
 - b. Reinsert the cartridge so its screen faces out of the housing, and so the three metallic, concentric rings at its other end contact the gold-colored terminals at the cable end of the probe housing.
 - c. Thread the housing's probe section back onto the cable section.
 - d. Turn the probe section until it is finger tight. Make sure the sections are tight enough to compress the housing's O-rings, which form a gas-tight seal.
9. Reinsert the sensor into the absorber.
10. Reconnect the sensor probe to the patient interface panel.
11. Calibrate the oxygen sensor as described in section 6.6.

WARNING: Defective oxygen-sensor cartridges may leak potassium hydroxide, which is caustic. Use care when handling oxygen-sensor cartridges. Do not use any oxygen-sensor cartridge that shows signs of leaking. If you get the potassium hydroxide solution in your eyes, immediately flush with water, then seek medical attention.

CAUTION: Do not use cold sterilization, solvents or cleaning agents to clean the oxygen-sensor cartridge. These substances may damage the oxygen-sensor cartridge.

CAUTION: Following ethylene oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

CAUTION: Never immerse any part of the oxygen sensor assembly in cleaning solution. Immersion will destroy the sensor's electrical contacts.

G. Cleaning The Anesthesia Machine

Painted Areas:

Clean painted or enameled surfaces using a damp cloth and mild soap. Do not use abrasive cleansers; abrasive cleaners may scratch the paint.

Stainless Steel And Chrome:

Clean stainless steel and chrome surfaces using a damp cloth. For stubborn stains, apply Bon Ami™ on a damp cloth, and scrub.

Anodized Aluminum:

Clean anodized aluminum surfaces using Bon Ami on a damp cloth. Do not use abrasive cleansers; they can mar the finish.

Clear Plastic Areas

Clean clear plastic surfaces using a soft, clean cloth,

dampened slightly in warm, clean water. To prevent spotting, immediately dry the surface with a soft, clean cloth. Cleaning agents (abrasive and non-abrasive), glass cleaners, and anesthetic agents will mar or damage the plastic.

Rubber And Plastic Components

Clean rubber and plastic components of the frame using a soft cloth and warm water. If necessary, a mild, alkali detergent may be used to remove stains.

The Care and Cleaning of Rubber Articles

Rubber goods, whether natural or synthetic, deteriorate over a period of time, and therefore must be considered as expendable items that are subject to periodic replacement. The presence of oxygen, ozone, ether, mineral or vegetable oils, phenols, cresols, terpenes, hydrocarbon solvents, chlorinated-hydrocarbon solvents, chlorinated hydrocarbons, esters, or oxidizing acids will hasten the deterioration.

Rubber articles should be checked often for swelling, tackiness, or cracking. When any of these are evident, the affected parts should be replaced.

Conductive rubber goods lose their electrical conductivity with age. National Fire Protection Association (NFPA) regulations (pamphlets number 56A) state the requirements for rubber conductivity.

The useful life of rubber articles can be prolonged by following a program of intelligent use and care. Hospital personnel should carefully review the following suggestions:

1. Remove metal connectors immediately after use.
2. When possible, store rubber articles in the dark, away from sources of ozone generation, such as fluorescent lighting fixtures, electric motors, and diathermy machines.

WARNING: Talc, zinc stearate, calcium carbonate, or corn starch that have been used to prevent tackiness of rubber articles could contaminate a patient's respiratory tract.

H. Sterilizing The Anesthesia Machine

Cold Sterilization:

Rubber goods may be washed with a mild, alkali detergent and sterilized in a cold, germicidal solution, intended for use with water. Always follow the sterilizing agent manufacturer's recommendations.

Steam Sterilization:

Do not steam sterilize the Ohmeda Modulus II Plus Anesthesia System.

Gas Sterilization:

For sterilizing rubber goods, ethylene oxide at 52 to 57°C (125-135°F) can be used. Room temperature sterilization is also effective: expose rubber goods to 100% ethylene oxide for 12 hours.

CAUTION: Following ethylene-oxide sterilization, quarantine the equipment in a well-ventilated area to allow dissipation of absorbed ethylene-oxide gas. In some cases, aeration periods of seven days or more may be required. Aeration time can be decreased when special aeration devices are used. Follow the sterilizer manufacturer's recommendations for aeration periods required.

6/Maintaining The System

I. Cleaning The Scavenging Interface Relief Valve

To clean the positive-and-negative relief valve, disassemble the interface valve assembly by removing the connectors from its four ports. Do not disassemble the relief valve. Clean the parts in soap and water; an ultrasonic bath may be used. Do not use any cleansing agent that contains abrasive materials. Rinse the parts with clean water and dry thoroughly. Then reassemble the interface valve assembly. (See figure 6-12.)

To lubricate the needle valve, use only an approved, oxygen-service lubricant. A small amount on the threaded portion is all that is needed.

WARNING: Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote™ is the recommended oxygen service lubricant (Stock number 0220-0091-300).

WARNING: After performing any maintenance or repair procedure, always verify proper operation of the Ohmeda waste gas scavenging interface valve.

6.3 Checking The Volume Sensor

This volume-sensing checkout procedure, which you should perform before each case, tests both the sensor cartridge and the sensor assembly. If the checkout fails, replace the volume cartridge, then repeat the procedure. If the checkout still fails after you replace the cartridge, replace the sensor assembly and repeat the test again.

To check volume sensing:

1. Move the ventilator's mechanical ventilation switch to "On."
2. Move the anesthesia system's master switch to "On."
3. Set the tidal volume to 500 mL.
4. Remove the volume sensor assembly, with the cartridge attached to the sensing clip, from the breathing system. (See figures 6-13 and 6-14.)

5. Fit the cartridge over the anesthesia system's common gas outlet. The arrows on the sensor clip must point away from the common gas outlet.
6. Adjust oxygen flow to eight liters per minute.
7. Wait at least 70 seconds.
8. VE on the control module's screen must read between 6.0 and 10.
9. Reinstall the sensor cartridge into the patient breathing system either between the absorber's exhalation port and the beginning of the expiratory limb, or at the proximal end of the "Y" connector. The arrows on the sensor must point in the direction of gas flow during expiration; the arrows must point toward the absorber and away from the patient.

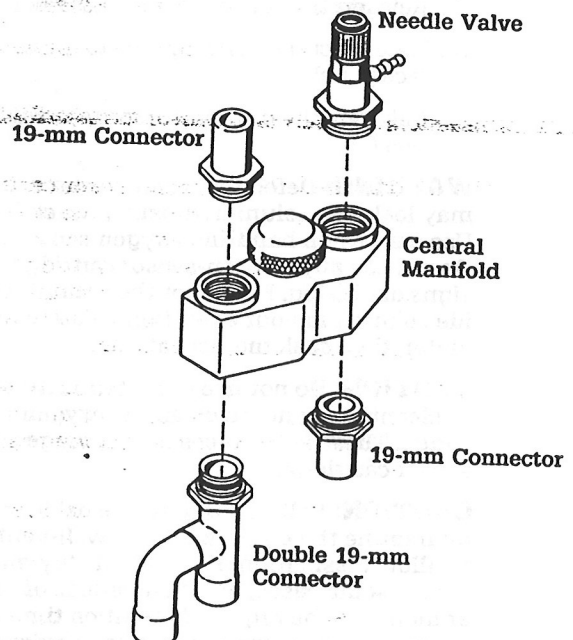


Figure 6-12
The scavenging interface valve, exploded view

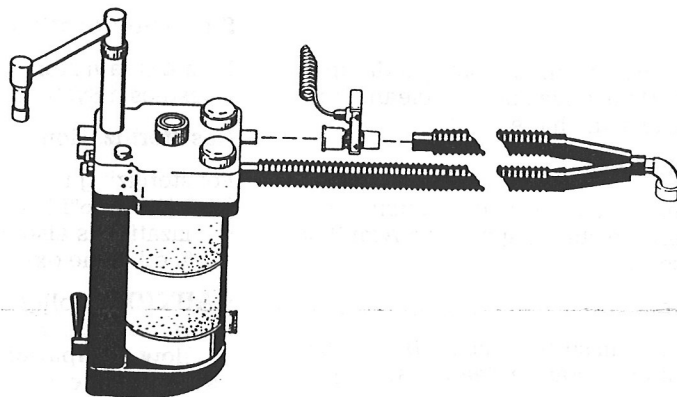


Figure 6-13
Remove the volume sensor cartridge from the expiratory limb of the patient circuit

6/Maintaining The System

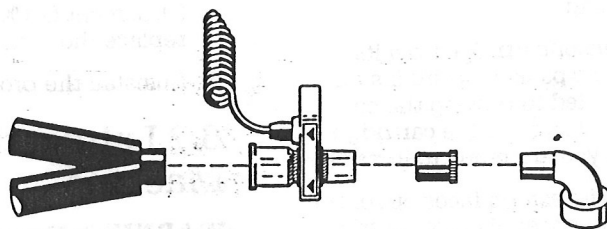


Figure 6-14

Removing the volume sensor cartridge from the distal position of the patient circuit

6.4 Maintaining The Oxygen Sensor

The oxygen sensor translates the partial pressure of oxygen into electrical current. The sensor is an electrochemical device that lets oxygen diffuse through a membrane to reach a base-metal electrode inside the sensor. Oxygen then oxidizes the electrode, which produces a DC current that is directly proportional to the percentage of oxygen in the sensor's gas sample. Because oxidation also gradually consumes the electrode, the oxygen sensor must be checked periodically and occasionally replaced.

The service life of the oxygen-sensor cartridge is affected by storage time and conditions, as well as the amount of oxygen the cartridge is exposed to while in service. The sensor cartridge will typically last for about 438,000 percent hours. For example, it will typically last for one year at 50 percent oxygen or six months at 100 percent oxygen. Continuous exposure to carbon dioxide also will shorten the life of the sensor cartridge. The sensor cartridge's expected service life is 5000 percent hours when exposed to 100 percent carbon dioxide. For example, Using the sensor for five hours in a gas mixture containing one percent carbon dioxide will reduce its service life by about 0.1 percent.

To maximize its shelf life, the sensor cartridge is packaged in an inert atmosphere. Do not puncture or open the package until you are ready to install the sensor cartridge into the probe. Even with its package intact, the sensor cartridge has a finite shelf life, which will vary depending on the conditions in which the sensor is stored. A storage atmosphere with a temperature of about 6°C ($\pm 3^\circ\text{C}$) and high relative humidity will help keep the sensor from drying out. Placing unopened sensors in a refrigerator will extend the sensors' shelf life. However, do not freeze oxygen-sensor cartridges.

Check the oxygen sensor's calibration at least once a month. (See section 6.6.)

6.5 Replacing The Oxygen Sensor Cartridge

Handle the cartridge with care to avoid damage.

1. Unplug the oxygen sensor probe from the anesthesia system's patient interface panel.

2. Hold the probe housing so that the cable hangs down and the probe points up.
3. Grasp the housing's knurled surfaces and turn the housing's probe end counterclockwise until it is free.
4. Remove and discard the oxygen sensor cartridge. Do not reuse these cartridges.

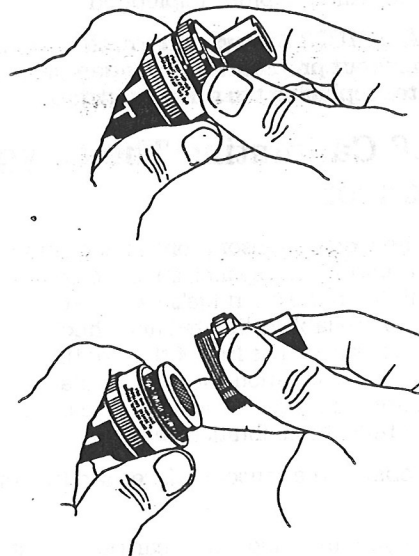


Figure 6-15

Opening the oxygen sensor

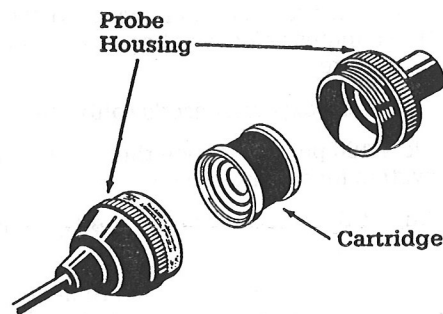


Figure 6-16

Oxygen sensor, exploded view

6/Maintaining The System

5. Inspect the probe housing for damage. If necessary, replace the housing.
6. Remove an oxygen sensor cartridge from its protective package. This package contains an inert atmosphere intended to prolong the cartridge's shelf life. Do not remove the cartridge from its package until you are ready to install it.
7. Insert the cartridge so its screen faces out of the housing, and so the three metallic, concentric rings at its other end contact the gold-colored terminals at the cable end of the probe housing.
8. Thread the housing's probe section back onto the cable section. Turn the probe section until it is finger tight. Make sure the sections are tight enough to compress the housing's O-rings, which form a gas-tight seal.
9. Insert the sensor cable plug back into the receptacle marked "Oxygen Monitor" on the patient interface panel. If the oxygen-sensor probe is not plugged into the panel, an oxide coating will accumulate on the cartridge's sensor screen. The sensor can be properly calibrated and checked only when the sensor's screen is free of this coating. Although plugging the probe into the patient interface panel will gradually remove this oxide coating, to reduce cartridge wear, avoid leaving the probe unplugged.

CAUTION: Always perform the preoperative checkout procedures for oxygen-sensing functions after replacing the sensor cartridge.

6.6 Calibrating The Oxygen Sensor

If the oxygen sensor probe is not plugged into the patient interface panel, an oxide coating will accumulate on the cartridge's sensor screen. The sensor can be reliably calibrated and checked only when the sensor's screen is free of this coating. If the sensor fails the calibration checkout, replace the oxygen-sensor cartridge. Do not continue to use any sensor that fails the calibration checkout.

To ensure the sensor surfaces are free of oxide coating:

1. If you are using a new cartridge, install the cartridge immediately after removing it from its protective package.
2. Install the sensor assembly at least twelve hours before you begin the calibration procedure.
3. Move the system master switch to "On" at least five minutes before you begin the calibration procedure.

To check the oxygen sensor's calibration:

1. Flow 100 percent oxygen through the breathing system for at least two minutes.
2. Adjust the O₂ Cal dial until the O₂% display reads 99 percent.
3. Make a note of the time, then remove the probe from the absorber socket to expose the sensor to room air.

4. Within three minutes the O₂% display should read 21 percent ($\pm 1\%$). If it doesn't read 21 percent, replace the cartridge as described in section 6.5.
5. Reinstall the probe into the absorber.

6.7 Lubricating The Anesthesia Machine

WARNING: Never oil or grease any oxygen equipment unless the lubricant used is made and approved for this type of service. In general, oils and greases oxidize readily, and—in the presence of oxygen—will burn violently. Vac Kote™ is the recommended oxygen service lubricant.

When required, apply Vac Kote sparingly to the yoke tee handle threads. This will prolong their life and make it easier to seal cylinder gaskets. Vac Kote (Stock No. 0220-0091-300) can be ordered from Ohmeda.

Do not lubricate the absorber post assembly.

6.8 Maintaining The Gas Supply Module

Install yoke plugs and gaskets in unused yokes to help prevent check valve leaks and to keep dust and lint from accumulating in the strainer nipples. The strainer nipples are located in the cylinder yokes and, even with conscientious use of yoke plugs, should be replaced at least once a year.

To replace a strainer nipple:

1. Remove the gas cylinder, if present.
2. Swing the yoke gate to the left.
3. Use a flat-tipped screwdriver to unscrew the old strainer nipple out of the cylinder inlet.
4. Screw the replacement strainer securely into the cylinder inlet.

The tee handle screw can be unscrewed from the yoke gate and replaced if necessary.

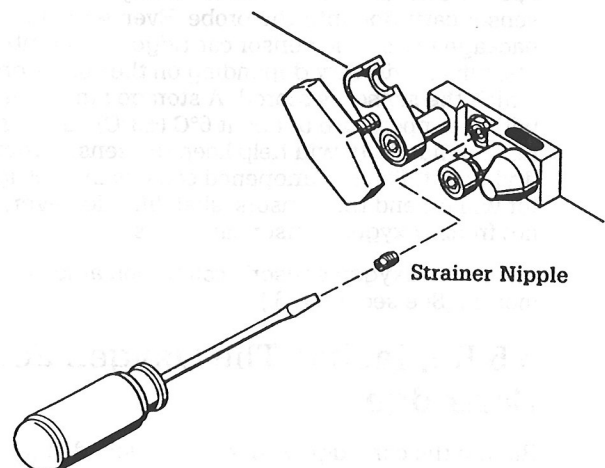


Figure 6-17
Replacing a strainer nipple on a gas supply module

7/Service Procedures

7.1 Repair Policy

Do not use malfunctioning equipment. Make all necessary repairs, or have the equipment serviced by an authorized Ohmeda 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 Ohmeda 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 the Ohmeda Modulus II Plus Anesthesia System and having appropriate test and calibration equipment.

CAUTION: No repair should ever be undertaken or attempted by anyone not having proper qualifications and equipment.

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

In some cases, special diagnostic equipment may be required to properly service components of the Ohmeda Modulus II Plus Anesthesia System. The components must then be sent to the nearest Ohmeda Service Center.

Contact the nearest Ohmeda Service Center for service assistance. If you send any unit to an Ohmeda Service Center, package it securely in the original shipping container, if possible, and ship it prepaid. Enclose a letter with the unit describing in detail any difficulties experienced and the repairs felt necessary. In all cases, other than where Ohmeda's warranty is applicable, repairs will be made at Ohmeda's current list price for the replacement part(s) plus a reasonable labor charge.

7.2 Troubleshooting Guide

This guide is divided into three sections: system problems, ventilator problems, and ventilator failure messages.

A. Troubleshooting System Problem

| Symptom | Possible Cause | Recommended Action |
|---|---|---|
| System won't power on when connected to functional AC outlet. | Master switch is off. | Move master switch to "On." |
| | Battery completely discharged. | Press battery bypass button to restart system, then recharge battery. |
| No gas flow | Master switch is off. | Move master switch to "On." |
| | O ₂ supply pressure too low. | Check the pipeline, switch to cylinder. |
| | Supply hose disconnected. | Connect supply hose. |
| | Kinks in supply hose. | Remove kinks from supply hose. |
| Electrical/Disconnect failure alarm activates | System power cord unplugged. | Plug in power cord. |
| | Circuit breaker tripped. | Reset circuit breaker (see section 7.3). |
| | System's DC power supply has failed. | Call service personnel. |
| O ₂ supply failure alarm activates. | O ₂ supply pressure too low. | Check the pipeline, switch to cylinder. |
| | Cylinder empty. | Replace cylinder. |
| | Supply hose disconnected. | Connect supply hose. |
| | Kinks in supply hose. | Remove kinks from supply hose. |

7/Service Procedures

| Symptom | Possible Cause | Recommended Action |
|--|--|---|
| Excessive high pressure circuit leak | Yoke gate loose. Cylinder gasket leaking. Unused cylinder yoke is unplugged. | Tighten yoke tee handle. Replace cylinder gasket(s). Install yoke plug in unused cylinder yoke. |
| Excessive low pressure circuit leak | Vaporizer filler or drain valve loose. Vaporizer mounted improperly. | Tighten vaporizer filler and drain valves. Ensure proper vaporizer mounting. |
| Cannot make a connection to the absorber at one of the anti-disconnect fittings. | Release tab engaged. | Depress the release tab button on the female fitting and try again. |
| "BATTERY FAIL" message displayed. | Not user serviceable. | Call service personnel. |
| Monitor does not come on with system power. | Monitor's power switch is in "Off" position. Monitor is disconnected. | Switch monitor on. Connect monitor. |
| Record Keeper does not come on with system power. | Record Keeper's power-interrupt switch is in "Off" position. | Move switch to "On." |

B. Troubleshooting Ventilator Problems

| Symptom | Possible Cause | Recommended Action |
|--|--|--|
| No display on the ventilator screen. No alarms sounding. | System power has failed and backup battery is completely discharged. | Have anesthesia system's AC power supply repaired and press battery bypass button to restart system. Then recharge battery. |
| Bellows does not expand during ventilation or tends to collapse. | Leak in the breathing system. Bellows not installed properly. Tear or leak in bellows. Insufficient fresh gas flow. | Check breathing system hoses and connections. Check bellows to base attachment. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions. Check that settings on flowmeters are adequate. |
| Bellows distended or slips off the base. | Incorrect scavenging system pressure. | Check the scavenging system for vacuum or high pressure. |
| Low pressure alarm sounds continuously. | Leaks in pressure sensing tube. Circuit disconnected. Circuit occluded. | Replace pressure sensing tube. Reconnect circuit. Clear circuit. |

7/Service Procedures

| Symptom | Possible Cause | Recommended Action |
|---|---|--|
| Volume readings are consistently low. | Low oxygen supply pressure. | Check, and repair, the oxygen supply. |
| | Failed volume sensor cartridge. | Replace the volume sensor cartridge. |
| | Breathing system leak. | Find and repair leaks. |
| System sounds alarms at incorrect pressures. | Liquid in pressure sensing tube. | Drain the sensing tube. |
| | Tube disconnected. | Reconnect the tube. |
| | Kink in tube. | Replace tube. |
| Alarms sound without apparent cause and cannot be silenced. | Certain electronic failures may be so significant as to cause the system to lose the ability to generate ventilator failure messages even though the ventilator has failed. If such a serious, failure occurs, the alarm silence button will not silence the alarm. | Do not use the ventilator. |
| Reverse flow alarm is activated. (While the volume sensor is in the distal position of the expiratory limb of the breathing circuit.) | Expiratory check valve on absorber is functioning incorrectly. | Replace disk. |
| Reverse flow alarm is activated during every breath. | If the volume sensor is located in the proximal end of the "Y" connector in the patient circuit, the alarm may sound for each breath. | Either locate sensor in the distal position of the expiratory limb, (see section 2.5.B.) or use the Setup Page to disable the reverse flow alarm. (See section 5.3.) |
| | Volume sensor cartridge is connected backwards to sensor clip. | Correctly connect the clip to the volume cartridge. (See section 2.5.B.) |

C. Troubleshooting Ventilator Failure Messages

Ventilator failure messages can indicate anything from a defective IC chip to excessive pressure in the ventilator's driving gas supply. All messages indicate problems that will cause the ventilator to shut down. However, some ventilator problems may not generate any ventilator failure message, even though the ventilator may not be functioning correctly. Do not attempt to use the ventilator while a ventilator failure message is displayed. And, even if no ventilator failure message is displayed, do not use the ventilator if you suspect a malfunction has occurred.

Some ventilator failure alarm conditions may be caused by transitory electrical interference that devices such as electrocautery instruments can generate. Although the ventilator will disable mechanical ventilation during most ventilator failure alarms, during certain of these alarms, whose causes may be transitory, the ventilator will continuously attempt to reset its circuits for correct operation. If the ventilator successfully resets its circuits, it will remove the alarm message and will resume normal operation.

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

Except for "VENT. FAIL 4!" none of the causes of ventilator failure messages are user serviceable. If your ventilator displays a ventilator failure message other than "VENT. FAIL 4!" please note the failure number, any other symptoms, and any corrective actions you took, then call trained service personnel.

7/Service Procedures

| Ventilator Failure Messages | Possible Cause | Monitoring Continue? | Mechanical Ventilation Continue? | Ventilator Attempt To Restart? |
|-----------------------------|--|----------------------|----------------------------------|--------------------------------|
| VENT. FAIL 0! | Electronic Failure | No | No | Yes |
| VENT. FAIL 1! | Electronic Failure | No | No | No |
| VENT. FAIL 2! | Electronic Failure | No | No | No |
| VENT. FAIL 3! | Electronic Failure | No | No | No |
| VENT. FAIL 4! | Supply gas pressure more than 30 psig | Yes | No | Yes |
| VENT. FAIL 5! | Anesthesia system power failure and delivered backup-battery voltage less than 4.6 VDC | Yes | No | Yes |
| VENT. FAIL 6! | Servo Valve Failure | Yes | Yes | Yes |
| VENT. FAIL 7! | Not used | N/A | N/A | N/A |
| VENT. FAIL 8! | Gas inlet valve failure | Yes | Yes | Yes |
| VENT. FAIL 9! | Electronic failure | No | No | Yes |
| VENT. FAIL 10! | Electronic failure | No | No | Yes |
| VENT. FAIL 11! | Reference voltage incorrect | No | No | Yes |
| VENT. FAIL 12! | RAM table values incorrect | Yes | No | Yes |
| DRIVE CKT. OPEN! | Exhalation Valve Failure or Bag/APL switch in wrong position | Yes | Yes | Yes |

7/Service Procedures

7.3 Resetting Circuit Breakers

Two circuit breakers are located on the electrical pod's back panel. These are push-to-reset devices that service the system's electrical outlets and monitors. If a breaker repeatedly trips, or cannot be reset, remove the Ohmeda Modulus II Plus Anesthesia System from service until it is repaired.

Electrical
Pod

Circuit
Breakers

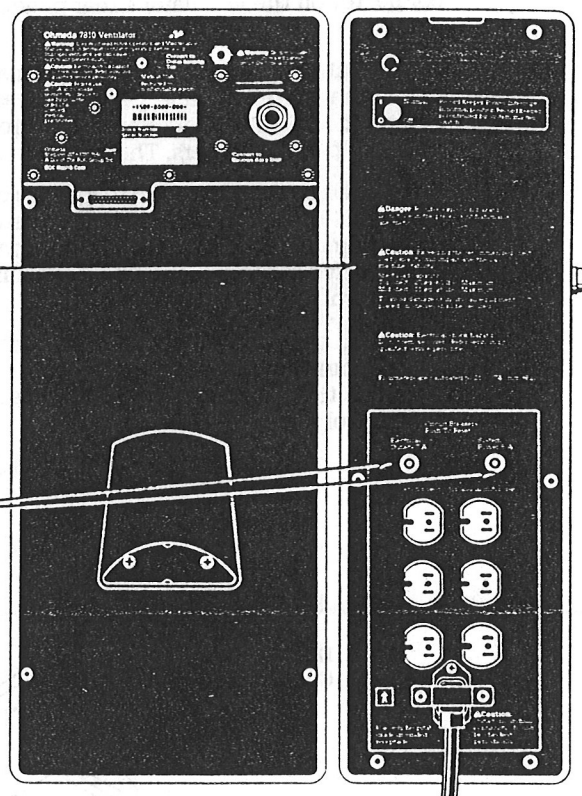


Figure 7-1

Location of the circuit breakers

7.4 Removing The Ventilator Control Module

Normally, if the ventilator's control module needs repair, it will be removed from the anesthesia system by trained service personnel. If necessary, however, you can remove or install the control module yourself.

WARNING: Do not use the anesthesia system without proper, functioning oxygen monitoring installed.

1. Move the ventilator's mechanical ventilation switch to "Off."
2. Move the anesthesia system's master switch to "Off."
3. Disconnect the ventilator tube from the control module's connector labeled "Connect to Bellows Ass'y Inlet."
4. Disconnect the clear, pressure-sensing tube from the control module's barbed connector labeled "Connect To Distal Sensing Tee."

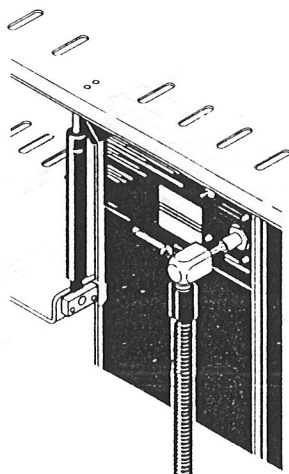


Figure 7-2

Disconnecting the drive oxygen from the control module

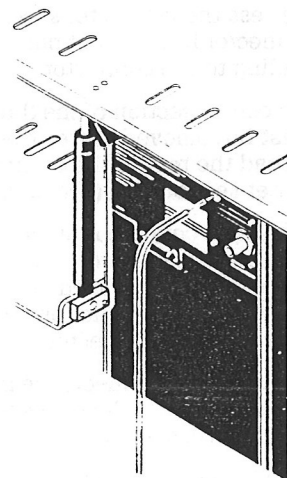


Figure 7-3

Disconnecting the pressure sensing tube from the control module

7/Service Procedures

5. If a connector is plugged into the serial interface connector on the ventilator's rear panel, disconnect it.
6. A panel at the rear of the anesthesia machine, below the control module, permits access to the control module's cabling. Remove the four screws from the panel's corners. Then remove the panel.
7. The drive gas hose connects to a fitting on the underside of the module's base. Rotate the disk on the fitting counterclockwise to disconnect the hose's drive gas connector from the connector on the control module.
8. A knurled thumbscrew secures the control module to the mounting rail on the anesthesia machine. Turn this thumbscrew counterclockwise to release the control module.
9. Slide the control module out the back of the anesthesia machine until the connectors at the module's base are exposed. (See figure 7-4.)
10. A 14-pin connector provides the monitor signals to the control module. Grasp this connector by the body, near the module's base, depress the connector's locking tab, and pull the connector free. Do not pull directly on the cables leading to the connector.

CAUTION: Do not pull on the wires leading to the ventilator's electrical connectors. Pulling directly on the ventilator's electrical wires may cause the ventilator to malfunction.

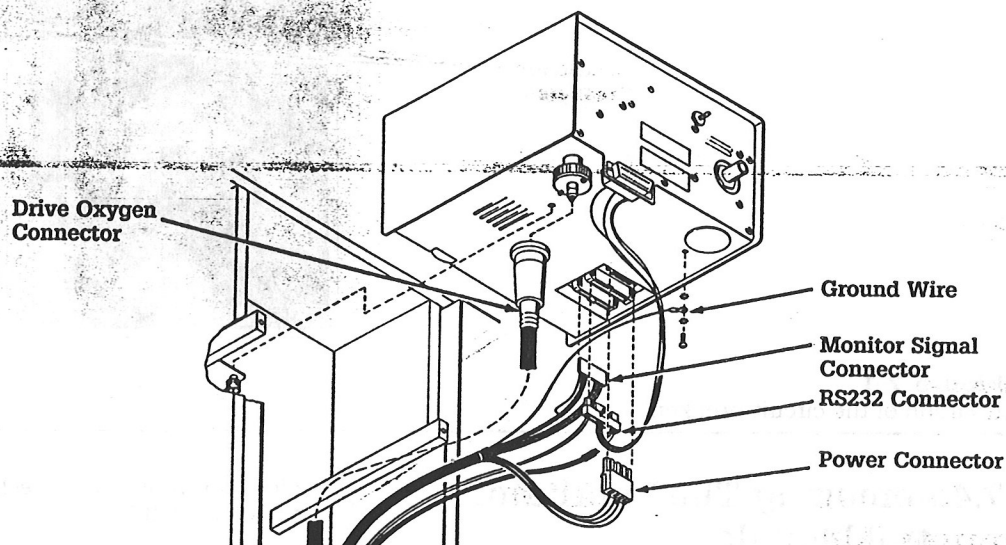


Figure 7-4
Removing the control module

11. A three-part connector—which carries RS232 signals—connects to both the anesthesia machine and the ventilator's rear panel. Grasp this connector by the body, near the module's base, depress the connector's locking tab, and pull the connector free. Do not pull directly on the cables leading to the connector.
12. The center section of the three-part connector must be removed to free the control module. Spread the rear of the connector and pull the center section out. (See figure 7-5.)
13. A four-pin connector provides the control module's electrical power. Grasp this connector by the body, near the module's base, and pull the connector free. Do not pull directly on the cables leading to the connector.
14. A single wire connects the module's chassis to ground. Remove the screw that fastens this wire to the chassis and disconnect the wire.
15. Slide the control module out of the anesthesia machine.

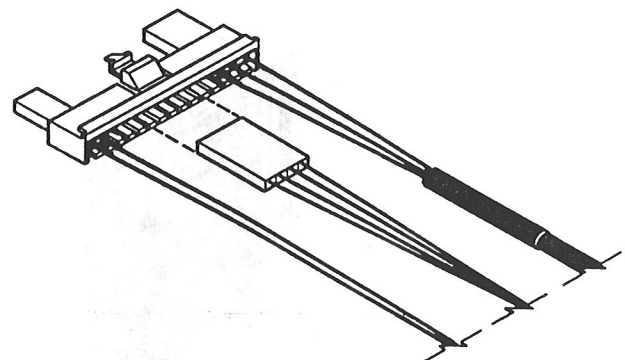


Figure 7-5
Removing the center section of the three-part connector

7/Service Procedures

7.5 Reinstalling The Ventilator Control Module

Normally, if the ventilator's control module has been repaired, it will be reinstalled into the anesthesia system by trained service personnel. If necessary, however, you can reinstall the control module yourself.

WARNING: Do not use the anesthesia system without proper, functioning oxygen monitoring installed.

1. Move the ventilator's mechanical ventilation switch to "Off."
2. Move the anesthesia system's master switch to "Off."
3. A panel at the rear of the anesthesia machine, below the control module, permits access to the control module's cabling. If this panel is in place, remove the four screws from the panel's corners. Then remove the panel.
4. From the anesthesia machine's rear, slide the control module about halfway into the machine.
5. A single wire connects the module's chassis to ground. Use two external star washers and a screw to connect this wire to the module. (See figure 7-4.)
6. A four-pin connector provides the control module's electrical power. Insert this connector onto the four-pin connector on the module's base.
7. A three-part connector—which carries RS232 signals—connects to both the anesthesia machine and the ventilator's rear panel. The center section of this three-part connector must be reinstalled. Slide the center section into the connector. The two molded guide bars on the section must slide into the slots on the connector. Align the center section so that—when the

three-part connector is assembled—the section lines up with pins 7, 8, 9, and 10 in the mating connector in the ventilator. (see figure 7-5.)

8. Insert the three-part connector into the center position on the control module's base.
9. A 14-pin female connector provides the monitor signals to the control module. Insert this connector onto the 14-pin male connector on the module's base.
10. The drive gas hose connects to a fitting on the underside of the module's base. Attach the drive-gas hose to the connector on the module.
11. Slide the control module completely into the anesthesia machine.
12. A knurled thumbscrew secures the control module to the mounting rail on the anesthesia machine. Turn this thumbscrew clockwise to fasten the control module to the anesthesia machine.
13. Reinstall the panel to the rear of the anesthesia machine. Tighten the four screws at the panel's corners.
14. Connect the clear, pressure-sensing tube from the barbed connector on the absorber to the control module's barbed connector, which is labeled "Connect To Distal Sensing Tee."
15. Connect the ventilator tube from the bellows assembly to the control module's connector, which is labeled "Connect to Bellows Ass'y Inlet."
16. Perform the ventilator preoperative checkout (sections 4.6 and 4.7).

WARNING: After installing the ventilator, perform the ventilator's preoperative checkout before using the system.

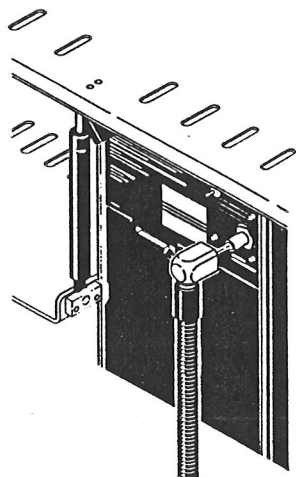


Figure 7-6
Connecting the drive oxygen to the control module

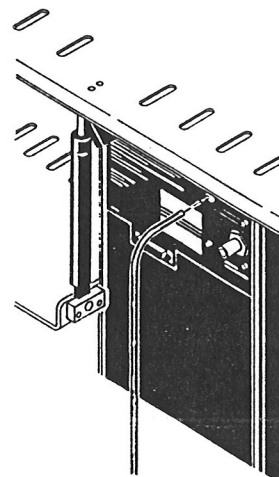


Figure 7-7
Connecting the pressure sensing tube to the control module

Notes

Appendix

Appendix A—Specifications

A. The Anesthesia Machine

All specifications are nominal and subject to change without notice.

Important Notice: The standard Ohmeda Modulus II Plus Anesthesia System has a minimum oxygen flow rate of 200 mL/min. Some systems can be equipped with a low oxygen flow modification kit that allows a minimum oxygen flow capability of 50 mL/min.

Systems with the 50 mL/min minimum oxygen-flow modification:

1. Have an oxygen flowmeter module with a range of 50 mL/min to 12 L/min,
2. Allow oxygen flow rate adjustments through the entire range,
3. Have a WARNING label affixed to the flowmeter shield that identifies the system as having a minimum oxygen flow rate of 50 mL/min.

Each reference in this manual to the standard 200 mL/min minimum oxygen flow is followed by a bracketed value of 50 mL/min. Use this value if your system has the low flow modification.

WARNING: The Ohmeda Link 25 Proportion Limiting Control System ensures only that oxygen-nitrous oxide mixtures will have a minimum (nominal 25 percent) oxygen concentration. *Hypoxic mixtures may be delivered if gases other than oxygen, nitrous oxide and/or air are used, or when operating at low oxygen flow rates.* When using carbon dioxide, helium or nitrogen as an additional gas, make sure the proportions of all gases are carefully adjusted in accordance with accepted clinical practice. Gas mixtures within the breathing system must be monitored when using these gases.

WARNING: The Ohmeda Modulus II Plus Anesthesia System is restricted to use with nonflammable anesthetic agents.

Electrical

Maximum Internal Power Requirements—Standard System:

350 W at 100/120 VAC 50/60 Hz

(Includes Ohmeda 7810 Ventilator and all options except Record Keeper.)

Maximum Internal Power Requirements—with Record Keeper:

700 W at 100/120 VAC 50/60 Hz

(Includes Ohmeda 7810 Ventilator, and all options including the Record Keeper.)

CAUTION: The voltage for this system was set in the factory. Do not change the original factory setting. Other system changes must be made before changing the voltage setting. If the available voltage differs from the voltage setting, call a qualified service representative to make all the required system changes.

Line Voltage Outlets:

7 Amperes maximum available total for all outlets at 100/120 VAC

3 Amperes maximum available total for all outlets at 220/240 VAC

Leakage Current:

Less than 100 μ A at 100/120 VAC

Less than 200 μ A at 220/240 VAC

Circuit Breakers:

7A to line voltage outlets; 5A for internal circuitry at 100/120 VAC

3A to line voltage outlets; 3A for internal circuitry at 220/240 VAC

Electrical Failure Alarm:

An intermittent alarm sounds for three seconds on, about five minutes off, when line voltage fails or when the internal main power supply fails.

Pneumatics

Oxygen Pressure Sensor Shut Off Valve System:

Pressure Sensor Shut Off Valves shut off all other gas flows if oxygen-supply pressure falls to about 20 psig (138 kPa).

Oxygen Supply Failure Alarm:

An alarm sounds continuously when oxygen pressure falls below 28 psig (193 kPa).

Pipeline Supply Pressure:

A nominal 50 psig (345 kPa) pressure supply is required for all pipeline gases.

Gas-Supply Modules

Pipeline Inlet Connections:

DISS (diameter index safety system) inlets are standard for oxygen, nitrous-oxide and air connections.

Cylinder Hanger Yokes:

Safety pin-indexed, locking-gate style requiring CGA standard medical-gas cylinders with pin-indexed, post-type valves. Built-in check valves minimize loss of cylinder gas.

Cylinder Pressure Regulators:

Set at nominal 45 psig (310 kPa) for all gases. Primary regulator diaphragm minimum-burst pressure is 250 psig (1750 kPa).

Gas Pressure Gauges:

White on black, dual-scale gauge faces within color coded and labeled identification plates. Cylinder gauge scales range from 0 to 3000 psig (0 to 20,000 kPa). Pipeline gauge scales range from 0 to 100 psig (0 to 700 kPa).

Safety Relief Valves:

Set at 75 psig (517 kPa).

Oxygen Flush:

Recessed, self-closing push button provides a flow of 45-75 L/min when fully depressed.

Appendix

Calibrated Ranges Of Flowmeters

Oxygen, Double Tube:

[200\50]-650 mL/min and 700 mL/min-12 L/min

Nitrous Oxide, Double Tube:

20-650 mL/min and 700 mL/min-12 L/min

Air (optional):

1-15 L/min

Carbon Dioxide (optional):

20-700 mL/min

Helium (optional):

200 mL/min-10 L/min

Nitrogen (optional):

1-15 L/min

Flowmeter Accuracy (at 740 mm Hg, 21°C):

±2.5% of reading at flow rates 100 mL/min and over,
and ±5% of reading for flow rates below 100 mL/min.

Ohmeda Link 25 Proportion Limiting Control System:

Provides nominal minimum 25% oxygen concentration for gas mixtures containing only oxygen and nitrous oxide.

Minimum Oxygen Flow:

The oxygen flow-control valve is set to deliver a minimum flow of 200 mL/min (50 mL/min) (nominal) when the system master switch is set to "On."

Vaporizer Manifold:

The vaporizer manifold can accommodate up to three Ohmeda Tec 4® Vaporizers.

Outlet Relief Valve:

The anesthesia machine is equipped with an internal relief valve set to open at a pressure of 120 to 150 mm Hg.

Gas Evacuation System:

Can be used in either active or passive mode.

Positive pressure relief: 40 cm H₂O

Negative pressure relief: 0.25 cm H₂O

Connection ports: Three 19-mm male

Reservoir: Three liter reservoir bag

Physical Characteristics

Overall System:

Weight:

166 kg (365 lb.) (without optional equipment)

Weight Added by Options:

Third Gas Circuitry: 5 kg (11 lb.)

One Vaporizer: 7.6 kg (17 lb.)

Ohmeda GMS Absorber: 9.5 kg (21 lb.)

Ventilator: 8.5 kg (19 lb.)

Record Keeper: 25 kg (55 lb.)

Monitor weights vary. Check the weight specification for each monitor in the system and add the monitor weights to the total.

Height:

155 cm (61 in.)

Width:

87 cm (34 in.)

Depth:

64 cm (25.2 in.)

Depth with Record Keeper:

74 cm (29 in.)

Stationary Shelf:

Height from Floor: 127 cm (50 in.)

Maximum Shelf Load: 11.3 kg (25 lb.)

Size: 37 x 30 cm (14.7 x 12 in.)

Usable Height: 25 cm (10 in.) minimum; 27 cm (10.5 in.) maximum

Tilting (Top) Shelf:

Height from Floor: 255.3 cm (61.1 in.) (horizontal position)

Maximum Shelf Load: 27.2 kg (60 lb.)

Size: 38 x 82 cm (32.4 x 15 in.)

Table top:

Height from Floor: 82.5 cm (32.5 in.)

Size: 68.5 x 38.1 cm (25 x 15 in.)

Size with Record Keeper Printer: 63.5 x 40.1 cm (25 x 15.8 in.) (The printer is built into the table top so that usable surface area is less than that of a standard table top.)

Drawer Cabinet:

Contains three 35.5 cm (14 in.) deep, 38 cm (15 in.) wide, foam-lined, ball-bearing slide drawers.

Bottom drawer height: 20.3 cm (8 in.) high.

Two top drawers heights: 10.1 cm (4 in.) high.

Absorber Post Mounting Assembly:

Absorber Swivel Arm Length: 35.5 cm (14 in.)

Push Button Vertical Adjustment: 25.4 to 66 cm (10 to 26 in.) from floor.

Range of Horizontal Adjustment: 16.5 cm (6.5 in.) minimum; 28 cm (11 in.) maximum

Casters:

12.7 cm (5 in.) diameter; non-conductive; front casters have brake lock.

Common Gas Outlet:

Equipped with a latching, positive engagement, bayonet-type connector. The common gas outlet connector will also accept standard 22-mm ID or 15-mm OD conical, friction-fit connectors.

Appendix

B. The Ventilator

Electrical

Power Consumption:

15 watts maximum

Display Type:

Liquid Crystal Display

Circuitry:

Microprocessor-controlled.

RS232C serial output for remote recording.

Controls

Read section 3.2 for specific information.

| Control | Range | Display Resolution |
|-----------------------------|----------------------------|---|
| Tidal Volume: | 50-1500 mL | From 50 mL to 100 mL: 2-mL increments From 101 mL to 250 mL: 5-mL increments From 251 mL to 1000 mL: 10-mL increments From 1001 mL to 1500 mL: 10-mL or 20-mL resolution |
| Rate: | 2-100 B/min | 1 B/min increment |
| Inspiratory Flow: | 10-100 L/min | Resulting I:E Ratio: 1:0.5 minimum, 0.5 resolution |
| Inspiratory Pressure Limit: | 20-100 cm H ₂ O | 1 cm H ₂ O increment |
| Inspiratory Pause: | 25% T _I | |

Monitoring

Oxygen Monitoring:

Display:

Range: 0 to 105 percent oxygen

Resolution: 1 percent of full scale

Update: Once per second

Sensor:

Sensor type: Galvanic fuel cell

Response time: 90 percent of total change in oxygen concentration in less than 15 seconds at 25°C (77°F)

Drift: ±1 percent over 8 hour period

Monitor linearity: ±1 percent of full scale

Life: 12 months typical (assuming average O₂ equal to 50% concentration at 25°C (77°F))

Low Oxygen Alarm Limit: 18-99%, 1% increment

High Oxygen Alarm Limit: 18-99%, 1% increment (disabled when set to zero)

Volume Monitoring:

Display range:

Tidal volume: 0 to 9999 mL, 1 mL resolution

Minute volume: 0.0 to 99.9 L, 0.1 mL resolution

Breath rate: 0 to 99 Breaths per minute, 1B/min resolution

Accuracy:

Tidal Volume: 300 mL to 1.5 L range: ±8 percent or ±40 mL (whichever is greater)

50 mL to 299 mL range: ±20 percent or ±20 mL (whichever is greater)

Sensor:

Type: Expendable turbine vane flow cartridge with clip-on, heated, optical coupler

Turbine Resistance: Approximately 1 cm H₂O at 60 L/min

Flow Range: 3 to 600 L/min

Repeatability, same cartridge: At a constant flow rate, ±5 percent of original reading

Repeatability, different cartridges: ±35 mL over a range of 0.1 to 3.0 L

Dead air space: 6 to 10 mL depending upon breathing circuit adapters

Minimum breath:

Volume: 20 mL

Flow:

≥6.5 L/min when tidal volume dial set to 300 mL or more.

≥4.0 L/min when tidal volume dial set to less than 299 mL.

Breathing circuit connections:

Inlet: 22 mm male tapered or 15 mm female tapered with tracheal tube adapter

Outlet: 22 mm female tapered

Low Minute Volume Alarm Limit: 0-9.9 L/min, 0.1 liter increment

Airway Pressure Monitoring:

Pressure Transducer Range: -20 to +120 cm H₂O, ±3 cm H₂O

Response Time: 10 milliseconds

Accuracy: ±3 cm H₂O over the range of -20 to 120 cm H₂O

High Pressure Alarm Limit: 20-100 cm H₂O, 1 cm H₂O increment

Sustained Pressure Alarm Limit: 10-30 cm H₂O, 1 cm H₂O increment

Alarms

Apnea, Low Oxygen, High Pressure, Low Pressure, Sustained Pressure, Subatmospheric Pressure, Low Minute Volume, High Oxygen, Low Battery, Power Failure, Limit Setting Error, Ventilator Setting Error, Check O₂ Probe/Check Gas Supply, Reverse Flow, Low Supply Pressure, Ventilator Failure, Pressure Limit, Apnea Alarm Off, Volume Monitor Standby, Check Settings, Drive Circuit Open

Read section 3.5 for specific information about the alarm system.

Appendix

Performance Characteristics

Driving Gas Oxygen Supply Requirements:

35 to 80 psig at 100 L/min continuous flow at inlet to ventilator; 50 psig nominal at pipeline.

Ventilator Compliance:

Adult Bellows: Approximately 3 mL per cm H₂O

Pediatric Bellows: Approximately 1.5 mL per cm H₂O

Compliance for connecting hoses are not included in these compliance specifications.

Ambient Operating Temperature Range:

10 to 40°C (50 to 104°F)

Ambient Operating Humidity Range:

0 to 100 percent Relative Humidity (non-condensing)

Ambient Operating Pressure:

500 to 800-mm Hg

Altitude Compensation:

Sea level to 3000 meters

Physical Characteristics

| | Bellow Assembly | Control Module |
|---------|-------------------|--------------------|
| Weight: | 1.8 kg (4.0 lb.) | 5.1 kg (11.2 lb.) |
| Depth: | 20.3 cm (8.0 in.) | 27.3 cm (10.7 in.) |
| Width: | 19.0 cm (7.5 in.) | 21.6 cm (8.5 in.) |
| Height: | 22.9 cm (9.0 in.) | 13.3 cm (5.2 in.) |

Approximate tidal volume Scale Range:

Adult Bellows Housing: 1600 mL maximum

Pediatric Bellows Housing: 300 mL maximum

Storage Requirements:

Temperature: -20 to +70°C. (-4 to +158°F)

Humidity: 0 to 100 percent relative humidity (non-condensing)

Appendix B-Optional Accessories

| Description | Stock Number |
|--|---------------|
| Add-on yoke, oxygen (factory installed) | 0236-5015-810 |
| Add-on yoke, oxygen (field installed) | 0236-6114-810 |
| Add-on yoke, nitrous oxide (factory installed) | 0236-5015-811 |
| Add-on yoke, nitrous oxide (field installed) | 0236-6114-811 |
| Standard suction regulator kit | 1010-8015-000 |
| Free flow regulator kit | 1010-8016-000 |
| Suction regulator bracket (only) kit | 1010-8021-000 |

Absorber Accessories

| | |
|---|---------------|
| GMS PEEP Valve kit for Ohmeda GMS Absorber | 0216-6781-870 |
| Bain circuit adapter for Ohmeda GMS Absorber | 0236-0483-800 |
| Bain circuit adapter non-GMS Absorber | 0216-6498-802 |
| Dome Adapter Kit for oxygen sensing port on Ohmeda Models 20 and 21 Absorbers | 0236-0035-800 |

Bellows Assemblies And Accessories

| | |
|--|---------------|
| Adult bellows assembly (quick release) w/GMS mount | 1500-8002-000 |
| Pediatric bellows assembly w/GMS mount | 0236-0504-801 |
| Pediatric bellows assembly | 0219-7520-871 |
| Remote bellows mounting kit | 0219-7543-870 |

Optional Monitors And Monitor Accessories

| | |
|---|---------------|
| Ohmeda 5210 CO ₂ Monitor (factory installed) | 0236-5041-810 |
| Ohmeda 5210 CO ₂ Monitor (field installed) | 1010-8014-000 |
| Ohmeda 3710 Pulse Oximeter (factory installed) | 0236-5042-810 |
| Ohmeda 3710 Pulse Oximeter (field installed) | 0236-6125-870 |
| Ohmeda 2120 Non-Invasive Blood Pressure Monitor (factory installed) | 0236-5043-810 |
| Ohmeda 2120 Non-Invasive Blood Pressure Monitor (field installed) | 0236-6127-870 |
| Manual blood pressure gauge, large case (mounts in monitor pod) (factory installed) | 0236-5044-810 |
| Manual blood pressure gauge, large case (mounts in monitor pod) (field installed) | 0236-6128-870 |
| Manual blood pressure gauge, small case (mounts next to pod) | 0236-6148-870 |
| Inflation system for manual blood pressure gauge (adult) | 0211-1100-300 |
| Ohmeda Record Keeper (factory installed) | 0309-3300-810 |
| Ohmeda Record Keeper (field installed) | 0236-6135-870 |
| Extra-long volume-sensor cable (16 foot) | 1201-3002-000 |
| Oxygen-sensing tee (22-mm Tee manifold) for non-Ohmeda GMS Absorber | 0500-3115-000 |
| Pressure-sensing tee (patient-circuit adapter) for non-Ohmeda GMS Absorber | 6050-0000-456 |

Scavenging Interface Valve Assembly Supplemental Parts

| | |
|--|---------------|
| Tubing, Corrugated, w/19-mm bushings 18" long | 0225-0810-700 |
| Tubing, Corrugated, w/19-mm bushings 24" long | 0225-0809-700 |
| Tubing, Corrugated, w/19-mm bushings 60" long | 0225-0808-700 |
| Tubing, Corrugated, w/19-mm bushings 90" long | 0225-0807-700 |
| Tubing, Corrugated, w/19-mm bushings 240" long | 0225-0811-700 |
| Cap for 19-mm connector | 0203-0142-300 |
| Reservoir bag, three-liter w/19-mm bushing | 0225-3212-700 |
| 19-mm exhaust grille adapter assembly | 0219-1291-800 |

WARNING: After installing the Ohmeda GMS PEEP Valve, perform the Preoperative Checkout Procedures before using the system.

WARNING: After installing the pediatric bellows assembly, perform the Preoperative Checkout Procedures before using the system.

Appendix

Appendix C—Replaceable Parts

| Description | Stock Number |
|---|---------------|
| Monitoring | |
| Volume sensor clip | 0237-2226-700 |
| Volume sensor cartridges (10) | 0237-2228-870 |
| Pressure sensing tube, 8' long | 6026-0000-014 |
| Pressure-sensing tee (patient-circuit adapter) for non-Ohmeda GMS | |
| Absorber | 6050-0000-456 |
| Oxygen cartridge | 0237-2034-700 |
| Oxygen probe (without cartridge) | 0237-2030-700 |
| Oxygen probe, front housing only (w/ O-rings) | 0237-2035-800 |
| Oxygen probe O-ring (outside) | 0210-0503-300 |
| Oxygen probe O-ring (inside) | 0210-0499-300 |
| Oxygen-sensing tee (22-mm Tee manifold) for non-Ohmeda GMS | |
| Absorber | 0500-3115-000 |
| Bellows Assembly | |
| Adult bellows | 0229-1013-700 |
| Adult bellows housing (quick release) | 1500-3117-000 |
| Quick release bracket | 1500-3119-000 |
| Pediatric bellows | 0229-1018-700 |
| Pediatric bellows housing | 0229-0034-300 |
| Thumbscrew (bellows assembly mounting, all) | 0400-3524-300 |
| Thumbscrew (pop-off valve, all) | 0400-3507-300 |

Anesthesia Machine

| | |
|-----------------------------|---------------|
| Gas yoke strainer | 0206-2806-725 |
| Yoke plug | 0206-7129-525 |
| Yoke gasket | 0210-6460-300 |
| Yoke tee-handle screw | 0219-3372-600 |
| Vac Kote | 0220-0091-300 |

Appendix D—Monitoring Locations On Non-Ohmeda GMS Absorbers

The Ohmeda GMS Absorber includes ports that connect both the oxygen sensor and the pressure-sensing tube directly to the inspiratory side of the breathing system. If your system does not include an Ohmeda GMS Absorber, you must use optional, Ohmeda adapters to connect these devices to the breathing system's inspiratory limb. To provide a port for the oxygen probe, either use a 22-mm Tee manifold (stock number 0212-0763-100) or—for Ohmeda model 20 and 21 absorbers, use a dome adapter kit (stock number 0236-0035-800). To provide a tap into the inspiratory limb for the pressure monitoring, use a patient circuit adapter (stock number 6050-0000-456).

WARNING: When used, the oxygen-sensor adapter and the pressure-sensor's patient-circuit adapter must be connected to the inspiratory side of the breathing system. If these devices are not correctly connected to the inspiratory side of the breathing system, oxygen and pressure monitoring and related alarms will not function properly.

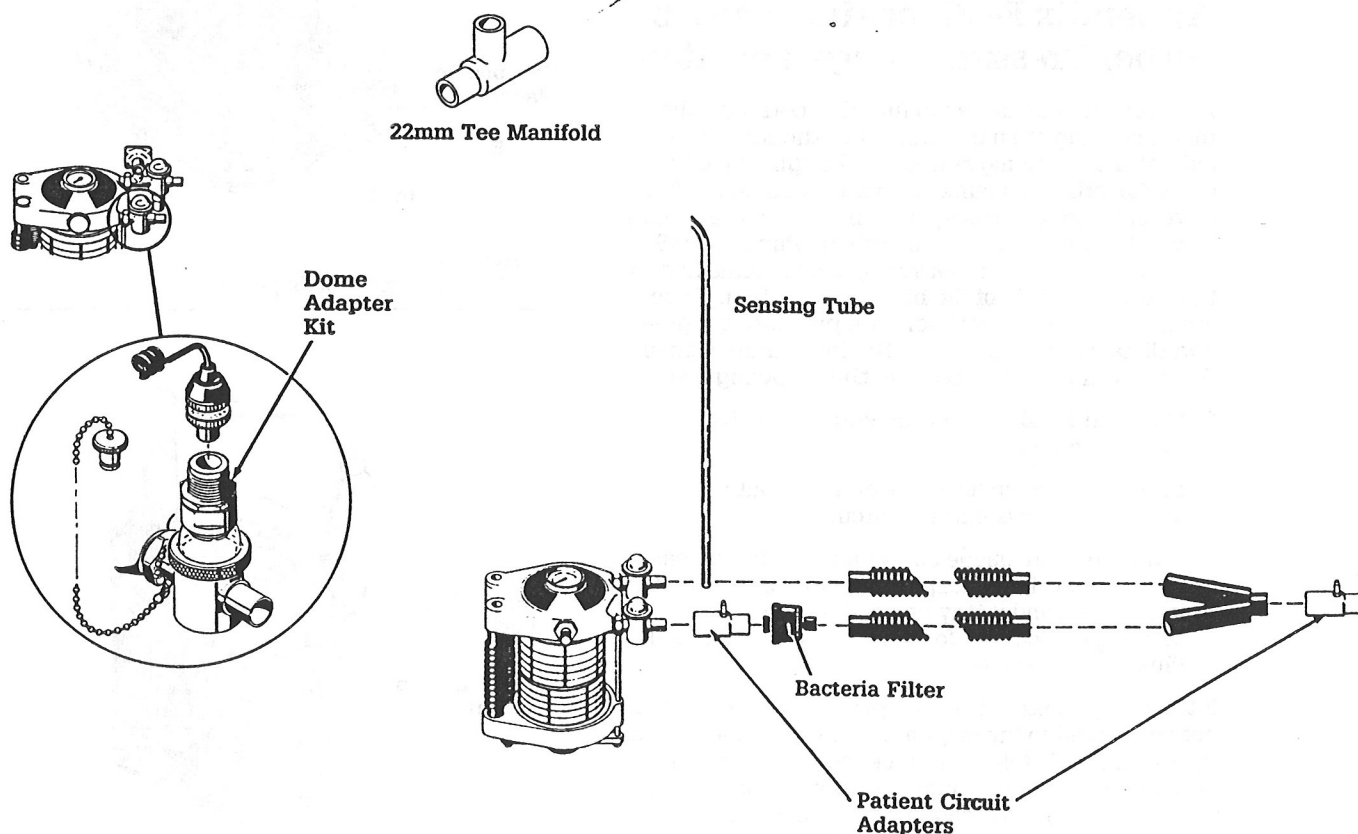


Figure 8-1
Monitoring adapters for alternate devices

Appendix

Appendix E—Connecting A Remotely Mounted Bellows Assembly

If either you do not use an Ohmeda GMS Absorber, or you do not use the absorber interface manifold to mount the bellows assembly to the Ohmeda GMS Absorber, you must use tubing to connect the absorber to the bellows assembly.

1. Use 15-mm tubing to connect the bellows assembly's port labeled "Inlet" to the control module's drive gas outlet labeled "Connect To Bellows Ass'y Inlet."
2. Use 22-mm, corrugated tubing to connect the bellows assembly's port labeled "To Anesthesia Machine" to the absorber's ventilator port.
3. Use 19-mm, yellow-banded, corrugated tubing to connect the bellows assembly's port labeled "Exhaust" to the gas scavenging system.

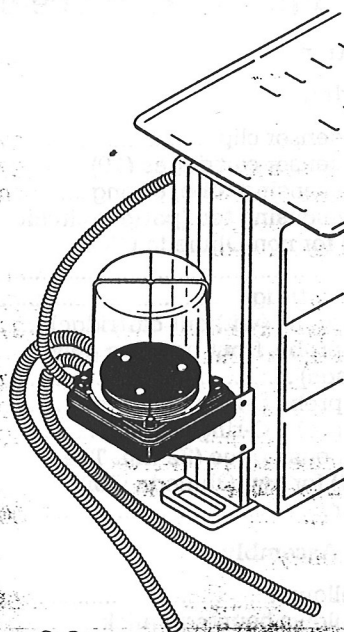


Figure 8-2
Remotely mounted bellows

Appendix F—Checking The Absorber Pressure Gauge Location

For pressure monitoring to function correctly, the distal-sensing tee must connect to the inspiratory side of the breathing system. Although all Ohmeda GMS Absorbers manufactured after January 1, 1986 have their pressure gauges connected to the inspiratory side, certain older, unmodified Ohmeda GMS Absorbers have their pressure gauges connected to the expiratory side of the breathing system. If you are not sure that your absorber's pressure gauge—and distal sensing tee—is in the inspiratory side of the breathing system, perform the following test.

1. Use your hand to cover the end of the absorber's inhalation port.
2. Press the oxygen flush button for about three seconds to pressurize the circuit.
3. If the pressure gauge shows a pressure increase, the gauge is in the inspiratory side of the breathing system and it may be used as the distal-sensing tee location for the Ohmeda Modulus II Plus Anesthesia System.

If the gauge does not show a pressure increase, it is not connected to the inspiratory side. Do not use this gauge as the distal-sensing tee location. Instead either use the patient circuit adapter (stock number 6050-0000-456) described in appendix D, or contact Ohmeda to have trained service personnel modify your absorber.

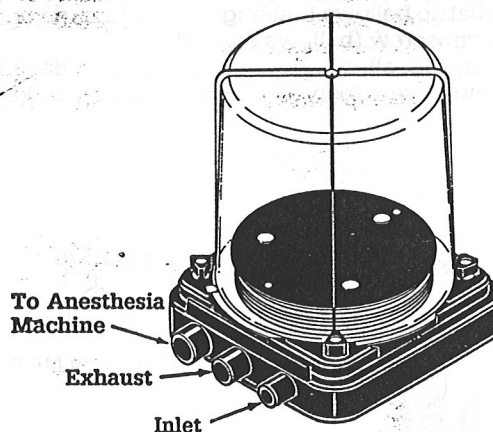


Figure 8-3
The bellows assembly's ports

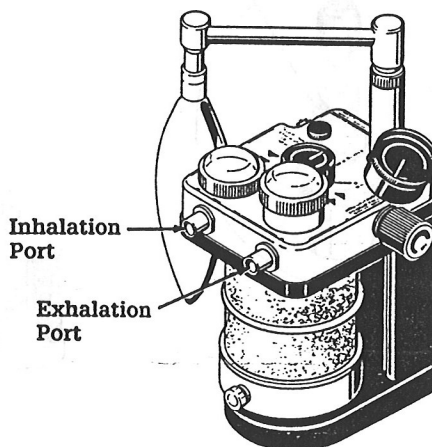


Figure 8-4
The absorber's ports

Appendix

Appendix G—Ventilator Communications Protocol

For remote recording, a 25-pin female "D" type connector on the ventilator's rear panel provides access to an RS232C serial port, which conforms to the Ohmeda standard communications protocol.

WARNING: Writing to the ventilator's RS232 port can alter the operation of the ventilator's software, which may result in unpredictable performance. Do not alter the ventilator's hardware or software.

The connector's assigned pin outs conform to DTE (Data Terminal Equipment) specifications and is listed below.

25 pin female D connector

pin 2 - transmit data (transmitted from ventilator)
pin 3 - receive data (received by ventilator)
pin 7 - signal ground

To reset alarms, momentarily ground pin 11.

Note: See Front Panel Commands for software reset.

The RS-232 data format for this protocol is summarized as follows:

Signal Levels: ± 5 volts minimum

Baud rate: 1200 baud

Character Code: 7-bit ASCII

Data bit format: (1)start bit, logic 0
(7)data bits
(1)odd parity bit
(1)stop bit, logic 1

When the ventilator is first turned on, the default transmission mode is set to "AUTO," the data format mode is set to "PRINTER," and the checksum mode is "disabled."

Two standard forms of the device commands are shown below and detailed in the following sections.

<ESC>VTxc<CR>

where:

<ESC>VT = header
x = command
c = checksum
<CR> = terminator

<ESC>VTxaac<CR>

where:

<ESC>VT = header
x = command
aa = parameter
c = checksum
<CR> = terminator

The header consists of the escape character (27 decimal) followed by the device designator for the 7810 Ventilator, "VT." The command terminator for all commands is a carriage return (13 decimal). If the checksum is enabled, a 7-bit checksum (2's complement of the sum of the transmitted bytes) is added before the command terminator at the end of the device command.

Device Commands - sent to ventilator

Data Transmit Mode Select Commands:

<ESC>VTXc<CR> Auto mode command (also selects printer data format)
Causes ventilator to output data at each breath or every 10 seconds.

<ESC>VTSc<CR> Slave mode command (also selects compressed data format)
Ventilator outputs data when requested by communications device using send all data command.

Data Format Mode Select Commands:

<ESC>VTPc<CR> Printer mode command (default at turn on)
Ventilator outputs data in a printer format, a 75-byte frame.

<ESC>VTQc<CR> Compressed mode command
Ventilator outputs data in a compressed format, a 58-byte frame.

Data Request Command:

<ESC>VT?c<CR> Send all data command
This command is active in slave mode only, and requests a data frame from the ventilator.

Front Panel Control Commands:

<ESC>VTCSc<CR> Reset all alarms command
The ventilator responds just as if the front panel alarm reset switch had been pressed.

<ESC>VTLaac<CR> Set Audio Alarm Sound Level command
sound level (01-10)
Sets sound level to indicated value, with 01 being softest, 10 being loudest.

<ESC>VTJaac<CR> Set LCD Contrast Level
contrast level (01-10)
Sets LCD contrast level to indicated value, with 01 being minimum, 10 being maximum.

<ESC>VTHaac<CR> Set Altitude (100's of meters)
altitude (00-30)
Sets altitude to indicated value. Example:
09 = 900 meters.

Appendix

Checksum Control Commands:

- <ESC>VTEc<CR> Enable checksum command
This command invokes checksum mode.
- <ESC>VTDc<CR> Disable checksum command

The checksum byte will be ignored in this mode. This is the default mode at power-on. (Checksum byte cannot be a <CR> character)

DEVICE RESPONSES - sent back by ventilator

- :VTYc<CR> Acknowledge Only Response:

For valid commands, other than send data or reset all alarms commands, the ventilator will respond by transmitting a positive acknowledge response.

- :VTNc<CR> Negative Acknowledge Response:

For unrecognized or invalid commands, the monitor will respond by transmitting a negative acknowledge response.

- :VTRc<CR> Alarm Reset Switch Pressed Response:

For valid reset all alarms commands and when the front panel alarm reset switch is pressed, the ventilator will respond with an alarm reset switch pressed response.

Format for data in compressed mode:

:VTCaaaabbbdddeeeeffghhijjjkkkkllmmnnnnnoooppqqqqqqc<CR>

| field | parameter | unit of measure |
|--------|---------------------------------------|---------------------|
| aaaa | tidal volume setting | mL |
| bbb | respiratory rate setting | B/m |
| ddd | inspired flow setting | L/m |
| eeee | I:E ratio setting | 1:eee.e |
| fff | peak pressure setting | cm H ₂ O |
| gg | low minute volume alarm limit | liters*10 |
| hh | low oxygen alarm limit | % O ₂ |
| ii | high oxygen alarm limit | % O ₂ |
| jijj | measured tidal volume | mL |
| kkkk | measured minute volume | liters*100 |
| lll | measured respiratory rate | B/m |
| mmm | measured oxygen level | % O ₂ |
| nnn | measured peak inspiratory pressure | cm H ₂ O |
| ooo | measured inspiratory plateau pressure | cm H ₂ O |
| ppp | measured end expiratory pressure | cm H ₂ O |
| qqqqqq | status (1) | |
| c | checksum | |

(1) Status bytes (bit set = condition active):

Status bits reset in Auto Mode when alarm condition ends.

Status bits reset in Slave Mode immediately after data is transmitted.

| bit | byte 1 | status bit number |
|--------------------------------------|--------|-------------------|
| D0 - O ₂ > high set limit | | 1 |
| D1 - O ₂ < low set limit | | 2 |
| D2 - Apnea alarm | | 3 |
| D3 - Low patient MV alarm | | 4 |
| D4 - High pressure alarm | | 5 |
| D5 - Low pressure alarm | | 6 |
| D6 - 1 | | |

| bit | byte 2 | |
|---|--------|----|
| D0 - Sustained pressure alarm | | 7 |
| D1 - Sub-atmospheric pressure alarm | | 8 |
| D2 - AC fail (primary supply voltage low) | | 9 |
| D3 - Low battery alarm | | 10 |
| D4 - O ₂ Limit set error | | 11 |
| D5 - Setting range error | | 12 |
| D6 - 1 | | |

| bit | byte 3 | |
|--|--------|----|
| D0 - O ₂ probe failure alarm | | 13 |
| D1 - TVX probe failure | | 14 |
| D2 - Maximum pressure > 60 cm H ₂ O | | 15 |
| D3 - Reverse flow | | 16 |
| D4 - Low gas supply pressure alarm | | 17 |
| D5 - Apnea alarm off | | 18 |
| D6 - 1 | | |

| bit | byte 4 | |
|------------------------------------|--------|----|
| D0 - A/D conversion failure | | 19 |
| VENT FAIL 0 | | |
| D1 - CPU failure | | 20 |
| VENT FAIL 1 | | |
| D2 - ROM checksum failure | | 21 |
| VENT FAIL 2 | | |
| D3 - RAM read/write failure | | 22 |
| VENT FAIL 3 | | |
| D4 - Gas supply > 32 psig | | 23 |
| VENT FAIL 4 | | |
| D5 - Power loss: +5v & Vbat < 4.7v | | 24 |
| VENT FAIL 5 | | |
| D6 - 1 | | |

| bit | byte 5 | |
|---|--------|----|
| D0 - Flow output incorrect or continuously on | | 25 |
| VENT FAIL 6 | | |
| D1 - Exh. valve not on/off in insp/exp | | 26 |
| DRIVE CKT.OPEN | | |
| D2 - Gas supply control solenoid not on | | 27 |
| VENT FAIL 8 | | |
| D3 - D/A write/read failure | | 28 |
| VENT FAIL 9 | | |
| D4 - Pressure Transducer board failure | | 29 |
| VENT FAIL 10 | | |
| D5 - 7.5v supply out of range | | 30 |
| VENT FAIL 11 | | |
| D6 - 1 | | |

each entry is zero filled, right justified (ie. aaaa = 0095)

Appendix

bit

byte 6

D0 - Flow table values 0,FF or
non-increasing VENT FAIL 12

31

D1 - Inspiratory Pause on

32

D2 - 0

D3 - 0

D4 - 0

D5 - 0

D6 - 1

| MEAS | TV | MV | RR | O2 | PK | PT | EE | SET | TV | RR | IF | I:E | PL | LMV | LO | HO |
|------|------|----|----|----|----|----|----|------|----|----|----|-----|----|-----|----|----|
| 836 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 22 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.37 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 2 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.37 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 836 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 845 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 845 | 8.41 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.39 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 842 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.42 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 842 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 836 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 836 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 839 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |
| 836 | 8.40 | 10 | 21 | 18 | 0 | 1 | 1 | 1000 | 10 | 30 | 11 | 2.1 | 60 | 5.0 | 18 | 92 |

Figure 8-5
Printed sample of serial output

Format for data in printer mode:

output format

Heading frame (including 6 blank lines):

<LF><CR><LF><CR><LF><CR><LF><CR><LF><CR><LF><CR><LF><CR>

MEAS*TV*MV*RR*O₂*PK*PT*EE*SET*TV*RR*IF*I:E*PL*LMV*LO*HO

Data frame:

<LF><CR>

* = ascii space character (32 decimal)

Measured Parameters

| Heading | Format | Description | Units |
|----------------|--------|------------------------------|---------------------|
| TV | dddd | tidal volume | mL |
| MV | dd.dd | minute volume | L |
| RR | ddd | respiratory rate | B/m |
| O ₂ | ddd | oxygen concentration | % O ₂ |
| PK | ddd | peak inspiratory pressure | cm H ₂ O |
| PT | ddd | inspiratory plateau pressure | cm H ₂ O |
| EE | ddd | end expiratory pressure | cm H ₂ O |

Appendix

Parameter Settings

| Heading | Format | Description | Units |
|---------|---------|--|---------------------|
| TV | dddd | tidal volume | mL |
| RR | ddd | respiratory rate | B/m |
| IF | ddd | inspiratory flow | L/m |
| I:E | 1:ddd.d | inspiratory time: expiratory time ratio | --- |
| PL | ddd | inspiratory pressure limit | cm H ₂ O |
| LMV | d.d | low minute volume alarm limit | L |
| LO | dd | low oxygen alarm limit | % O ₂ |
| HO | dd | high oxygen alarm limit | % O ₂ |

Heading will be printed once every 59 outputs.

If the measured breath rate exceeds 60 breaths/minute, data will be output every other breath in order to prevent partial loss of data.

Leading zeros are suppressed except for 1's digit.

If in auto mode and in ventilator mode, output printed at each breath.

If in auto mode and in Monitoring mode, output printed at each breath or every 10 seconds.

If in slave mode, output printed in response to each send all data command.

Appendix H—Using A Bain Circuit

When you connect a Bain circuit and Bain circuit adapter to the Ohmeda 7810 Ventilator, you must place the volume sensor assembly in the proximal position, between the end of the Bain circuit and the patient connector to the ET tube or mask. The volume sensor must be located in the proximal position to correctly measure the patient's exhaled volume in systems that include a Bain circuit.

With a Bain circuit, fresh gas from the gas machine flows through the breathing circuit for the entire respiratory cycle. If the volume sensor is located distally, the ventilator will measure both the patient's exhaled volume and the fresh gas flow the Bain circuit adds to the exhaled volume. To avoid

measuring this fresh gas flow, the volume sensor must be placed proximally. When the volume sensor is in the proximal position, between the end of the Bain circuit and the patient connector to the ET tube or mask, the ventilator will measure and display the patient's exhaled volume.

If you are using a Bain circuit:

1. Locate the volume sensor assembly in the proximal position, between the end of the Bain circuit and the patient connector to the ET tube or mask.
2. Disable the ventilator's reverse flow alarm (see section 5.3).

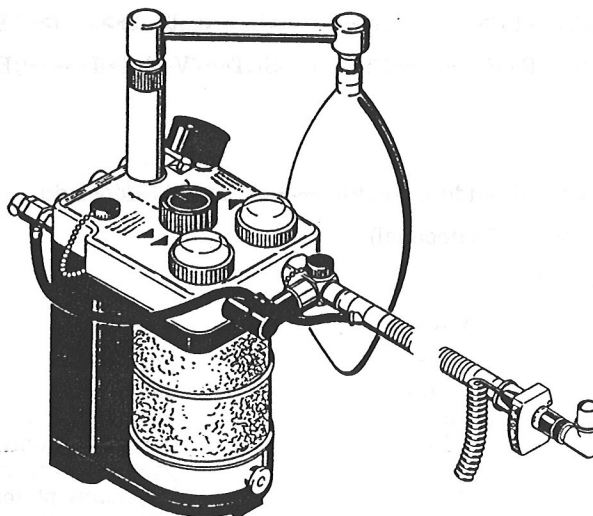


Figure 8-6

Correct placement of the volume sensor when used with a Bain circuit

Index

A

Absorber 3-11
Adjusting position 2-11
Bag/APL circuit
 testing 4-4
 Checking pressure gauge location 8-6
 Connecting to the bellows assembly 2-3
 installing 2-1
Accessories 8-4
Airway Pressure Monitoring
 Theory of operation 3-17
Alarms 3-22
 Anesthesia machine 3-22
 testing 4-4
 Apnea 3-25
 responding to 5-9
 setting 5-6
 testing 4-6
 Apnea alarm off message 3-27
 responding to 5-13
 Check O2 probe/check gas supply 3-26
 responding to 5-12
 Check settings 3-27
 Electrical disconnect or failure 3-22
 High oxygen 3-26
 responding to 5-10
 testing 4-5
 High pressure 3-25
 responding to 5-10
 testing 4-8
 Limit setting error 3-26
 responding to 5-12
 Limits, setting 5-5
 Low battery 3-26
 responding to 5-12
 Low minute volume 3-25
 responding to 5-11
 testing 4-6
 Low oxygen 3-25
 responding to 5-10
 testing 4-5
 Low pressure 3-25
 responding to 5-11
 setting 5-6
 testing 4-8
 Low supply pressure 3-26
 responding to 5-13
 Oxygen supply failure 3-13, 3-22
 Power failure 3-26
 responding to 5-12
 Responding to alarms 5-9
 Reverse flow 3-26
 responding to 5-12
 setting 5-4, 5-6
 testing 4-6
 Silencing 3-13
 Subatmospheric pressure 3-25
 responding to 5-11
 Sustained pressure 3-25
 responding to 5-11
 testing 4-8
 Ventilator 3-22
 responding to 5-9
 testing 4-5
 Ventilator failure 3-26
 responding to 5-13
 Ventilator setting error 3-26
 responding to 5-12

Volume, setting 5-5
Volume monitor standby 3-27
Alarm Indicator LEDs 3-14
Alarm Set Pushwheels
 Description 3-13
Alarm Silence Button
 Description 3-13
 Responding when alarms won't silence 5-14
Alarm System 3-22
Altitude Compensation, Setting 5-4
Anesthesia Machine
 Alarms, responding to 5-9
 Cleaning 6-7
 Framework 3-2
 Lubrication 6-10
 Powering on 5-3
 Specifications 8-1
 Sterilizing 6-7
 Shutting down 5-14
APL Valve, Testing 4-4
Apnea Alarm
 Definition 3-25
 Responding to 5-9
 Setting 5-6
 Testing 4-6
Apnea Alarm Off
 Definition 3-27
 Responding to 5-13

B

Bag, Breathing, Attaching 2-14
Bain Circuit 8-10
Battery 3-9, 3-10
 Alarm 3-26
 responding to 5-12
 Bypass button 3-6
 Checking 4-12
 Condition indicators 3-5
 Test button 3-6
Battery Bypass Button 3-6
Battery Test Button 3-6
Bellows Assembly
 Cleaning and sterilizing 6-1
 Connecting remotely 8-6
 Connecting to control module 2-3
 Connecting to the absorber 2-3
 Reassembly 6-3
 Theory of operation 3-15
Blood Pressure Gauge 3-8
 Inflation system, connecting 5-1
Breath Rate Dial Description 3-12
Breathing System
 Connections 2-14
 Excess Gas 3-15
 Testing 4-4
Breathing Bag, Attaching 2-14

C

Calibration, Oxygen thumbwheel 3-13
Check O2 Probe/Check O2 Supply Message
 Definition 3-26
 Responding to 5-12
Check Settings Alarm, Definition 3-27
Checkout Procedures 4-1
Circuit Breakers, Resetting 7-5

Index

Cleaning 6-1

- Anesthesia machine 6-7
- Bellows assembly 6-1
- Oxygen sensor assembly 6-5
- Oxygen sensor cartridge 6-6
- Scavenging interface relief valve 6-8
- Ventilator control module 6-1
- Volume sensor cartridge 6-4
- Volume sensor clip 6-4
- Common Gas Outlet 3-6
 - Connection to 2-14
- Communications Protocol 8-7
- Compliance Factor, Calculating 3-20
- Compliance Losses 3-20
- Control Module
 - Cleaning 6-1
 - Connecting to bellows assembly 2-3
 - Description 3-11
 - Front Panel
 - description 3-12
 - Reinstalling 7-7
 - Removing 7-5
- Control Range Computation 3-18
- Cylinder Yokes 3-9

D, E, F, G

- DC Power Supply Failure 3-10
- Electrical Disconnect/Failure Alarm 3-22
 - Responding to 5-9
- Electrical Pod 3-8
- Exhalation Valve 3-15
- Flow, Gas, Setting 5-6
- Flow Control Valves 3-4
- Flowmeters 3-4
- Gas Cylinders, Installing 2-10
- Gas Distribution Manifold 3-9, 3-10
- Gas Flow
 - Checking 4-3
 - Setting 5-6
- Gas Supply Module, Maintenance 6-10

H, I, J, K

- High Oxygen Alarm
 - Definition 3-26
 - Responding to 5-10
 - Testing 4-5
- High Pressure Alarm
 - Definition 3-25
 - Responding to 5-10
 - Testing 4-8
- I:E Ratio 3-18
- Indicator Lights 3-5
- Indicator Panel 3-5
- Inlet Adapter 2-14
- Inspiratory Flow Dial 3-12
- Inspiratory Pause Button 3-13
- Inspiratory Pressure Limit Dial
 - Description 3-12
 - Setting 5-5

L, M

- Language Selected 5-4
- Latching Strut 2-8
- Leak Check 4-1
- Leak Testing Device 4-2
- Lighting Panel 3-9

Limit Setting Error Alarm

- Definition 3-26
 - Responding to 5-12
 - Link 25 3-4
 - Testing 4-3
 - Low Battery Alarm
 - Definition 3-26
 - Responding to 5-12
 - Low Minute Volume Alarm
 - Definition 3-25
 - Responding to 5-11
 - Testing 4-6
 - Low Oxygen Alarm
 - Definition 3-25
 - Responding to 5-10
 - Testing 4-5
 - Low Pressure Alarm
 - Definition 3-25
 - Responding to 5-11
 - Setting 5-6
 - Low Pressure Gas Circuitry, Checking 4-2
 - Low Supply Pressure Alarm
 - Definition 3-26
 - Responding to 5-13
 - Lubrication, Anesthesia machine 6-10
 - Maintenance
 - Gas supply module 6-10
 - Oxygen sensor 6-9
 - Schedule 6-1
 - Mechanical Ventilation On/Off Switch 3-13
 - Monitor Pod 3-7
 - Adjusting 5-1
 - Monitoring
 - Alternate Locations 8-5
 - Checking connections 4-10
- ## O, P, Q
- Occluding, Warning 4-4
 - Optional
 - Accessories 8-4
 - Monitors 3-7
 - Oxygen Calibration Thumbwheel 3-13
 - Oxygen Flush Button 3-6
 - Oxygen Monitoring, Theory of operation 3-17
 - Oxygen Output 3-14
 - Oxygen Sensor, Calibration 6-10
 - Cartridge
 - cleaning and sterilizing 6-6
 - replacing 6-9
 - Cleaning and sterilizing 6-5
 - Connecting 2-7
 - Location (non-Ohmeda GMS absorber) 8-5
 - Maintenance 6-9
 - Theory of operation 3-15
 - Oxygen Supply Failure Alarm 3-10, 3-22
 - Responding to 5-9
 - Oxygen Supply Pressure 3-6
 - Patient Breathing Bag, Attaching 2-14
 - Patient Circuit Adapter 8-5
 - Patient Interface Panel 3-6
 - Pipeline 2-10
 - Connections 2-12
 - Inlets 3-9
 - Pipeline And Cylinder Supply, Checking 4-1
 - Pop-off Valve 3-15, 6-3
 - Power Failure Alarm
 - Definition 3-26
 - Responding to 5-12

Index

Preoperative Checklists 4-1
Pressure Gauge Window Panel 3-3
Pressure Limit Alarm 3-27, 5-13
Pressure Monitoring, Theory 3-17
Pressure Sensing
 Connecting tube 2-4
 Input 3-14
 Location on non-Ohmeda absorber 8-5
Pressure Sensor System 3-10

R, S

Record Keeper 3-3, 3-8
Reinstalling, Ventilator control module 7-7
Relief Valves, scavenging valve 3-10
Remote, Bellows assembly 8-6
Removing, Ventilator control module 7-5
Repair Policy 7-1
Replaceable Parts 8-5
Replacing, Oxygen sensor cartridge 6-9
Reverse flow alarm
 Definition 3-26
 Responding to 5-12
 Setting 5-4, 5-6
 Testing 4-6
RS232C 8-7
Scavenging Interface Relief Valve
 Cleaning 6-8
 Testing 4-12
Screen Contrast, Setting 5-4
Secondary Pressure Regulators 3-10
Serial Interface Connector 3-14
Setup Page
 Description 3-22
 Using 5-4
Shelves, Securing equipment 2-9
Shelves And Mounting Track 2-8
Specifications
 Anesthesia machine 8-1
 Ventilator 8-3
Sterilization 6-1
 Anesthesia machine 6-7
 Bellows assembly 6-1
 Oxygen sensor assembly 6-5
 Oxygen sensor cartridge 6-6
 Volume sensor cartridge 6-4
 Volume sensor clip 6-4
Subatmospheric Pressure Alarm 3-25, 5-11
Sustained Pressure Alarm
 Definition 3-25
 Responding to 5-11
 Setting 5-5
System Master Switch 3-5, 5-3
System Overview 3-1

T, U

Theory Of Operation 3-15
Testing
 Anesthesia machine alarms 4-4
 Battery 4-12
 Breathing system 4-4
 Gas flow controls 4-3
 Low pressure gas circuitry 4-2
 Pipeline and reserve cylinder supply 4-1
 Scavenging interface relief valve 4-12
 Ventilator alarms 4-5
 Volume sensor 6-8

Tidal Volume Compensation 3-20
Tidal Volume Dial Description 3-12
Top Shelf, Adjusting 2-8
Troubleshooting
 Guide 7-1
 System problems 7-1
 Ventilator 7-2
 Ventilator failure messages 7-3
Unpacking 2-1

V

Vaporizer
 Filling 5-2
 Installing 2-11
 Manifold 3-9
 Removing 2-11
 Setting 5-7
 Testing 4-3
Ventilation
 Cycle 3-15
 Beginning 5-7
 Parameters, setting 5-7
Ventilator
 Circuit, testing 4-5
 Communications protocol 8-7
 Connections
 checking 4-9
 Control Module
 reinstalling 7-7
 removing 7-5
 Description 3-11
 Modes 3-22
 Range 3-18
 Screen 3-12
 Setup page
 description 3-22
 using 5-4
 Specifications 8-3
 Troubleshooting 7-2
Ventilator Failure Messages
 Definition 3-26
 Responding to 5-13
 Troubleshooting 7-3
Ventilator Setting Error
 Definition 3-26
 Responding to 5-12
Vertical Track 2-8
Volume, Audio, Setting 5-4
Volume Monitor Standby 3-27
Volume Monitoring, Theory of operation 3-16
Volume Sensor
 Checking 6-8
 Connecting 2-5
 Using with a Bain Circuit 8-10
Volume Cartridge, Cleaning/sterilizing 6-4
Volume Clip, Cleaning/sterilizing 6-4
Volume Sensor Failure 5-14

W, X, Y, Z

Waste Gas Scavenging Connections
 To a high vacuum disposal system 2-12
 To a passive disposal system 2-12
Waste Gas Scavenging Valve 3-10
 Adjusting 5-9
 Mounting 2-2

Notes