SurgiVet™

# Capnograph

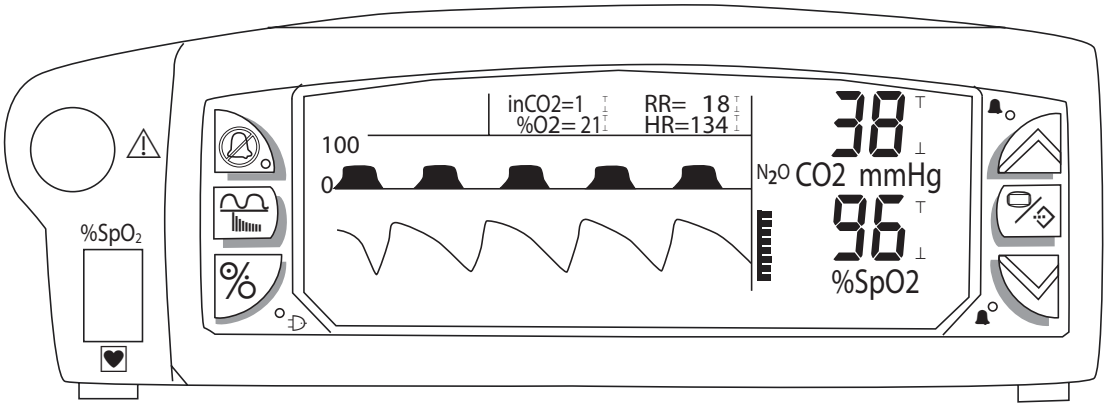
**V90040, V90041, V90043**

**Operation Manual**

# Low Flow Capnograph

**V900040LF, V90041LF, V90043LF**

**Operation Manual**




en English

Catalog Number V1872

Version 10, July 2008



smiths medical

# Table of Contents

**Warranty and Service Information ..... vii**

Proprietary Notice ..... vii
WARRANTY ..... vii
Limited Warranty ..... vii
Loaner Device (Domestic Sales Only) ..... viii
Disclaimer of Warranties ..... viii
Conditions of Warranty ..... viii
Limitation of Remedies ..... viii
Warranty Procedure ..... ix
CE Notice ..... ix

**Chapter 1: Introduction ..... 1-1**

About this Manual ..... 1-1
Definition of Symbols ..... 1-1
General Warnings, Cautions, and Notes ..... 1-2
Capnography Warnings, Cautions, and Notes ..... 1-4
Oximetry Warnings, Cautions, and Notes ..... 1-4
$FiO_2$ Warnings, Cautions, and Notes ..... 1-5

**Chapter 2: Intended Use and Monitor Description ..... 2-1**

Intended Use ..... 2-1
General Description ..... 2-1
Parameters ..... 2-1
Capnograph ..... 2-1
Oximeter (optional) ..... 2-1
$FiO_2$ (optional) ..... 2-1
Audio ..... 2-1
Serial Output ..... 2-2
Analog Outputs ..... 2-2
Power ..... 2-2
Front Panel ..... 2-2
VFD Display ..... 2-3
Keys ..... 2-4
Rear Panel ..... 2-5

**Chapter 3: Setting Up the Monitor ..... 3-1**

Unpacking the Monitor and Checking the Shipment ..... 3-1
Turning Alarm and Alert Tones On and Off ..... 3-1
Working With Menus ..... 3-1
Menu Structure ..... 3-1
Freezing and Releasing Displayed Waveforms ..... 3-2
Working With System-Wide Settings ..... 3-3

Setup/Volume Menu ..... 3-3
Setting the Time or Date ..... 3-3
Turning Parameter Monitoring On and Off ..... 3-4
Adjusting Waveform Sweep Time, Size or Scales ..... 3-4

**Chapter 4: Alarms ..... 4-1**

High Priority Alarms ..... 4-1
Medium Priority Alarms ..... 4-2
Alarm Limit Indicators ..... 4-2
Low Priority Alarms/Alerts ..... 4-3
Working with the Alarms Menu ..... 4-3
Adjusting or Viewing Alarm Limits ..... 4-4
Alarm Tones ..... 4-4
Turning Alarm Tones On and Off ..... 4-5
System Low Priority Alarm/Alert Condition: Low Battery ..... 4-5

**Chapter 5: Capnograph Theory of Operation ..... 5-1**

Theory of Operation ..... 5-1
Measuring $CO_2$ ..... 5-1
Measuring Respiration Rate ..... 5-1
$N_2O$ Compensation ..... 5-2

**Chapter 6: Pneumatics and $CO_2$ Calibration ..... 6-1**

Connecting a Non-Recirculating Scavenging System ..... 6-1
Checking for Leaks ..... 6-1
Calibrating the Capnometer ..... 6-1
Low Calibration ..... 6-2
Auto-Zero ..... 6-2
Low/High Calibration ..... 6-3
Connecting the Patient ..... 6-4
Attachment Selection Chart ..... 6-4

**Chapter 7: Capnograph and Display Menu ..... 7-1**

Capnograph Display ..... 7-1
Capnograph Menu ..... 7-2
Capnograph Messages ..... 7-3
High and Medium Priority Alarm Messages ..... 7-3
Low Priority Alarm/Alert Messages ..... 7-3
Status Message ..... 7-3
Calibration Messages ..... 7-4

**Chapter 8: Using the Oximeter Option ..... 8-1**
General Description ..... 8-1
Pulse Oximetry Theory of Operation ..... 8-1
Oximeter Display ..... 8-2
Oximeter Menu ..... 8-3
Adjusting the Pulse Beep Volume ..... 8-3
Adjusting or Viewing the Averaging Settings ..... 8-4
Oximeter Messages ..... 8-4
High Priority Alarm Messages ..... 8-4
Low Priority Alarm/Alert Messages ..... 8-5
Messages ..... 8-5
Attaching the Patient - Oximetry ..... 8-5
Choose the Sensor ..... 8-5
Clean or Disinfect the Sensors ..... 8-6
Attach the Sensor to the Patient ..... 8-6
Application Guide ..... 8-7
Universal "Y" (Lingual) Sensor ..... 8-7
Mini Clip ..... 8-7
Universal C-sensor ..... 8-8
Reflectance Sensor ..... 8-8
Pulse Oximeter Sensor Application Tips ..... 8-9
Testing Sensor Function ..... 8-9
Primary Applications for Sensors ..... 8-10
Lingual Sensor (Lingual and Mini Clip) ..... 8-10
C Sensor ..... 8-10
Reflectance Sensor ..... 8-10
Limitations ..... 8-10
Checking the Monitor's Performance ..... 8-10
**Chapter 9: Using the $FiO_2$ Option ..... 9-1**
Theory of Operation ..... 9-1
Connecting the $FiO_2$ Cell to the Monitor ..... 9-2
Calibrating the $FiO_2$ Cell ..... 9-2
$FiO_2$ Display ..... 9-3
$FiO_2$ Menu ..... 9-4
$FiO_2$ Messages ..... 9-4
High Priority Alarm Messages ..... 9-4
Low Priority Alarm/Alert Messages ..... 9-4
Indicators ..... 9-4
**Chapter 10: Trends ..... 10-1**
Trend Display ..... 10-1
Trends Menu ..... 10-2

**Chapter 11: Serial Output ..... 11-1**
Serial Out Menu ..... 11-1
Serial Output Setup ..... 11-2
Output Examples ..... 11-3
Patient Data ..... 11-3
Trend Table Data ..... 11-4
**Chapter 12: Analog Output ..... 12-1**
Analog Out Menu ..... 12-1
**Chapter 13: Routine Maintenance ..... 13-1**
Charging the Battery ..... 13-1
Cleaning and Disinfecting ..... 13-1
Maintenance Chart ..... 13-1
Long Term Storage ..... 13-2
**Chapter 14: Troubleshooting ..... 14-1**
Troubleshooting the Occlusion Low Priority Alarm/Alert ..... 14-2
**Chapter 15: Optional Supplies and Accessories ..... 15-1**
Ordering Information ..... 15-2
**Chapter 16: Specifications ..... 16-1**
Capnograph ..... 16-1
Respiration Rate ..... 16-1
$SpO_2$ ..... 16-2
Pulse Rate ..... 16-2
Pulse Strength ..... 16-2
$FiO_2$ ..... 16-2
Alarm Limits Ranges ..... 16-3
Audible Alarm Indicators ..... 16-3
Serial Output ..... 16-3
Analog Output ..... 16-4
Power ..... 16-4
Physical Dimensions ..... 16-4
Environment ..... 16-4
**Appendix A: Digital/Analog Output Protocol and Pinout ..... A-1**
General Description ..... A-1
Connector Pinout ..... A-1
**Appendix B: Guidance and Manufacturer's Declaration ..... B-1**
Guidance and Manufacturer's Declaration ..... B-1
Electromagnetic Emissions - Emissions Test ..... B-1
Electromagnetic Emissions – Immunity ..... B-1
Recommended Separation Distances ..... B-4
**Appendix C: Revision History ..... C-1**

The products described are covered by one or more of the following: 5,558,096, 5,386,833, and 5,615,091.

This page is intentionally left blank.

# Warranty and Service Information

## Proprietary Notice

Information contained in this document is copyrighted by Smiths Medical PM, Inc. and may not be duplicated in full or part by any person without prior written approval of Smiths Medical PM, Inc. Its purpose is to provide the user with adequately detailed documentation to efficiently install, operate, maintain and order spare parts for the device supplied. All information contained in this document is believed to be current and accurate as of the date of publication or revision, but does not constitute a warranty.

## WARRANTY

### Limited Warranty

Smiths Medical PM, Inc. ("Seller") warrants to the original purchaser that the Product, not including applicable accessories, shall be free from defects in material and workmanship under normal use, if used in accordance with its labeling, for two years from the date of shipment to the original purchaser.

Seller warrants to the original purchaser that the reusable oximeter sensors supplied as accessories shall be free from defects in materials and workmanship under normal use, if used in accordance with their labeling, for one year from the date of shipment to the original purchaser (USA only).

Seller warrants to the original purchaser that the AC Power supply/charger supplied, with the exception of part number 3005, shall be free from defects in materials and workmanship under normal use, if used in accordance with its labeling, for 1 year from the date of shipment to the original purchaser (USA only).

Seller warrants to the original purchaser that the reusable temperature cable supplied as an accessory shall be free from defects in materials and workmanship under normal use, if used in accordance with its labeling, for 6 months from the date of shipment to the original purchaser (USA only).

Seller warrants to the original purchaser that the reusable ECG leads, reusable invasive pressure cable, reusable NIBP purple hose, disposable temperature probe, disposable invasive pressure transducer and disposable sample lines supplied as accessories shall be free from defects in materials and workmanship under normal use, if used in accordance with its labeling, for 90 days from the date of shipment to the original purchaser (USA only).

Blood pressure cuffs carry a (6) six month warranty, pending evaluation by Smiths Medical PM, Inc. (SMPM) Technical Services. Cuffs that are contaminated, have liquid in them, have been misused/abused or are older than (6) months will not be covered under warranty. The sole obligation of SMPM under this warranty will be to repair or replace, at its option, products that prove to be defective during the warranty period.

The foregoing shall be the sole warranty remedy. Except as set forth herein, Seller makes no warranties, either expressed or implied, including the implied warranties of merchantability and fitness for a particular purpose. No warranty is provided if the products are modified without the express written consent of Smiths Medical PM, Inc., and Seller shall not be liable in any event for incidental or consequential damage. This warranty is not assignable.

Warranties are subject to change.  Please contact Smiths Medical PM Inc. for current warranty information.

## Loaner Device (Domestic Sales Only)

Smiths Medical PM, Inc. (SMPM) will, for the period of warranty, make loaner devices available at no charge (domestic sales only) if, in the opinion of SMPM, the repair of the customer's device would require an unreasonable period of time to repair, and there is a suitable loaner available during the time of the repair.

SMPM may make available a loaner device, for a fee, should it be requested while an out of warranty device is in for service.

## Disclaimer of Warranties

**THE FOREGOING EXPRESS WARRANTY, AS CONDITIONED AND LIMITED, IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED, BY OPERATION OF LAW OR OTHERWISE, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**

Seller disclaims responsibility for the suitability of the Product for any particular medical treatment or for any medical complications resulting from the use of the Product. This disclaimer is dictated by the many elements which are beyond Seller's control, such as diagnosis or patient, conditions under which the Product may be used, handling of the Product after it leaves Seller's possession, execution of recommended instructions for use and others.

## Conditions of Warranty

This warranty is void if the Product has been altered, misused, damaged by neglect or accident, not properly maintained or recharged, or repaired by persons not authorized by Seller. Misuse includes, but is not limited to, use not in compliance with the labeling or use with accessories not manufactured by Seller. This warranty does not cover normal wear and tear and maintenance items.

## Limitation of Remedies

The original purchaser's exclusive remedy shall be, at Seller's sole option, the repair or replacement of the Product. **THIS IS THE EXCLUSIVE REMEDY. In no event will Seller's liability arising out of any cause whatsoever (whether such cause is based in contract, negligence, strict liability, tort or otherwise) exceed the price of the Product, and in no event shall Seller be responsible for consequential, incidental, or special damages of any kind or nature whatsoever, including but not limited to, lost business, revenues and profits.**

## Warranty Procedure

To obtain warranty service or repair of SurgiVet® equipment in the USA, please contact Veterinary Clinical Support to obtain a Return Authorization Number. Please provide the serial number of all equipment that will be returned. **Any equipment returned for evaluation must be cleaned and decontaminated prior to being handled by our service technicians.** For cleaning instructions, please refer to the appropriate section in the operation manual. If equipment is returned prior to cleaning, and in our opinion it represents a potential biological hazard, the equipment will be returned to the sender as is.

Reference the return authorization number when returning your Product, freight and insurance prepaid by Purchaser, to:

Smiths Medical PM, Inc.
Attn: Repairs / return #
N7W22025 Johnson Drive
Waukesha, WI 53186

Veterinary Clinical Support
Telephone: 1-262-513-8500
Toll-Free: 1-888-745-6562 (USA only)
Fax: 1-262-513-9069
Web: www.surgivet.com

Seller will not be responsible for unauthorized returns or for loss or damage to the Product during the return shipment. The repaired or replaced Product will be shipped, freight prepaid by Seller, to Purchaser.

To obtain warranty information outside the USA, contact your local distributor.

**NOTE! Shipments received without a return number will be returned to sender.**

Keep all original packing material, including foam inserts. If you need to ship the device, use only the original packaging material, including inserts. Box and inserts should be in original condition. If original shipping material in good condition is not available, it should be purchased from Smiths Medical PM, Inc.

Damages occurred in transit in other than original shipping containers are the responsibility of the shipper. All costs incurred returning devices for repair are the responsibility of the shipper.

## CE Notice

Marking by the symbol CE indicates compliance of this device to the Medical Device Directive 93/42/EEC.

Authorized Representative (as defined by the Medical Device Directive):

Smiths Medical International Ltd.
Colonial Way, Watford, Herts,
WD24 4LG, UK

Tel: (44) 1923 246434
Fax: (44) 1923 240273

This page is intentionally left blank.

# Chapter 1: Introduction

## About this Manual

The Operation Manual provides installation, operation, and maintenance instructions for the veterinary professional trained in monitoring respiratory and cardiovascular activity.

**These instructions contain important information for safe use of the product. Read the entire contents of these Instructions For Use, including Warnings and Cautions, before using the monitor. Failure to properly follow warnings, cautions and instructions could result in death or serious injury to the patient.**

## Definition of Symbols

| SYMBOL | DEFINITION |
|---|---|
| Rx ONLY | Caution: Federal (U.S.A.) law restricts this device to sale by or on the order of a licensed veterinarian. |
|  | Type CF equipment. |
|  | Attention, see instructions for use |
|  | Refer servicing to qualified service personnel. |
|  | Output voltage |
|  | Input voltage |
|  | Printer output |
|  | Direct Current |
|  | Moisture Sensitive |
| IPX1 | Drip Proof (Monitor Only) |
|  | Serial Number |
|  | Catalog Number |
|  | Date of Manufacture |
|  | Non-AP Device |
|  | Class II Equipment |
|  | Alarm Silence |
|  | WAVE/TREND |
|  | On/Off |
|  | Up and Down Arrows |
|  | MENU/ENTER |
|  | Charge LED |
|  | Alarm LED |

| | |
|---|---|
|  Collect Separately | **Disposal (EU Countries)**<br>Under the Waste Electrical and Electronic Equipment (WEEE) Directive 2006/96/EC and implementing regulations, all devices and service items within the scope of the Directive purchased new after August 13, 2005 must be sent for recycling when ultimately becoming waste. Devices and items must not be disposed of with general waste.<br><br>If purchased before that date, they may also be sent for recycling if being replaced on a one-for-one, like-for-like basis (this varies depending on the country). Recycling instructions to customers using Smiths Medical products are published on the internet at: **http://www.smiths-medical.com/recycle** |
|  | **Disposal (other countries)**<br>When disposing of this device, its batteries or any of its accessories, ensure that any negative impact on the environment is minimized. Contact your local waste disposal service and use local recycling or disposal schemes. Separate any other parts of the equipment where arrangements can be made for their recovery; either by recycling or energy recovery. The main batteries are potentially harmful and will require separate disposal according to manufacturer's instructions or local regulations.<br><br>**Note: If applicable, EU, national or local regulations concerning waste disposal must take precedence over the above advice.** |

| KEYWORD | DEFINITION |
|---|---|
| **WARNING!** | Tells you about something that could hurt the animal or hurt the operator. |
| **CAUTION!** | Tells you about something that could damage the monitor. |
| **NOTE!** | Tells you other important information. |

## General Warnings, Cautions, and Notes

**WARNING! Do not use this device in the presence of flammable anesthetics.**

**WARNING! Do not autoclave, ethylene oxide sterilize, or immerse in liquid. Unplug before cleaning or disinfecting.**

**WARNING! ⚠ ELECTRICAL SHOCK HAZARD when cover is removed. Do not remove covers. Do not disassemble unit. Unit not user serviceable. Refer servicing to qualified personnel.**

**WARNING! Operation of this device may be adversely affected in the presence of computed tomograph (CT) equipment.**

**WARNING! Operation of this device may be adversely affected in the presence of conducted transients or strong EM or RF sources, such as electrosurgery and electrocaudery equipment, x-rays, and high intensity infrared radiation.**

**WARNING! Do not use this device in the presence of magnetic resonance imaging (MR or MRI) equipment.**

**WARNING! Do not plug the monitor into an outlet controlled by a wall switch.**

**WARNING! This device is intended for use by persons trained in professional health care. The operator must be thoroughly familiar with the information in this manual before using the monitor.**

**WARNING! This device must be used in conjunction with clinical signs and symptoms. This device is only intended to be an adjunct in patient assessment.**

**WARNING! If the accuracy of any measurement is in question, verify the patient's vital sign(s) by an alternative method and then check the monitor for proper functioning.**

**WARNING! Patient safety can be compromised by the use of a power supply not supplied by Smiths Medical PM, Inc. Use only the power supply included with your monitor, or approved by Smiths Medical PM, Inc.**

**WARNING! Ensure the device's AC rating is correct for the AC voltage at your installation site before using the monitor. The monitor's AC rating is shown on the external power supply. If the rating is not correct, do not use the monitor; contact Smiths Medical PM, Inc. service department for help.**

**WARNING! Disconnect the AC power supply from the outlet before disconnecting it from the monitor. Leaving the AC power supply connected to an AC power outlet without being connected to the monitor may result in a safety hazard.**

**WARNING! Do not allow any moisture to touch the AC power supply connectors or a safety hazard may result. Ensure that hands are thoroughly dry before handling the AC power supply.**

**WARNING! Do not place the monitor in the patient's bed. Do not place the monitor on the floor.**

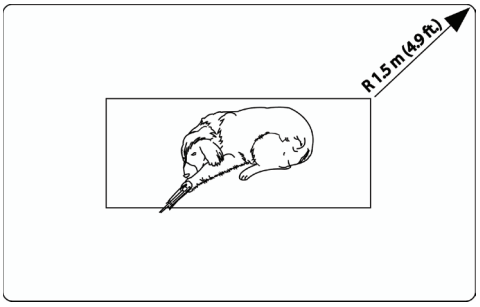
**WARNING! If there is a risk of the AC power supply becoming disconnected from the monitor during use, secure the cord to the monitor several inches from the connection.**

**WARNING! In the event that earth ground integrity is lost, the performance of this device and/or other devices nearby may be affected due to excessive RF emissions.**

**WARNING! When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the instrument's user manual for full instructions. Accessory equipment connected to the monitor's data interface must be certified according to the respective IEC standards, i.e., IEC 60950 for data-processing equipment or IEC 601-1 for electromedical equipment. All combinations of equipment must be in compliance with IEC 601-1-1 systems requirements. Anyone connecting additional equipment to the signal input port or signal output port configures a medical system, and, therefore, is responsible that the system complies with the requirements of the system standard IEC 601-1-1.**

**WARNING! IEC 60950 approved equipment must be placed outside of the "patient environment." The patient environment is defined as an area 1.5m (4.92 feet) from the patient.**

Figure 1.1: Patient Environment




**WARNING! Any monitor that has been dropped or damaged, should be inspected by qualified service personnel, prior to use, to insure proper operation.**

**WARNING! It is the operator's responsibility to set alarm limits appropriately for each individual patient.**

**CAUTION! Do not allow water or any other liquid to spill onto the monitor. Unplug the external power supply from the monitor before cleaning or disinfecting the monitor. Evidence that liquid has been allowed to enter the monitor voids the warranty.**

**CAUTION! Should the device become wet, wipe off all moisture and allow sufficient time for drying before operating.**

**CAUTION! The monitor should be operated from its internal power source (if fitted) if the integrity of the protective earth conductor is in doubt.**

**CAUTION! Follow local governing ordinances and recycling instructions regarding disposal and recycling of device components.**

**CAUTION! The monitor contains a 2 hour Ni-Cad battery. If the battery fails to hold a charge or otherwise becomes inoperable, the battery should be replaced and the old battery should be disposed of properly. Consult local officials for information about the proper disposal of the Ni-Cad battery. Smiths Medical Pm, Inc. Veterinary Division cannot dispose of monitor batteries.**

**CAUTION! Pressing front panel keys with sharp or pointed instruments may permanently damage the keypad. Press front panel keys only with your finger.**

**NOTE! All user and patent accessible materials are non-toxic.**

**NOTE! Each input and output connection of the monitor is electrically isolated. Connection of this monitor to other equipment will not increase leakage current.**

**NOTE! Performance and safety test data are available upon request.**

## Capnography Warnings, Cautions, and Notes

**CAUTION! Pump motors in the capnometer may adversely affect other medical equipment, e.g. ECG tracings.**

**CAUTION! Use of monitor during continuous nebulized medication delivery, will result in damage to the monitor (not covered by factory warranty). Disconnect the $ETCO_2$ sample line from the patient circuit or power off during medication delivery.**

**NOTE! During the autocal sampling, the $CO_2$ waveform and digits will disappear for 1-5 seconds. After this, breath detection restarts. This should happen only during extreme temperature changes, and not during normal patient monitoring.**

**NOTE! The auto-zero cal is the similar to a low cal, excluding ambient pressure, so as not to stop the pump.**

## Oximetry Warnings, Cautions, and Notes

**WARNING! Use only $SpO_2$ sensors supplied with, or specifically intended for use with, this device.**

**WARNING! Incorrectly applied sensors may give inaccurate readings. Refer to the sensor insert for proper application instructions.**

**WARNING! Failure to carefully route the cable from the sensor to the monitor may allow the patient to become entangled in the cable, possibly resulting in patient strangulation. Route the cable in a way that will prevent the patient from becoming entangled in the cable. If necessary, use tape to secure the cable.**

**WARNING! Prolonged use or the animal's condition may require changing the sensor site periodically. Change sensor site and check skin integrity, circulatory status, and correct alignment at least every 4 hours.**

**WARNING! When attaching $SpO_2$ sensors with Microfoam® tape, do not stretch the tape or attach the tape too tightly. Tape applied too tightly may cause inaccurate readings and blisters on the animal's skin (lack of skin respiration, not heat, causes the blisters).**

**WARNING! Dyes introduced into the bloodstream, such as methylene blue, indocyanine green, indigo carmine, patent blue V (PBV), and fluorescein may cause an inability to determine accurate $SpO_2$ readings.**

**WARNING! Any condition that restricts blood flow, such as use of a blood pressure cuff or extremes in systemic vascular resistance, may cause an inability to determine accurate pulse and $SpO_2$ readings.**

**WARNING! Significant levels of dysfunctional hemoglobins, such as carboxyhemoglobin or methemoglobin, will affect the accuracy of the $SpO_2$ measurement.**

**WARNING! $SpO_2$ measurements may be adversely affected in the presence of high ambient light. If necessary, shield the sensor area (with a surgical towel, for example).**

**WARNING! Optical cross-talk can occur when two or more sensors are placed in close proximity. It can be eliminated by covering each site with opaque material.**

**WARNING! Under certain clinical conditions, pulse oximeters may display dashes if unable to display SpO2 and/or pulse rate values. Under these conditions, pulse oximeters may also display erroneous values. These conditions include, but are not limited to: patient motion, low perfusion, cardiac arrhythmias, high or low pulse rates or a combination of the above conditions. Failure of the clinician to recognize the effects of these conditions on pulse oximeter readings may result in patient injury.**

**NOTE! The low $SpO_2$ alarm limit minimum test value is 80. If an operator changes the low $SpO_2$ alarm limit to a value less than 80, and a power down - power up sequence takes place, a minimum value of 85 takes the place of the operator entered value.**

## $FiO_2$ Warnings, Cautions, and Notes

**WARNING! The displayed message $FiO_2$ Ref Err indicates a factory calibration setting is incorrect. Contact your authorized repair center.**

**WARNING! Each $FiO_2$ cell has different output characteristics; changing the $FiO_2$ cell without calibrating the monitor can result in incorrect displayed $FiO_2$ values. The incorrect values are unpredictable in both magnitude and direction, possibly resulting in hypoxic $FiO_2$ gas mixtures while displaying high $FiO_2$ values. It is your responsibility to properly calibrate the monitor after changing $FiO_2$ cells.**

**NOTE! Store the $FiO_2$ cell as shipped in its protective wrapping, until it is ready to use. This maximizes the $FiO_2$ cell's shelf life.**

**NOTE! Prolong $FiO_2$ cell life by avoiding high $O_2$ and $CO_2$ concentrations when it is not in use.**

This page is intentionally left blank.

# Chapter 2: Intended Use and Monitor Description

## Intended Use

The SurgiVet® V9004 Capnograph is a low cost $CO_2$ monitor with optional $SpO_2$ and $FiO_2$. It may be used in veterinary hospitals, clinics and during emergency transport. It is intended to be used in all critical environments, including ventilatory applications, animal transport, and anesthesia. The oximetry option works with all SurgiVet® oximetry sensors, providing $SpO_2$ and pulse rate on all patients. The V9004 permits continuous monitoring with adjustable alarm limits as well as visible and audible alarm signals. It is not intended nor designed to be used as an apnea monitor. The V9004 Capnograph will operate accurately over an ambient temperature range of 0 to 50°C (32 to 122°F).

## General Description

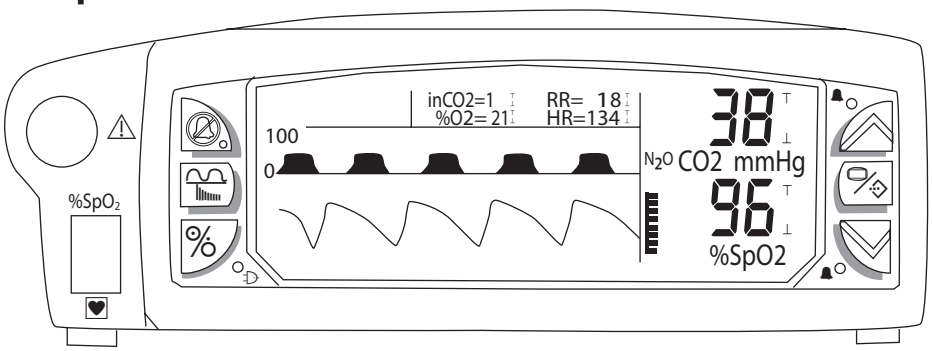



Figure 2.1: Expanded Waveform Mode

### Parameters

The SurgiVet® V9004 Capnograph monitor is a capnograph with optional oximetry and $FiO_2$ monitoring. Alarm limits can be set on all monitored parameters.

### Capnograph

The monitor performs side-stream capnography and continuously displays End-Tidal $CO_2$ ($ETCO_2$) and Inspired $CO_2$ ($inCO_2$) in measurement units of millimeters of Mercury (mmHg), kilo Pascals (kPa), or percent volume (%), as well as Respiration Rate (RR). An optical microbench provides the $CO_2$ measurements. A $CO_2$ waveform is displayed. The user may enable 40% Nitrous ($N_2O$) compensation. A water removal system prevents moisture and obstructions from occluding the pneumatic system.

### Oximeter (optional)

The monitor also supports oximetry, which continuously measures and displays arterial blood oxygen saturation ($SpO_2$) and Pulse Rate (HR). Oximetry includes the display of a plethysmogram and pulse strength bar. The monitor beeps with each pulse beat. The volume of the pulse beep is adjustable. The pitch of the pulse beep varies with the $SpO_2$ value. A variety of sensors are available for monitoring this parameter.

### $FiO_2$ (optional)

An additional option is the display of Fractional Inspired Oxygen ($FiO_2$ or $\%O_2$). The monitor uses electrochemical $O_2$ sensors from Catalyst Research, Teledyne, or Draeger.

### Audio

The monitor uses a multi-frequency speaker for beeps and alarm/alert sounds. Volumes are adjustable.

### Serial Output

An RS-232C interface allows serial output of text data to either a PC or a compatible serial printer. There is no waveform data on the serial output.

### Analog Outputs

There are three analog channels with user-selectable outputs of waveform or parameter data, or calibration signals.

### Power

The SurgiVet® V9004 operates on power from an external power supply. In addition, the monitor contains an internal battery which will allow operation for approximately two hours.

## Front Panel

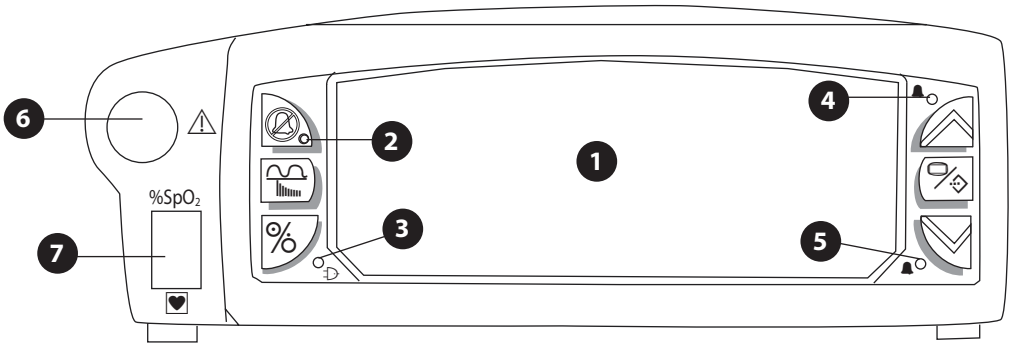



Figure 2.2: Front Panel

**1 VFD Display**
The vacuum fluorescent display (VFD) provides continuous, real-time updates of one or two waveforms or measurement trends, all measured values, and alarm or alert messages. The display also shows alarm limits indicators, menus, a pulse strength bar (if the oximeter is installed) and the $N_2O$ compensation "enabled" indicator.

**2 Alarm Silence LED (yellow)**
Flashes during two-minute alarm silence. Stays on steady during indefinite alarm silence.

**3 Charge LED (green)**
Is on steady while external power is applied and battery is fully charged. Indicates battery is charging by blinking very slowly while external power is applied. If there is no external power, then this LED is off.

**4 HIGH PRIORITY ALARM LED (red)**
This ALARM indicator flashes during patient alarms.

**5 LOW PRIORITY ALARM/ALERT LED (yellow)**
This ALERT indicator flashes during a system alarm, but remains on steady if there is no system alarm and a low battery condition exists.

**6 Gas Inlet Port**
The capnograph moisture trap and sample line are connected here. **The patient sample line should never be connected directly to this port.** A disposable moisture trap connects to the port, and the sample line connects to the moisture trap.

**7 $SpO_2$ Connector**
The oximeter sensor patient cable is connected here.

## VFD Display

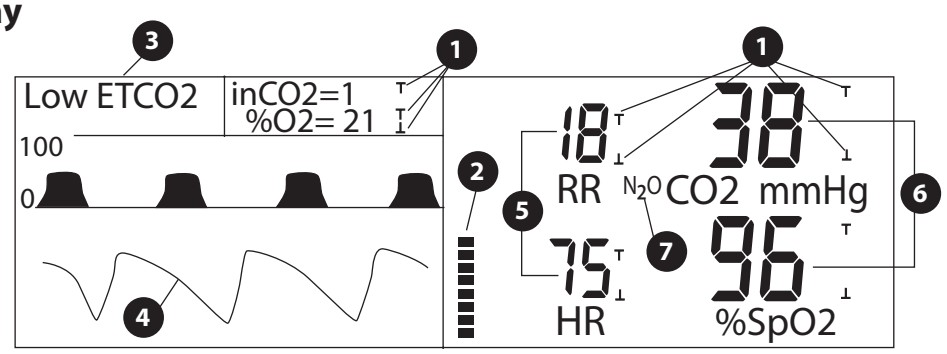



Figure 2.3: VFD Display (Normal Mode)

### 1 Alarm Limit Indicator

Displayed if the corresponding limit is not set to OFF. Indicator blinks if limit is violated. Every set of digits has at least one alarm limit. The top indicator of a pair is for the High Limit, the bottom indicator is for the Low Limit.

### 2 Pulse Bargraph

The pulse signal strength is displayed here if the oximeter is installed.

### 3 Message Area

Messages for alarms, alerts, and system information are displayed here on two lines. If more than one message must be displayed on the same line, then they alternate once per second.

### 4 Waveforms, Trends, Menus

One or two waveforms are displayed here in either expanded wave mode [fig 2.1] or normal mode [fig 2.3]. A trend graph or a menu can be displayed in place of waveforms. Trends and menus always expand this waveform area, relocating the parameters as described below.

### 5 Relocatable Parameters

Respiration Rate (RR) and Pulse Rate (HR) are shown as medium-size digits in this area in NORMAL display mode. Normal display mode can exist only if an oximeter is installed. In EXPANDED waveform mode, these parameters become small digits and move next to in$CO_2$ and %$O_2$ above the waveform area. [fig. 2.1].

### 6 Main Parameters

If the oximeter is installed, $ETCO_2$ and $SpO_2$ readings are always displayed in this area as large digits.

**NOTE! If there is no oximeter, then $ETCO_2$ and RR are displayed here, and the waveform area is always expanded.**

### 7 $N_2O$ Comp Indicator

This indicator, **N20**, is displayed next to the $CO_2$ label whenever 40% $N_2O$ compensation is enabled through menus.

## Keys

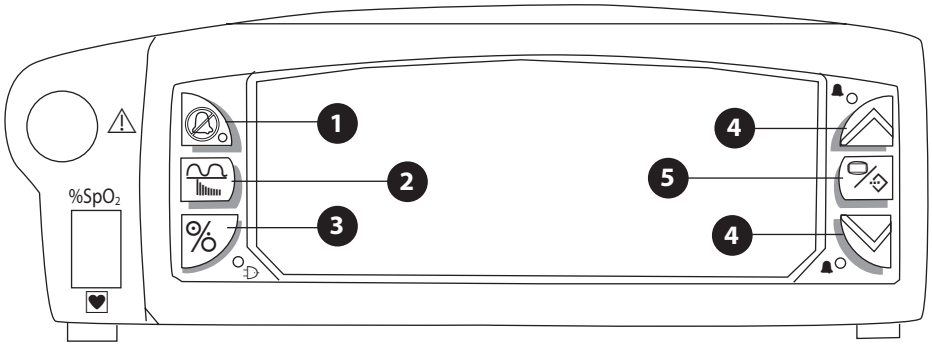



Figure 2.4: Keys

### 1 ALARM SILENCE

Pressing disables the audible alarm tone for two minutes. (Yellow light on this key flashes.) Pressing and holding this key for about three seconds disables the alarm tone indefinitely. (Yellow light on this key is lit and not flashing.) Pressing this key momentarily cancels either alarm silence condition.

The monitor defaults to two minute alarm silence at power up.

### 2 WAVE/TREND

This key controls the waveform area display. Press this key to display the $CO_2$ wave by itself, or both $CO_2$ and the oximeter's plethysmogram, or a trend.

Press while menus are displayed for a quick menu exit. The waveform or trend previously displayed will replace the menu.

### 3 STNBY/ON

Pressing switches the monitor between ON (monitoring a patient) and STANDBY (monitor off, but power is applied if the green indicator is lit.)

### 4 UP/DOWN ARROWS

If a Menu is displayed, press the or to move among menu items or to adjust the value of a selected item. If a Trend is displayed, the ARROW keys cycle between trended parameters.

### 5 MENU/ENTER

Press this key to display the list of menus. While menus are displayed, press to select a menu item or to accept a value which has been adjusted.

## Rear Panel

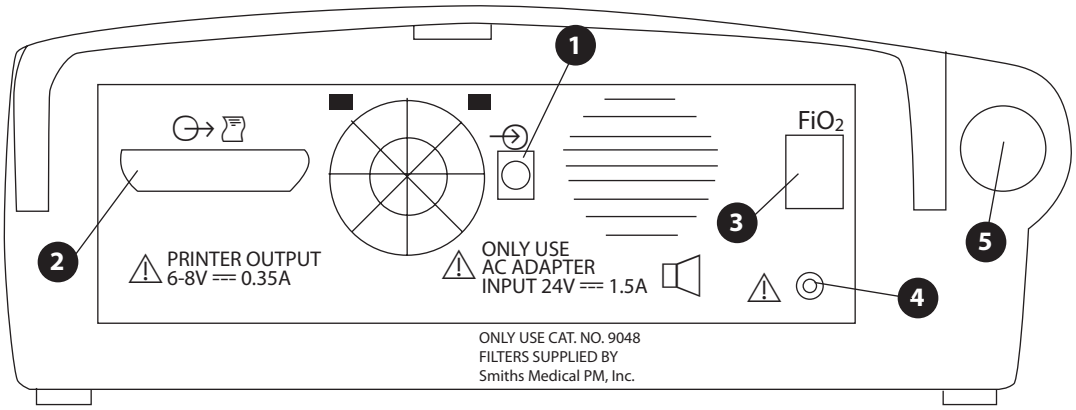



Figure 2.5: Rear Panel

### 1 Power Input

The external power supply attaches to this connector.

### 2 Digital/ Analog Outputs

An external RS-232C communication device can be connected to the monitor through this port. Use printer cable (catalog #3365) to attach to a printer or cable (catalog #3366) to attach to a computer's serial port.

Analog signals representing $ETCO_2$, $inCO_2$, $CO_2$ waveform, plethysmogram, pulse rate, respiration rate, $FiO_2$, and $SpO_2$ are routed to this connector for use with chart recorders and similar devices.

### 3 $FiO_2$ Connector

Optional $FiO_2$ sensor (catalog #9190) connector.

### 4 Gas Exhaust Port

A scavenging line may be connected to this port. Gas sampled by the monitor is removed through this port.

### 5 Filter Port

Connect the filter (catalog #9048) to this port. The filter provides additional protection against moisture.

To connect the filter:

1. Connect the female end into the male Luer on the tubing. Push in and twist the filter until it is firmly seated.
2. Connect the male end to the port on the monitor.
3. Perform a leak test according to the monitor's instructions.

**NOTE! Attach Luer-Lock fittings with a strong twisting motion to insure an air tight seal.**

This page is intentionally left blank.

# Chapter 3: Setting Up the Monitor

## Unpacking the Monitor and Checking the Shipment

Carefully remove the monitor and accessories from the shipping carton. Save the packing materials in case the monitor or accessories must be shipped or stored. Compare the packing list with the accessories received to make sure the shipment is complete.

**WARNING! Any monitor that has been dropped or damaged, should be inspected by qualified service personnel, prior to use, to insure proper operation.**

## Turning Alarm and Alert Tones On and Off

When the monitor is turned on, the alarm and alert tones are silenced for two minutes. The SILENCED indicator, which is on the 🔔 key, flashes during the two minute time-out.

- To silence the alarm and alert tones indefinitely: Press and hold 🔔 for about three seconds; the SILENCED indicator lights steady.

**NOTE! To comply with government requirements for patient monitoring, the indefinite alarm and alert tone silence feature may not be available in monitors shipped to your country.**

- To silence the alarm and alert tones for two minutes: Momentarily press 🔔; the SILENCED indicator flashes. If tones are already silenced, press 🔔 twice (the first press cancels alarm silenced; the second press silences the alarms for two minutes).
- To cancel either two minute or indefinite alarm silence and enable alarm and alert tones: Momentarily press 🔔; the SILENCED indicator turns off.

## Working With Menus

### Menu Structure

**Freeze Wave**

**Alarm Limits**

Set ETCO2 High and Low Alarms
Set Resp Rate High and Low Alarms
Set inCO2 High Alarm
Set SpO2 High and Low Alarms
Set Pulse Rate High and Low Alarms
Set FiO2 High and Low Alarms

**Setup/Volume**

Adjust Alarm Volume
Adjust Pulse Volume
Expand/Shorten Waveform
Set Clock Time and Date

**Capnograph**

Low CO2 Calibration
Low/High CO2 Calibration
Enable/Disable 40% N20 Compensation
Change Filter Yes/No
Disable/Enable Capnograph Function
Select CO2 Waveform Scale
Select CO2 Waveform Sweep Speed
Select CO2 Units (mmHg, kPa, %)

**Oximeter (Optional)**

Adjust Pulse Volume
Disable/Enable Oximeter Function
Select Averaging Parameters
Select Pleth Waveform Sweep Speed

**FiO2 (Optional)**

Disable/Enable FiO2 Function
Calibrate at 21% O2
Calibrate at 100% O2
Check Time & Date of Last Cal

| Trends |
| --- |
| Select Display Time<br>Select Trend Display Scales for Each Parameter<br>Clear Trend Memory |

| Analog Out |
| --- |
| Assign Data/Waveform Output to Each of 3 Channels<br>Assign 1V Cal Signal<br>Assign 0V Cal Signal |

| Serial Out |
| --- |
| Start/Stop Serial Output<br>Select Data Format<br>Select Print Interval or Duration |

The operator chooses various monitor settings through menus which appear in the waveform area. The (MENU/ENTER) keys and ARROW ( ∧ or ∨) keys are used to select menu items and change settings.

1. To show the Main menu: Press the (MENU/ENTER) key. Menus replace any waveforms displayed and may relocate some parameter digits.

2. To select a menu item: Press the ARROW ( ∧ or ∨) keys until the selector arrow points to the desired item, then press (MENU/ENTER). This will either take you to a new menu, start a function such as calibration, or allow the selected item to be adjusted.

3. To change a setting for a selected menu item: After pressing (MENU/ENTER) as in step 2, the item which can be changed will be highlighted. Use the ( ∧ or ∨) keys to select the desired setting, then press (MENU/ENTER) to accept that setting.

4. To exit the current menu: Select the **[EXIT]** menu item

5. To exit all menus quickly and return to the previous monitoring screen: Press (WAVE/TREND).

**NOTE! If menus are shown and you do not press menu keys for 20 seconds, the waveform display will return, and any current menu selections will be accepted.**

## Freezing and Releasing Displayed Waveforms

Displayed waveforms, except trends, can be frozen and released quickly. To freeze or release waveforms, press: MENU/ENTER, MENU/ENTER (MENU/ENTER MENU/ENTER).

- The first key press displays the Main Menu.
- The second key press selects the first item in the Main Menu, which is "Freeze Wave". This automatically exits to the waveform screen to show the results.
- If waveforms are already frozen, "Freeze Wave" allows them to update again.

**NOTE! While waveforms are frozen, the message "Waves Frozen" is shown in the message area at the top of the display (subject to message priority.)**

**NOTE! Trends are not affected by the waveform freeze feature. Trends continue to be collected while the waveforms are frozen.**

**NOTE! Analog outputs are not affected by the waveform freeze feature. If waveforms are selected for the analog output channels, then waveform data will continue to be output while the displayed waveforms are frozen.**

**NOTE! Displayed numeric values are not affected by the waveform freeze feature. The numeric values continue to be updated and displayed while the displayed waveforms are frozen.**

## Working With System-Wide Settings

This section describes working with system-wide settings using the **Setup/Volume** menu. Some system-wide settings also can be viewed or adjusted using one of the parameter menus (**Capnograph**, **Oximeter**, or **FiO2 Cell** menu). For information on the parameter menus, refer to the chapter of the manual that describes the parameter.

### Setup/Volume Menu

The following system-wide settings are viewed and/or adjusted from the Setup/Volume menu:

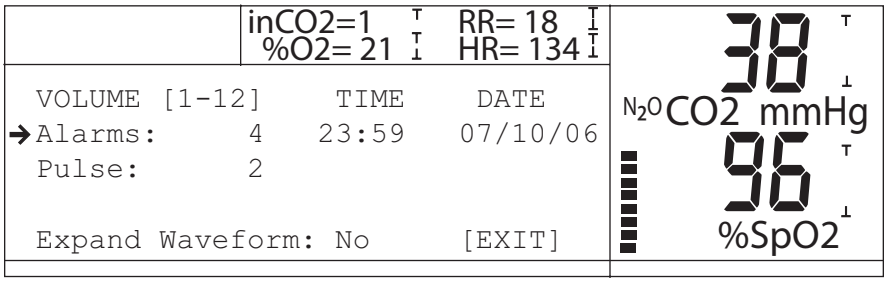



Figure 3.1: Setup menu

### VOLUME
Indicates the Alarm and Pulse volume. Allows the volume to be adjusted in the range of 1 to 12. Pulse volume can be set to OFF. Alarm volume cannot be shut off.

### TIME & DATE
Indicates the clock's time and date setting. Allows the time and date setting to be changed.

### Expand Wave
**No** means the waveform area will be shortened when not in menus nor trends. In this mode, four sets of large digits can be displayed adjacent to the waveform area. **Yes** means the waveform area will be expanded. It will remain the same length as the menu area. In expanded mode, only two sets of large digits can be shown to the right of the waveform area. The rest appear above the waveforms.

In either mode, the pulse bar is always displayed to the right of the waveform area.

### Setting the Time or Date

The monitor has a real-time clock and calendar. It remembers the time and date, even when the monitor is turned off or is not connected to the external charger. The time and date are used for the trends and printouts.

To set the time and/or date, do the following:

1. From the Main menu, select the "**Setup/Volume**" item:
2. Use the ARROW ( ^ or ^) keys to select the time or date item to be changed, then press MENU/ENTER. ( ).
3. Use the ARROW ( ^ or ^) keys to adjust the setting, then press MENU/ENTER ( ) to accept the value.
4. Repeat steps 2 and 3 for each time and date field to be changed.
5. Select **[EXIT]** or press WAVE/TREND ( ) to exit menus.

## Turning Parameter Monitoring On and Off

Monitoring for the following parameters can be turned on or off:

- Capnograph ($CO_2$ waveform, $ETCO_2$, inspired $CO_2$, respiration rate)

**NOTE! $CO_2$ monitoring can be turned off only if oximetry or $FiO_2$ is installed.**

- Oximeter (Plethysmogram, $SpO_2$%, pulse rate, pulse strength)
- $FiO_2$ (% Oxygen)

When turned off, displays, indicators, and alarms related to the parameter are disabled. The parameter occupies a space on the display and in the serial output, but its value is shown as dashes (---). If the parameter is assigned to an analog channel, that channel shows 0 Volts. If a parameter has a waveform, its waveform area shows a monitor off message.

To turn a parameter's monitoring on or off, do the following:

1. From the Main menu, select the desired parameter's menu item: **Capnograph**, **Oximeter**, or **FiO2**.
2. In the parameter's menu, select the monitor on/off item.
3. Press MENU/ENTER ( ) and use the ARROWS ( ^ or v ) to adjust the setting.
4. Select **[EXIT]** or press WAVE/TREND to exit menus.

## Adjusting Waveform Sweep Time, Size or Scales

The sweep time, height, and scales for waveforms can be adjusted as follows:

1. The $CO_2$ waveform sweep time and display scales can be adjusted in the capnograph menu.
2. The $CO_2$ waveform can be displayed by itself to use the full height of the waveform area by selecting this format with the WAVE/TREND ( ) key.
3. The Plethysmogram sweep time can be adjusted in the **Oximeter** menu. The waveform is scaled automatically to fit the display area.
4. Waveform displays can be made longer or shorter through the **Setup/Volume**, **Expand Wave** menu item. [See fig. 3.1: Setup Menu]
5. Each parameter's trend display scales can be adjusted separately through the **Trends**, **Set Scales** menu.

# Chapter 4: Alarms

## High Priority Alarms

A *high priority alarm* warns you when a patient's measurement matches or exceeds the high or low alarm limit for that measurement. For example, if the low $ETCO_2$ alarm limit is set to 37, and the patient's measured $ETCO_2$ is 30, an alarm is triggered. During an alarm:

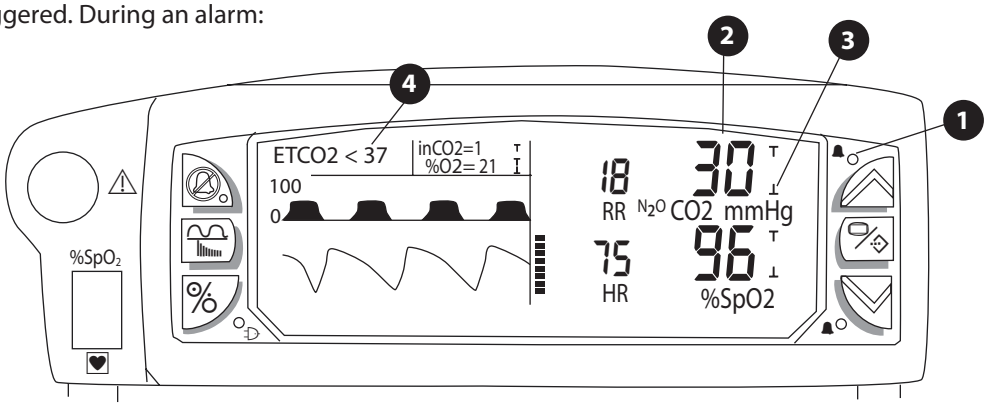



Figure 4.1: Alarm Example

1. The HIGH PRIORITY ALARM LED flashes.
2. The digits for the violated alarm limit flash.
3. The alarm limit indicator for the violated parameter flashes.
4. A message is displayed (subject to the display priority).
   - The high priority alarm tone sounds (if not silenced).

**NOTE! The alarm actions occur for each violated alarm, even if more than one alarm is violated at the same time.**

**CAUTION! It is the operator's responsibility to set alarm limits appropriately for each individual patient.**

## Medium Priority Alarms

A *medium priority alarm* warns you when a patient's $ETCO_2$, $inCO_2$, or respiration rate measurement matches or exceeds the high or low alarm limit for that measurement during the first 2 minutes after power up. After 2 minutes, the medium priority alarm will become a high priority alarm, if the alarm limits are still exceeded. During a medium priority alarm:

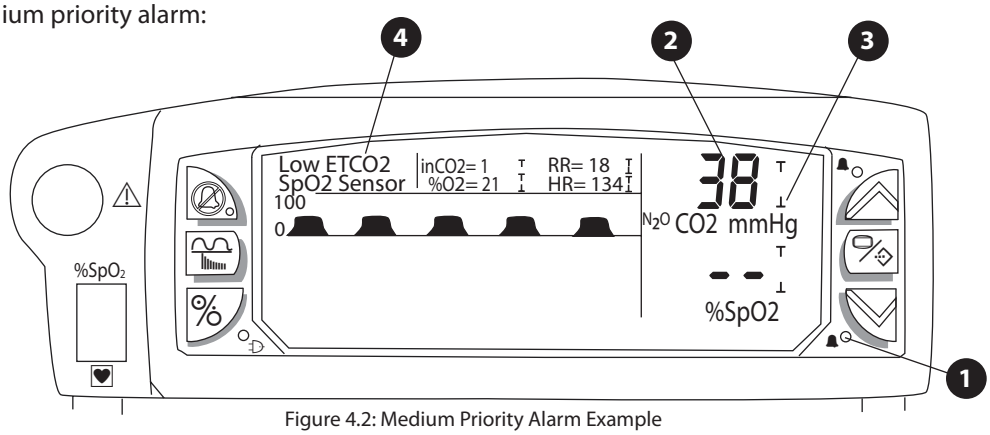



Figure 4.2: Medium Priority Alarm Example

1. The MEDIUM/LOW PRIORITY ALARM/ALERT LED flashes.
2. The digits for the violated parameter flash.
3. The alarm limit indicator for the violated parameter flashes.
4. A message is displayed (subject to the displayed priority).
   - The medium priority alarm tone sounds (if not silenced).

## Alarm Limit Indicators

The uppermost indicator represents the high alarm limit; the lowermost indicator represents the low alarm limit. Each indicator shows three conditions:

| ALARM INDICATOR | ALARM LIMIT CONDITION |
|---|---|
| Not Displayed | The alarm limit is set to OFF. |
| On Steady | The alarm limit is set and is not violated. |
| On and Flashing | The alarm limit is violated. |

## Low Priority Alarms/Alerts

A *low priority alarm/alert* warns you about a condition that prevents the monitor from taking a measurement. For example, if the $SpO_2$ sensor is not connected to the monitor, the monitor cannot measure the patient's pulse rate or $SpO_2$ value. In this case, an low priority alarm/alert is triggered. During a low priority alarm/alert:

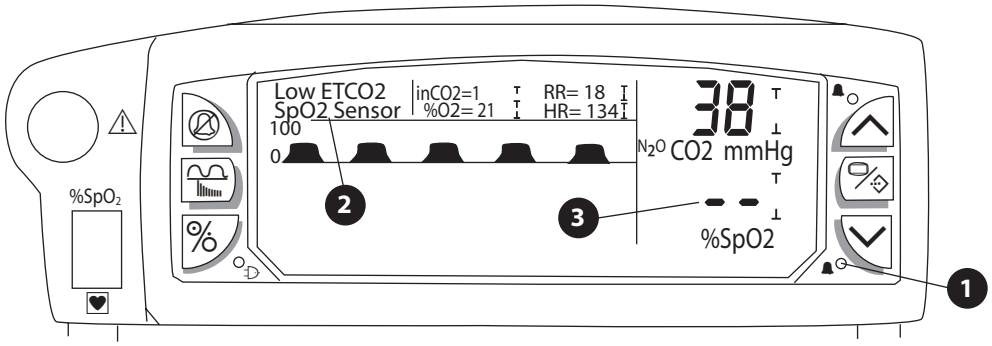



Figure 4.3: low Priority Alarm/Alert Example

1. The MEDIUM/LOW PRIORITY ALARM/ALERT LED is lit.
2. A message is shown on the display (subject to the display priority).
3. Dashes indicate measurement is unavailable.
   - The low priority alarm/alert tone sounds (if not silenced).

## Working with the Alarms Menu

This section describes working with alarms using the Alarms menu. For information on the parameter menus, refer to the chapter of the manual that describes the parameter.

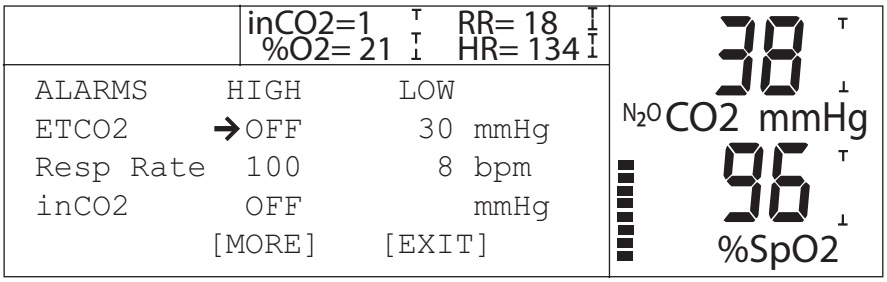



Figure 4.4: Alarm Limits Menu

### HIGH and LOW
Indicates the high and low alarm limit for each measurement. Allows the alarm limits to be adjusted.

### [MORE]
Accesses an additional alarm limits menu.

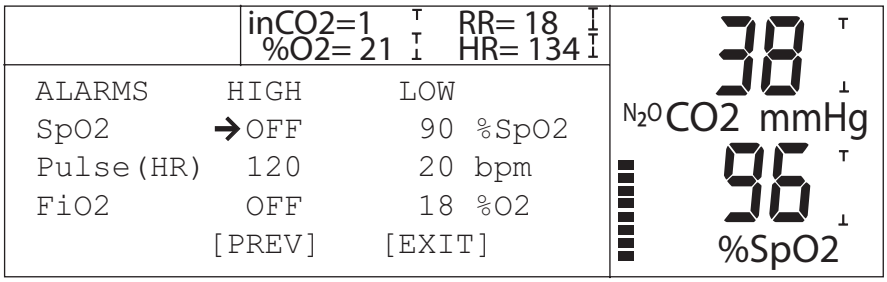



Figure 4.5: More Alarm Limits Menu

**[PREV]**
Accesses the previous alarm limits menu.

## Adjusting or Viewing Alarm Limits

**NOTE! User set alarm limits will be retained through power cycles.**

1. From the Main menu, select the Alarm Limits item.
2. Using the ARROW( ∧ or ∨) keys, select the alarm limit to be changed under the HIGH or LOW column.
3. Press the MENU/ENTER ( ) key to highlight the value. Use the arrow keys to adjust the value. Press the MENU/ENTER ( ) key to set the value.
4. Select **[MORE]** or **[PREV]** to access other alarm limits.
5. Select **[EXIT]** or press the WAVE/TREND ( ) key to exit menu.

**NOTE! Alarms can be tested while the monitor is in use by setting alarm limits such that the measured parameter reading is outside the alarm limits. Be sure to restore alarm limits to the required settings after testing.**

## Alarm Tones

The high priority alarm tone is a series of two bursts of five beeps (beep, beep, beep, pause, beep, beep) repeated every 10 seconds. The medium priority alarm tone is a series of 3 beeps repeated every 20 seconds. The low priority alarm/alert tone is a series of 2 beeps repeated every 30 seconds.

- The high, medium, and low priority alarm/alert tones sound at the same volume.
- The volume can be adjusted in the **Setup/Volume** menu.
- The volume cannot be set to OFF.
- All alarm tones except the Low Battery low priority alarm can be silenced.

## Turning Alarm Tones On and Off

When the monitor is turned on, the alarm tones are silenced for two minutes. The SILENCED indicator on the ALARM SILENCE (🔕) key flashes during the two minute time-out.

- To silence the alarm tones indefinitely: Press and hold ALARM SILENCE (🔕) for about three seconds; the SILENCED indicator lights steady.

**NOTE! To comply with government requirements for patient monitoring, the indefinite alarm and low priority/alert alarm tone silence feature may not be available in monitors shipped to your country.**

- To silence the alarm tones for two minutes: Momentarily press ALARM SILENCE (🔕); the SILENCED indicator flashes. If tones are already silenced, press ALARM SILENCE (🔕) twice (the first press cancels alarm silenced; the second press silences the alarms for two minutes).
- To cancel either two minute or indefinite alarm silence and enable alarm tones: Momentarily press ALARM SILENCE (🔕); the SILENCED indicator turns off.

## System Low Priority Alarm/Alert Condition: Low Battery

A low battery condition will be detected when the battery has about 30 minutes remaining. As soon as the condition is detected:

- The message "**L0W BATTERY**" is displayed on the second message line. It alternates with other messages at once per second.
- This message remains displayed until the monitor is connected to power.
- The MEDUIM/LOW PRIORITY ALARM LED remains on steady (if it is not flashing for another medium priority alarm)
- A unique low priority alarm tone, a burst of 5 beeps at mid-volume, sounds as soon as the low battery condition is detected, and every 3 minutes thereafter while the condition persists.
- The volume of the low battery low priority alarm/alert tone is not adjustable.
- The low battery audible cannot be disabled by the ALARM SILENCE (🔕) key.

This page is intentionally left blank.

# Chapter 5: Capnograph Theory of Operation

## Theory of Operation

### Measuring $CO_2$

The device draws a sample of gas through the sample chamber. A light source shines infrared (IR) light through an optical bandpass filter and then through the sample chamber. An IR detector responds to the amount of IR light that passes through the sample chamber.

**1 IR Light Source**
**2 Gas Chamber**
**3 Filters**
**4 Detector**
**5 Sample In**
**6 Sample Out**

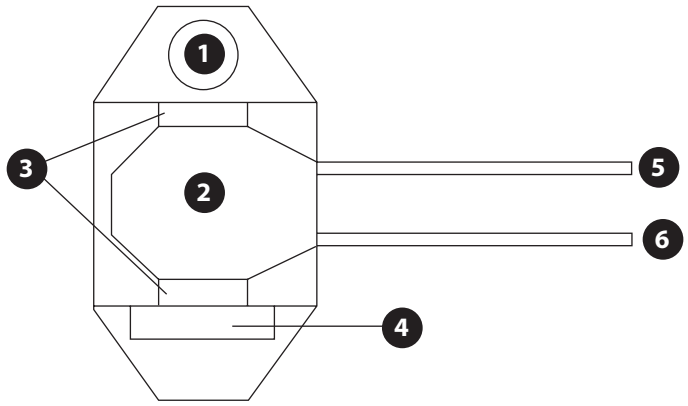



Figure 5.1: $CO_2$ Measurement

Because $CO_2$ absorbs IR light at a specific wavelength, the amount of light passing through the sample chamber varies according to the concentration of $CO_2$ in the sample chamber. When there is a high concentration of $CO_2$ in the sample chamber, the detector senses a smaller amount of the $CO_2$ absorption wavelength light than when there is a low concentration of $CO_2$.

The device computes the partial pressure of $CO_2$ based on measured levels of IR light intensity. The $ETCO_2$ measurement is shown as an average of 4-breaths.

**CAUTION! Pump motors in the capnometer may adversely affect other medical equipment, e.g. ECG tracings.**

### Measuring Respiration Rate

The device uses the continuous $CO_2$ waveform to detect each breath cycle. It uses an adaptive algorithm to recognize each breath in the waveform, even in the presence of an elevated baseline (rebreathing) and higher frequencies in the $CO_2$ waveform (cardiogenic oscillations).

The device computes respiration rate from the total number of seconds for the last four breaths according to this formula:

$$RR = \frac{60 \text{ seconds x breaths}}{\text{Number of seconds for 4 breaths}}$$

## $N_2O$ Compensation

The interfering effect of $N_2O$ results in inaccurate $CO_2$ readings, however the device has the ability to compensate for this.

With the $N_2O$ compensation ENABLED, the device adjusts the $CO_2$ reading by an algorithm that assumes the concentration of $N_2O$ is 40% and compensates accordingly. If $N_2O$ compensation is enabled and the concentration of $N_2O$ is not 40%, the displayed value must be adjusted by the following equation to get the actual $CO_2$ concentration.

$$\text{Actual } CO_2 = \frac{CO_2 \text{ reading x } 1.0625}{1 + \left( \frac{0.0625 \text{ x } N_2O\%}{40\%} \right)}$$

With the $N_2O$ compensation DISABLED, the device adjusts the $CO_2$ reading by an algorithm that assumes the concentration of $N_2O$ is 0%. If $N_2O$ compensation is disabled and the concentration of $N_2O$ is not 0%, the displayed value must be adjusted by the following equation to get the actual $CO_2$ concentration.

$$\text{Actual } CO_2 = \frac{CO_2 \text{ reading}}{1 + \left( \frac{0.0625 \text{ x } N_2O\%}{40\%} \right)}$$

# Chapter 6: Pneumatics and $CO_2$ Calibration

## Connecting a Non-Recirculating Scavenging System

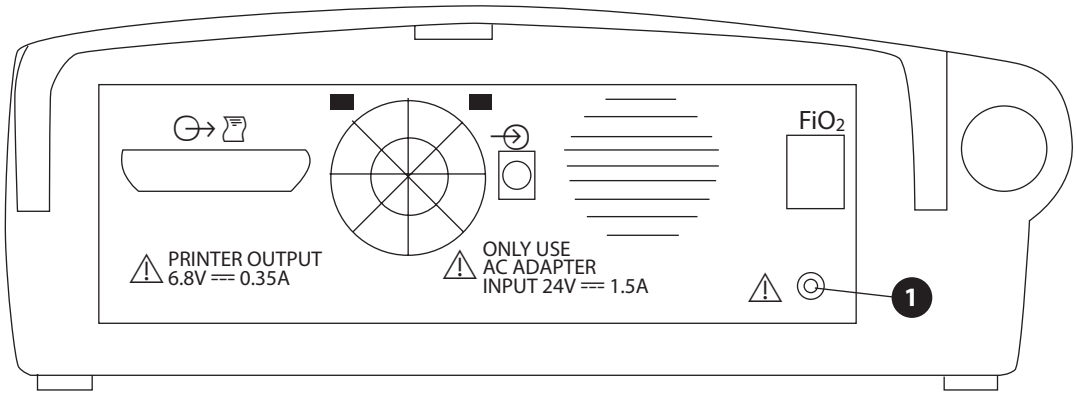



Figure 6.1: Connecting a Non-Recirculating Scavenging System

**1 Connect fitting to exhaust port**
If desired, connect a non-recirculating scavenging system to the exhaust port on the monitor's rear panel as shown.

**CAUTION! When connecting a non-recirculating scavenging system, use only Catalog #V1175 Exhaust Line. Failure to comply may result in damage to the monitor.**

## Checking for Leaks

1. Pinch the sample line near the moisture trap connection.

2. Make sure the "**OCCLUSION**" message appears in the upper left of the display. If no message appears, go to the *Chapter 14: Troubleshooting* section.

**NOTE! Leaks may cause lower $ETCO_2$ readings.**

## Calibrating the Capnometer

Calibration ensures that the $ETCO_2$ and Inspired $CO_2$ measurements are accurate. Calibrate about once a month.

**NOTE! Use only the calibration gas canister and flow regulator supplied with or specifically intended for use with this device. See *Chapter 15: Supplies and Accessories* for information on ordering calibration gas.**

The device has 2 calibration modes: Low Calibration (LO CAL) and Low/High Calibration (LO/HI CAL). The LO CAL process is required if a significant change in altitude occurs. It is not necessary to remove the device from the patient while performing a LO CAL procedure because a three-way valve closes the patient inlet and opens to room air. The LO/HI CAL procedure requires the delivery of a gas mixture from a canister.

**NOTE! Remove the device from the animal before performing a Low/High Calibration procedure.**

## Low Calibration

To perform a LO CAL, do the following:

1. Turn on the device.
2. Depress the MENU/ENTER ( ) key. Select **Capnograph**. Select **CO2 Low Cal**.
3. A menu screen appears with the message: "**CO2 Low Cal In Progress.**"
4. When the unit is finished, a "**Calibration Complete**" message will appear.

## Auto-Zero

**NOTE! During the autocal sampling, the $CO_2$ waveform and digits will disappear for 1-5 seconds. After this, breath detection restarts. This should happen only during extreme temperature changes, and not during normal patient monitoring.**

**NOTE! The auto-zero cal is similar to a low cal, excluding ambient pressure, so as not to stop the pump.**

$CO_2$ bench temperature data is accumulated and averaged about every 17 seconds. The current temperature is then compared with the previous average temperature. If the difference is less than 0.3 °, the temperature is considered stable, and the following check is performed:

- Compare the current average bench temperature with the temperature of the last $CO_2$ calibration (zero cal, low cal, or high/low cal). If there is no previous cal, this "low cal temp" is set to 25 degrees C.

When the current bench temperature is greater than 40 degrees C (104 ° F), and a 5 °C variation in the previous "low cal temp" is detected, and Auto-Zero calibration will be initiated.

When the current bench temperature is less than 40 degrees C (104 ° F), and a 12°C variation in the previous "low cal temp" is detected, an Auto-Zero calibration will be initiated.

During an Auto-Zero calibration, the $CO_2$ waveform and digits will disappear for 1-5 seconds while the monitor resets the "low temp cal."

There are no quantitative effects of barometric pressure because of the Auto-Zero calibration.

## Low/High Calibration

To perform a Low/High Cal do the following:

1. Disconnect the patient attachment from the Luer-lock adapter.
2. Turn on the device.
3. Locate the calibration gas canister.
4. Remove the moisture trap and adapter and attach the calibration adapter (Catalog #8223) to the gas inlet.
5. Press the MENU/ENTER ( ) key. Select **Capnograph**. Select **Low/High Cal** and follow the directions on the display.
6. After the message "**PLEASE TURN ON CAL GAS**" appears, quickly open the flow control valve on the calibration gas canister. The valve must be fully opened in less than 30 seconds.
7. When the message "**PLEASE TURN OFF CAL GAS**" appears, close the flow control valve of the calibration gas canister.

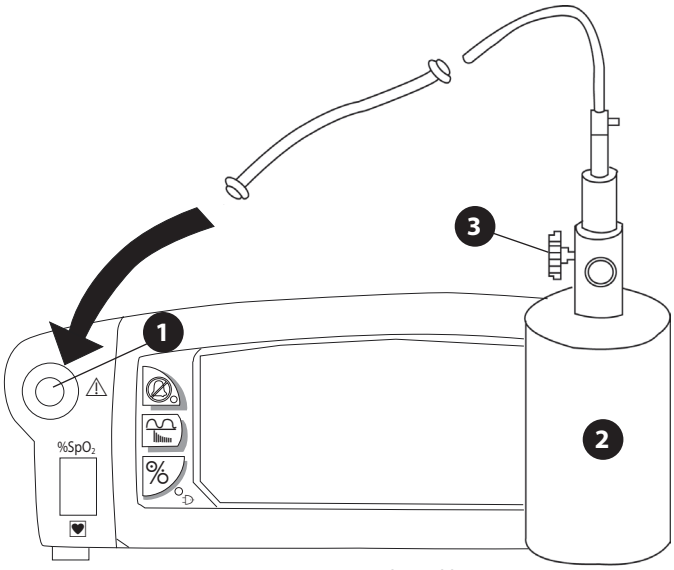



Figure 6.2: Connecting the Calibration Gas

**1 Gas Inlet**

**2 Calibration Gas**

**3 Flow Control Valve**

8. When the "**CALIBRATION COMPLETE**" message appears the unit is done. Disconnect the calibration test fixture and exit all menus.

An unsuccessful calibration procedure causes an error message to appear. Operation resumes using the old calibration data. Refer to **Capnograph Messages** for further instructions.

## Connecting the Patient

**NOTE! Capnograph patient attachments and sample lines are disposable, single-use items. Use a new patient attachment and sample line for each new animal.**

**NOTE! Discard and replace the patient attachment if it becomes occluded. If an air leak is noted, check all patient connections. If the air leak persists, discard and replace the patient attachment.**

Choose the appropriate patient attachment from the following chart, then turn to the figure indicated for attachment instructions.

### Attachment Selection Chart

| PATIENT | DESCRIPTION | FIGURE |
|---|---|---|
| Small or Large Animal | Nasal Cannula | 6.3 |
| | Ventilator Adapters | 6.4 |

Figure 6.3: Nasal Cannula

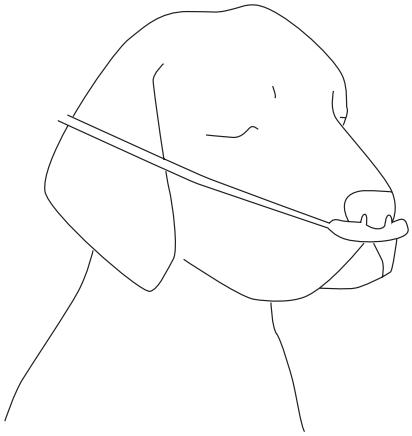
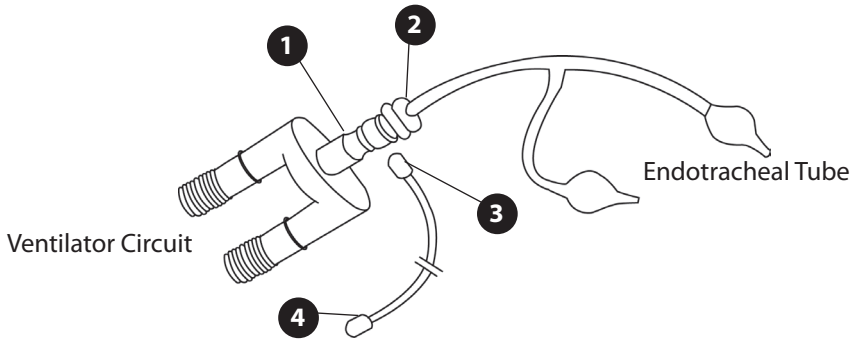


Figure 6.4: Ventilator Adapters for intubated patients




1. **Connect the large end of the airway adapter to the ventilator circuit.**
2. **Connect the small end of the airway adapter to the endotracheal tube.**
3. **Connect the sample line to the airway adapter and twist to tighten.**
4. **Connect to filter Luer and twist to tighten.**

This page is intentionally left blank.

# Chapter 7: Capnograph and Display Menu

## Capnograph Display

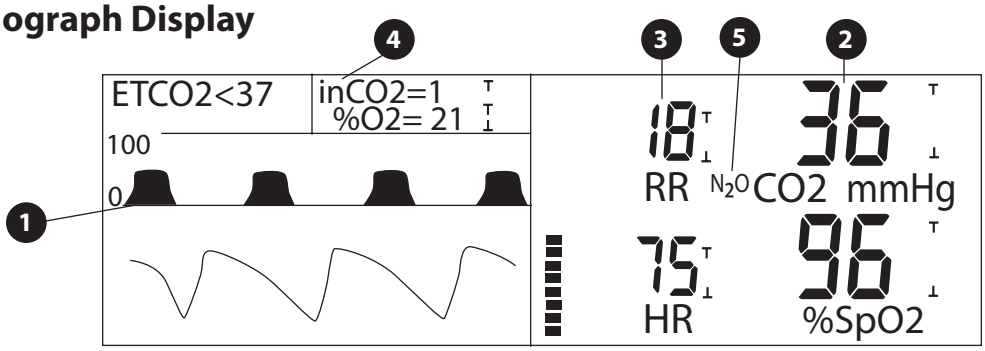



Figure 7.1: Capnograph Display

A few seconds after the patient is attached, the end-tidal $CO_2$ ($ETCO_2$), respiration rate (RR), and minimum inspired $CO_2$ ($inCO_2$) measurements should be shown.

**NOTE! If measurements are not shown, check the patient attachment and luer fittings to make sure they are applied correctly. If necessary, check for capnograph messages and see *Capnograph Messages* later in this chapter for help.**

### 1 $CO_2$ Waveform

The $CO_2$ waveform can be displayed either above the plethysmogram or by itself. Use the WAVE/TREND ( ) key to select the display. The wave's height, scale, speed, and length are remembered at power down.

### 2 $ETCO_2$ Measurement

The $ETCO_2$ measurement is labeled **CO2**. Dashes (--) indicate the measurement is invalid or unavailable. The displayed units of $CO_2$ measurement apply to $inCO_2$ as well.

### 3 Respiration Rate Measurement

The respiration rate measurement is labeled **RR**. Dashes (--) indicate the measurement is invalid or unavailable. If the waveform is expanded, or if menus or trends are displayed, then the RR digits are shown above the waveform area.

### 4 $inCO_2$ Measurement

The minimum inspired $CO_2$ measurement is labeled **inCO2**. The units of measurement are the same as for $ETCO_2$. Dashes (--) indicate the measurement is invalid or unavailable.

### 5 $N_2O$ Compensation Indicator

An indicator **$N_2O$** is shown next to the $CO_2$ label under the $ETCO_2$ measurement if 40% $N_2O$ compensation has been enabled through the **Capnograph** menu.

## Capnograph Menu

The **Capnograph** menu allows the user to view and/or adjust capnograph monitoring settings.

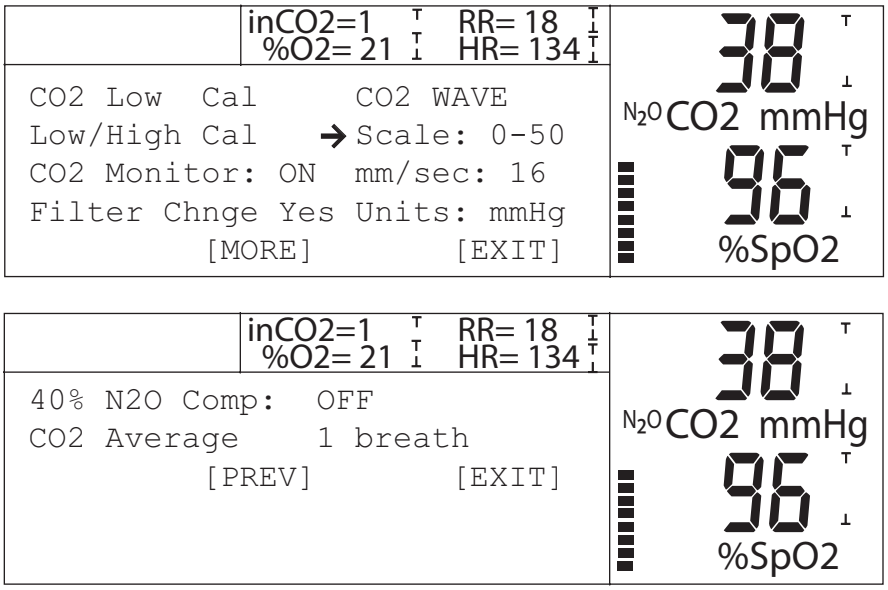



Figure 7.2: Capnograph Menu

### $CO_2$ Low Cal
Allows the capnograph to perform a low calibration.

### Low/High Cal
Allows the capnograph to be calibrated and verified.

### $CO_2$ Monitor
Indicates whether the $CO_2$ parameter is on or off. Allows $CO_2$ monitoring to be turned on or off.

### Filter Chng
Indicates if the moisture trap has been changed. It will indicate **NO** if there has been an occlusion for 15 minutes or more. In that case, the moisture trap should be changed and this option changed to **YES**.

### Scale
Indicates the scale of the $CO_2$ waveform. Allows the scale to be changed.

### mm/sec
Indicates the sweep speed of the $CO_2$ waveform. Allows the sweep speed to be changed.

### Units
Indicates the units of the capnograph measurement. Allows the units to be changed.

### 40% $N_2O$ Comp
Allows the capnograph to compensate in the presence of $N_2O$ (nitrous oxide)

### $CO_2$ Average
Allows the selection of $CO_2$ averaging (1 breath/4 breaths).

## Capnograph Messages

Alarm and alert messages related to the capnograph are shown on the top message line at the upper left of the display. If there are several messages to be displayed, then they rotate, showing one message every second.

If the capnograph monitoring is disabled through menus, then a message is displayed in the $CO_2$ waveform area. This applies to units with the oximeter option installed.

During calibration, status messages are shown in the calibration menu area.

## High and Medium Priority Alarm Messages

| MESSAGE | DESCRIPTION |
|---|---|
| ETCO2 > (x) | Indicates the $ETCO_2$ measurement is equal to or higher than the high $ETCO_2$ alarm limit. (x) is the high alarm limit setting. |
| ETCO2 < (x) | Indicates the $ETCO_2$ measurement is equal to or lower than the low $ETCO_2$ alarm limit. (x) is the low alarm limit setting. |
| inCO2 > (x) | Indicates the inspired $CO_2$ measurement is equal to or higher than the high $inCO_2$ alarm limit. (x) is the high alarm limit setting. |
| RESP > (x) | Indicates the respiration rate measurement is equal to or higher than the high respiration rate alarm limit. (x) is the high alarm limit setting. |
| RESP < (x) | Indicates the respiration rate measurement is equal to or lower than the low respiration rate alarm limit. (x) is the low alarm limit setting. |

## Low Priority Alarm/Alert Messages

| MESSAGE | DESCRIPTION |
|---|---|
| OCCLUSION | Indicates the monitor is attempting to clear a blockage in the pneumatic circuit. The monitor clears most occlusions automatically. If the alert persists, see *Chapter 13: Troubleshooting*. |
| CO2 SENSOR | Indicates the $CO_2$ sensor is not functioning properly. Perform a Low/High calibration, as described in *Chapter 6: Pneumatics and $CO_2$ Calibration*, if message persists, contact an authorized repair center. |

## Status Message

| MESSAGE | DESCRIPTION |
|---|---|
| CO2 Monitor: OFF | Indicates the capnograph function has been disabled through menus. This message replaces the $CO_2$ waveform. |
| CHANGE FILTER | Indicates that the water trap filter is full and must be changed or that there is an occlusion that cannot be cleared. To clear this message, go into the **Capnograph** menu and change the **Change Filter** option from **No** to **Yes**. |

**NOTE! The moisture trap can run over 50 hours in a heated wire circuit at 100% humidity without occluding.**

## Calibration Messages

| MESSAGE | DESCRIPTION |
|---|---|
| Calibration Complete | Indicates the calibration was successfully completed. |
| CO2 Sensor Error | Indicates the high $CO_2$ calibration was not within an acceptable range. Verify the proper calibration gas is being used, and calibrate again. If the message persists, contact your authorized repair center. |
| ERROR: High CO2 Unstable | Indicates the high $CO_2$ calibration was inconsistent. Calibrate again. If the message persists, contact your authorized repair center. |
| ERROR: Low CO2 Out Of Range | Indicates the low $CO_2$ calibration was not within an acceptable range. Calibrate again. If the message persists, contact your authorized repair center. |

# Chapter 8: Using the Oximeter Option

## General Description

The SurgiVet® V9004 Capnograph's Oximeter option noninvasively and continuously monitors and displays arterial blood oxygen saturation ($SpO_2$), pulse rate, and plethysmogram. The monitor beeps with each pulse beat. The pitch of the pulse beep depends on the $SpO_2$ value; the higher (or lower) the $SpO_2$ value, the higher (or lower) the pulse beep pitch.

The SurgiVet® V9004's flexible alarm system lets you choose alarm parameters and audible tone volumes. You can select the high and low alarm limits for $SpO_2$ and pulse rate, and independently choose the volume for alarm and pulse beep tones.

## Pulse Oximetry Theory of Operation

The pulse oximeter determines $\%SpO_2$ and pulse rate by passing two wavelengths of low intensity light, one red and one infrared, through body tissue to a photodetector. Information about wavelength range can be especially useful to clinicians. Wavelength information for this device can be found in the $SpO_2$ Specifications section of this manual.

Pulse identification is accomplished by using plethysmographic techniques, and oxygen saturation measurements are determined using spectrophotometric oximetry principles. During measurement, the signal strength resulting from each light source depends on the color and thickness of the body tissue, the sensor placement, the intensity of the light sources, and the absorption of the arterial and venous blood (including the time varying effects of the pulse) in the body tissues.

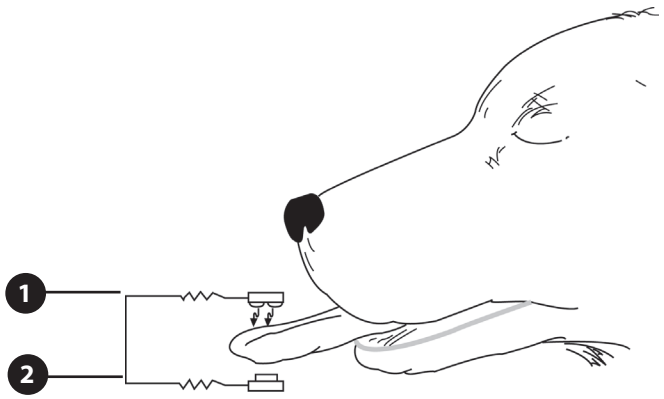



Figure 8.1: Pulse Oximetry Theory of Operation

**1 Low intensity Red and Infrared LED light sources**

**2 Detector**

Oximetry processes these signals, separating the time invariant parameters (tissue thickness, skin color, light intensity, and venous blood) from the time variant parameters (arterial volume and $SpO_2$) to identify the pulses and calculate functional oxygen saturation. Oxygen saturation calculations can be performed because blood saturated with oxygen predictably absorbs less red light than oxygen-depleted blood.

**WARNING! Since measurement of $SpO_2$ depends on a pulsating vascular bed, any condition that restricts blood flow, such as the use of a blood pressure cuff or extremes in systemic vascular resistance, may cause an inability to determine accurate $SpO_2$ and pulse rate readings.**

**WARNING! Under certain clinical conditions, pulse oximeters may display dashes if unable to display $SpO_2$ and/or pulse rate values. Under these conditions, pulse oximeters may also display erroneous values. These conditions include, but are not limited to: patient motion, low perfusion, cardiac arrhythmias, high or low pulse rates or a combination of the above conditions. Failure of the clinician to recognize the effects of these conditions on pulse oximeter readings may result in patient injury.**

## Oximeter Display

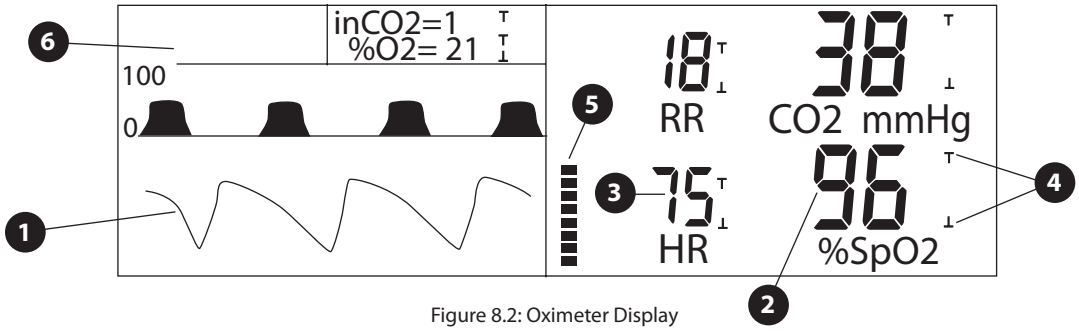



Figure 8.2: Oximeter Display

A few seconds after the patient is attached, the $SpO_2$ measurement, pulse rate measurement, and pulse bargraph should be shown.

**NOTE! If measurements are not shown, check the patient attachment to make sure it is applied correctly. Also check for oximeter messages in the alarm and alert message area and see** *Oximeter Messages* **later in this chapter for help.**

### 1 Plethysmogram

The plethysmogram is shown, assuming it is assigned to a trace. Press the WAVE/TREND ( ) key to assign the plethysmogram to a trace.

### 2 $SpO_2$ Measurement

The $SpO_2$ measurement is shown. Dashes (---) indicate the measurement is invalid or unavailable.

### 3 Pulse Rate Measurement

The pulse rate measurement is labeled **HR** (for heart rate). Dashes (---) indicate the measurement is invalid or unavailable.

### 4 Alarm Limit Indicators

The $SpO_2$ and pulse rate digits have a corresponding set of alarm indicators. The uppermost indicator represents the high alarm limit; the lowermost indicator represents the low alarm limit. For more about alarm indicators, see *Chapter 4: Alarms*.

The following alarm limits are provided for oximeter measurements:

- High and low $SpO_2$.
- High and low pulse rate.

For instructions on adjusting or viewing alarm limits, see *Chapter 4: Alarms*.

### 5 Pulse Strength Bargraph

Indicates the patient's pulse activity and strength. The bargraph is logarithmically scaled to indicate a wide range of pulse strengths.

### 6 Messages

Oximeter alarm and alert messages appear on the second line of the message area at the upper left of the display. The list is prioritized to show the most important alarm or alert messages from the top to the bottom. For details on the oximeter messages, see *Oximeter Messages* later in this chapter.

## Oximeter Menu

The oximeter menu allows the user to view and/or adjust oximeter monitoring settings.

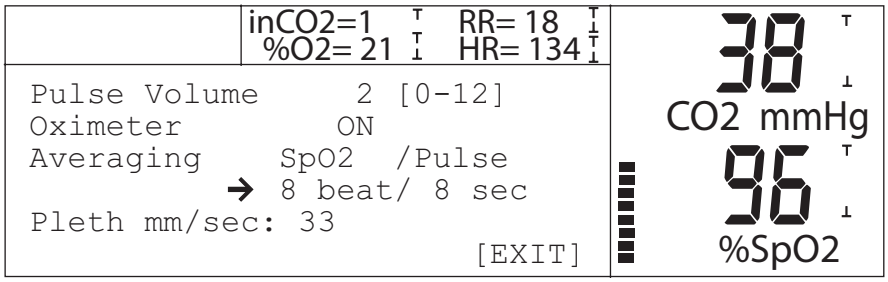



Figure 8.3: Oximeter Menu

### Pulse Volume (Audible)

An audible pulse beep sounds with each pulse beat. For information on changing the pulse beep volume, see *Adjusting the Pulse Beep Volume* later in this chapter.

**NOTE! The pitch of the pulse beep is determined by the $SpO_2$ value. The higher the $SpO_2$ value, the higher the pulse beep pitch. The lower the $SpO_2$ value, the lower the pulse beep pitch**

### Oximeter

Indicates whether the oximeter parameter is on or off. Allows the oximeter parameter to be turned on or off.

**NOTE! Turning off the $SpO_2$ parameter turns off the plethysmogram, $SpO_2$, pulse rate, and pulse strength measurements.**

### Averaging

Indicates the current $SpO_2$ and pulse rate averaging setting. Allows the averaging setting to be changed. See *Adjusting or Viewing the Averaging Settings* later in this chapter for more information on averaging settings.

### Pleth mm/sec

Indicates the plethysmogram sweep rate. Allows the sweep rate to be adjusted.

## Adjusting the Pulse Beep Volume

1. Select **Oximeter** from the Main menu. (Note: Pulse volume can also be adjusted in the **Setup/Volume** menu).

2. Select the **Pulse Volume** item.

3. Press the MENU/ENTER ( ) key to select the item. Use the ARROW ( or ) keys to adjust the pulse volume. Press MENU/ENTER ( ) to set the value.

**NOTE! The pulse beep sounds while adjusting the volume.**

4. Select **[EXIT]** or press WAVE/TREND ( ) to exit the menu.

## Adjusting or Viewing the Averaging Settings

$SpO_2$ averaging is the number of pulse beats over which the $SpO_2$ value is averaged. Rate averaging is the number of seconds over which the pulse rate is averaged. Four averaging settings are available:

### Averaging Settings

| SPO2 (BEATS) | RATE (SECONDS) |
|---|---|
| 4 | 8 |
| 8 | 8 |
| 16 | 16 |
| 16 | 8 |

To adjust or view the averaging settings, do the following:

1. Select the **Oximeter** item from the Main menu.
2. Select the **Averaging** item.
3. Press the MENU/ENTER ( ) key to select the item. Use the ARROW ( ^ or v ) keys to adjust the averaging. Press the MENU/ENTER key to set the value.
4. Select **[EXIT]** or press WAVE/TREND ( ) to exit the menu.

**NOTE! Increasing or decreasing the averaging setting has no effect on the data update rate.**

## Oximeter Messages

Oximeter messages are shown on the second line of the message area at the upper left of the display. The displayed messages are prioritized to show what is most important at the top.

### High Priority Alarm Messages

| MESSAGE | DESCRIPTION |
|---|---|
| SPO2 > (x) | Indicates the $SpO_2$ measurement is equal to or higher than the high $SpO_2$ alarm limit. (x) is the high alarm limit setting. |
| SPO2 < (x) | Indicates the $SpO_2$ measurement is equal to or lower than the low $SpO_2$ alarm limit. (x) is the low alarm limit setting. |
| Pulse > (x) | Indicates the pulse rate measurement is equal to or higher than the high PULSE alarm limit. (x) is the high alarm limit setting. |
| Pulse < (x) | Indicates the pulse rate measurement is equal to or lower than the low PULSE alarm limit. (x) is the low alarm limit setting. |
| Lost Pulse | Indicates that the sensor no longer detects a pulse while a finger is inserted in the sensor, where a pulse was previously detected. |

### Low Priority Alarm/Alert Messages

| MESSAGE | DESCRIPTION |
|---|---|
| SPO2 SENSOR! | Indicates the $SpO_2$ sensor is disconnected from the monitor or the patient. Make sure the patient cable and sensor connectors are all firmly seated. Make sure the sensor is positioned properly on the patient. If the message persists, contact your authorized repair center. |
| SPO2 LOST | Indicates the oximeter circuitry could not measure the patient's $SpO_2$ or pulse rate. Make sure the sensor is positioned properly on the patient. |

### Messages

| MESSAGE | DESCRIPTION |
|---|---|
| SPO2 SEARCH | Indicates the oximeter is adjusting to the patient's signal. If this message persists, make sure the sensor is positioned properly on the patient.<br><br>**NOTE! If the message "SpO2 SEARCH" stays up for 10 seconds or more, a system low priority alarm/alert will sound.** |
| SMALL PULSE | Indicates the oximeter signal strength is low. Try repositioning the sensor on the patient. |

## Attaching the Patient - Oximetry

### Choose the Sensor

Smiths Medical PM, Inc. manufactures a variety of pulse oximetry sensors to allow you to accurately and reliably monitor all of your different types and weights of patients. It is very important to select the proper sensor for each patient based on their size, color, condition, and type of procedure you are performing.

Experience will quickly teach you which probes work best under different conditions. Well-perfused sites, with little or no hair are preferable. It is also important to note that some anesthetic drugs such as xylazine, acepromazine, and domitor, can effect peripheral pulse pressures causing very weak pulsations. All pulse oximeters require a good pulse to work properly. The sensors available to you for your SurgiVet® pulse oximeters include a mini clip, universal 'Y' sensor and 'C' lingual sensors, and reflectance sensor.

| PATIENT | SITE | SENSOR #/DESCRIPTION |
|---|---|---|
| Small/Medium Animal up to 60 pounds | Tongue | V1703: Universal 'Y' Sensor with Lingual clip |
| | Ear, Toe webbing, Tongue, Thin Tissue | V3078: Mini Clip |
| | Rectum/Tail | V1700: Reflectance Sensor |
| | Hock, Achilles tendon, Thicker Tissue | V1707: Universal 'C' Sensor |
| Large Animals over 60 pounds | Tongue | V1703: Universal 'Y' Sensor with Lingual clip |
| | Rectum/Tail | V1700: Reflectance Sensor |
| | Hock, Achilles tendon, Thicker Tissue | V1707 Universal 'C' Sensor |
| Equine | Tongue | V1707: Universal 'C' Sensor |

## Clean or Disinfect the Sensors

Clean or disinfect the sensor before attaching a new patient.

**WARNING! Do not autoclave, ethylene oxide sterilize, or immerse the sensors in liquid.**

**CAUTION! Unplug the sensor from the monitor before cleaning or disinfecting.**

Clean the sensor with a soft cloth moistened in water or a mild soap solution. To disinfect the sensor, wipe the sensor with isopropyl alcohol.

## Attach the Sensor to the Patient

**WARNING! Prolonged use or the patient's condition may require changing the sensor site periodically. Change sensor site and check skin integrity, circulatory status, and correct alignment at least every 4 hours.**

**WARNING! When attaching sensors with Microfoam® tape, do not stretch the tape or attach the tape too tightly. Tape applied too tightly may cause inaccurate readings and blisters on the animal's skin (lack of skin respiration, not heat, causes the blisters).**

# Application Guide

## Universal "Y" (Lingual) Sensor

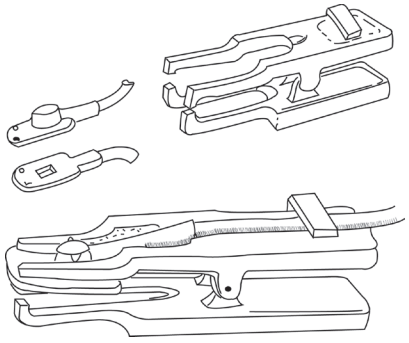
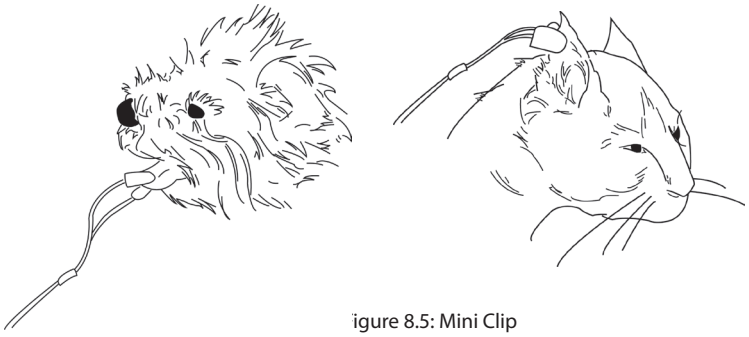


Figure 8.4: Universal 'Y' Sensor

Your monitor is equipped with a lingual sensor. Position the lingual clip on the base of the tongue; placement is dependent on the thickness of the tongue. Start at the tip and work your way towards the base. Always direct the light downward (towards the floor) regardless of the animal's position to reduce the effects of ambient light. Keep the tongue moist during longer procedures and monitor for significant temperature loss. Ensure that there is a minimum of 2 pulse strength bars displayed on the pulse oximeter.

If necessary, the lingual clip may also be positioned on lips, cheeks, prepuce, vulva and hocks. Moisten the hock area with isopropyl alcohol, water, and clip hair if needed. To get a better reading on the smaller tongues, fold the sides of the tongue up into a taco shape and pass the light through both layers. Don't fold the tip of the tongue back because you will restrict blood flow to the tongue.

## Mini Clip



igure 8.5: Mini Clip

The Mini Clip is much like the Universal 'Y' lingual sensor, but less than a quarter of the size of the lingual clip. The smaller clip proves effective on the small breeds and especially on smaller cats. The clip will work on a cat's ear, tongue, and toe webbing. The Mini Clip also works well on larger animals.

## Universal C-sensor

Figure 8.6: Universal C-Sensor

The 'C' sensor is designed specifically for use in the larger tissue areas. It has brighter LED's and therefore will shine through thicker tissues. The 'C' sensor can effectively be applied to the tongue or lip of larger dogs and equine. It can also be applied across the Achilles tendon, across the metatarsals or metacarpals of cats and dogs, on vulva, tails and across the front leg of smaller animals. The 'C' has a space between the two LED's. The tissue needs to be at least that thick to get an $SpO_2$ reading.

## Reflectance Sensor

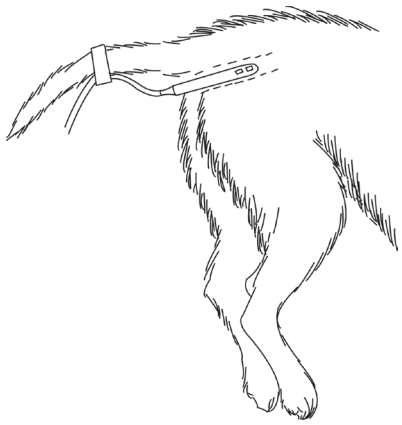


Figure 8.7: Reflectance Sensor

The reflectance sensor is an excellent sensor to use if you are doing dental procedures or other oral work that precludes you from using the lingual clip.

Clean the reflectance sensor by wiping it down with isopropyl alcohol or chlorhexidine. A thin coating of lubricant can be used, ensuring that the two LED's are kept clean and free of lubricant. This sensor may be used in the esophagus or cloaca of reptiles and large avians.

The animal does not need to be anesthetized when using the reflectance sensor, making it very useful in critical care or post operative settings and for spot checking. A simple glove swipe to remove existing feces may be needed. The sensor is placed very shallow, just so the 2 LED's are covered, reading the perfusion around the sphincter. A slight rotation may be needed to insure that the LED's are up against tissue and not in fecal material.

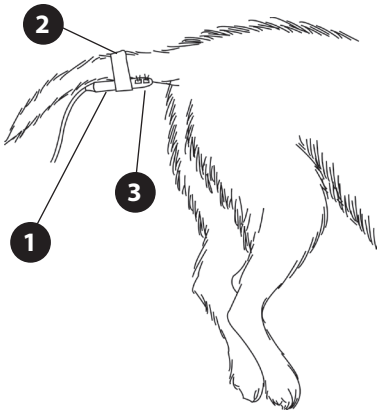



Figure 8.8: Reflectance Sensor

**1 Reflectance Sensor**

**2 Secure the sensor to the tail with a non-adhesive wrap**

**3 Lights should be positioned as shown**

The reflectance sensor may also be placed on the ventral base of the tail. The LED's should be positioned dorsally. You may need to clip a small patch of hair, only large enough for the LED's to lay on the skin, and clean surface. Hold the sensor snugly against the tail and wrap with non-adhesive wrap.

## Pulse Oximeter Sensor Application Tips

There is some variation depending on the manufacturer, but there are three basic types of pulse oximeter sensors made for the small animal patient:

- Lingual sensor
- 'C' sensor
- Reflectance (rectal, esophageal)

It is very important to have a variety of sensors in order to monitor the majority of the small animal patients. It is also important to select the proper sensor for animals based on their size, color, fur type, medical condition, and type of procedure.

## Testing Sensor Function

1. **To test the lingual clip function**, turn on the monitor with the lingual sensor attached. View the probe to make sure a red light is being emitted, then place the sensor on a small finger (without nail polish). Rest the hand with the sensor on it on a table to minimize motion. Note that in most cases the red light should be shining in the same direction as the overhead or surgical lights. It is important that the light receptor is shielded in order to avoid interference from ambient light. Once placed on a patient site, the red light should be shining continuously. In some cases a blinking light indicates that the tissue thickness is either too thin or thick. Once the sensor is placed properly, both the $SpO_2$ and pulse rate should appear in a short period of time (10-15 seconds).

2. **Testing the 'C' sensor is performed in the same manner.** This is a stronger sensor and can be used with greater tissue thickness.

3. **Testing the reflectance sensor is performed in the same manner**, but it should be pressed between thumb and index finger or into the palm of your hand.

# Primary Applications for Sensors

## Lingual Sensor (Lingual and Mini Clip)

- The primary application site is the tongue for most animals. On cats and small dogs, fold the tongue like a taco or use a wet gauze pad of single thickness folded over the tongue, and then place the sensor over the gauze.
- Other sites include the prepuce or vulva of larger dogs, the achilles tendon of a cat or small dog, ears, or toe webbing.

## C Sensor

- For cats and small breed dogs, place the sensor on the thigh, metatarsal or metacarpal, or hock near the saphenous vein.
- For larger breed dogs, place the sensor over the Achilles tendon, tongue, prepuce or vulva, or through toe webbing.
- It may be necessary to wet and part the fur with water in order to get the sensor closer to the skin of the patient.

## Reflectance Sensor

- In most animals, wet and part the fur at the ventral tail base and non-adhesive tape (not tape) in place. It may be necessary to shave a small spot on the ventral tail base in patients with a thick undercoat, such as a Husky.

# Limitations

Experience will quickly tell you which probes work best under different conditions. Fur, dark pigmentation, poor perfusion, and movement can all affect the sensors ability to obtain accurate readings. Well-perfused sites with little or no hair are preferable. It is also important to note that some anesthetic drugs, such as Xylazine (Rompun), Acepromazine, or Medetomidine (Domitor) can affect peripheral pulse pressures causing very weak pulsations. All pulse oximeters require a good quality pulse to work properly. Other drugs, such as ketamine, can cause the tongue to twitch, limiting the use of a lingual clip on that site.

# Checking the Monitor's Performance

Pulse oximeters do not require user calibration. If checking the function of the device is desired, an optional Oximeter Patient Simulator (SMPM catalog number 1606) is available as an accessory. The simulator attaches to the oximeter in place of the sensor or oximetry cable. It provides a known $SpO_2$ and pulse rate signal to the oximeter. This allows the oximeter's performance to be checked.

**NOTE! The 1606 Oximeter Patient Simulator does not calibrate the monitor; the monitor does not require calibration. The 1606 provides a known $SpO_2$ and pulse rate to the monitor that allows you to check the monitor's performance.**

**NOTE! The 1606 Oximetry/ECG Patient Simulator cannot be used to assess the accuracy of a pulse oximeter and/or sensor.**

**NOTE: ⚠ Follow the instructions included with the Oximeter Patient Simulator.**

# Chapter 9: Using the $FiO_2$ Option

## Theory of Operation

The Capnograph continuously monitors Fractional Inspired Oxygen ($FiO_2$). The $FiO_2$ cell behaves as a variable current source, with current output proportional to the partial pressure of oxygen. The $FiO_2$ cell's current output drives a resistor network to provide a temperature-stable voltage. The voltage is nominally zero at zero $O_2$ partial pressure, but increases linearly with increasing $O_2$ partial pressure. The monitor amplifies the resulting voltage then converts it to a digital value.

Because the $FiO_2$ cell generates an output proportional to the $O_2$ partial pressure, significant changes in atmospheric or operating pressure will change the monitor's $FiO_2$ reading . For this reason, it is recommended that you perform an O2 Calibration every day. Because the output of each $FiO_2$ cell varies, you should also perform an $O_2$ Calibration whenever a $FiO_2$ cell is disconnected then reconnected to the monitor (even if you're reconnecting the same $FiO_2$ cell).

**WARNING! Each $FiO_2$ cell has different output characteristics; changing the $FiO_2$ cell without recalibrating the monitor can result in incorrect displayed $FiO_2$ values. The incorrect values are unpredictable in both magnitude and direction, possibly resulting in hypoxic $FiO_2$ gas mixtures while displaying high $FiO_2$ values. It is your responsibility to properly calibrate the monitor after changing cells.**

**WARNING! The displayed message "$FiO_2$ Ref Err" indicates a factory calibration setting is incorrect. Do not use the $FiO_2$ parameter. Contact your authorized repair center.**

**NOTE! Store the $FiO_2$ cell as shipped in its protective wrapping, until it is ready to use. This maximizes the $FiO_2$ cell's shelf life.**

**NOTE! Prolong $FiO_2$ cell life by avoiding high $O_2$ and $CO_2$ concentrations when it is not in use.**

$FiO_2$ Humidity and Pressure Compensation:

Humidity (i.e. water vapor) is not an interferent, and does not affect the $FiO_2$ cell accuracy. Water vapor behaves as any diluting gas and reduces the oxygen partial pressure; the FiO2 cell will correctly indicate the reduced percent $FiO_2$. However when calibrating the $FiO_2$ cell, the humidity of the calibration gas reduces the oxygen partial pressure, it is for this reason that calibration gas must be dry. For example, at 37°C, water vapor pressure (PH2O) is 47 mmHg, reducing the oxygen partial pressure of 100% oxygen to (760-47) 713 mmHg and results in an oxygen concentration of 94%. If the sensor must be calibrated with humidified oxygen, then if the calibration gas is 100% humidified, the following equation provides a correction factor that must be applied to all $FiO_2$ readings:

$$C_{H2O} = \frac{P_{cal} - P_{H2O}}{P_{cal}} \qquad (1)$$

In addition, if the pressure of the calibrating gas (Pcal) is not 760 mmHg, then a further correction can be made according to the following:

$$C_{cal} = \frac{P_{cal}}{760\ mmHg} \qquad (2)$$

The $FiO_2$ cell manufacturer specifies an operating pressure (Psys) range of +/- 200 mmHg (+/- 4 psig). The $FiO_2$ cell response is proportional to oxygen partial pressure, the result being that indicated $FiO_2$ can be corrected for the difference in pressure between the operating system and the calibrating system pressure. The correction can be obtained from the following equation:

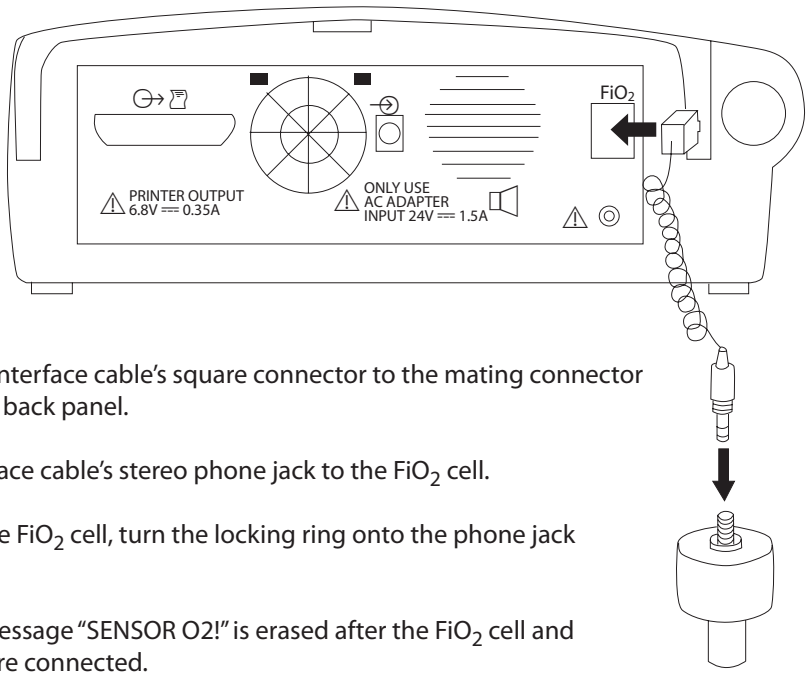
$$C_{sys} = \frac{760\ mmHg}{P_{sys}} \qquad (3)$$

The final result is that actual $FiO_2$ can be calculated from indicated $FiO_2$ by combining equations 1, 2 and 3:

$$FiO_2\ (actual) = FiO_2\ (indicated) \times C_{H2O} \times C_{cal} \times C_{sys}$$

## Connecting the $FiO_2$ Cell to the Monitor

Figure 9.1: Connecting the FiO2 to the Monitor




1. Attach the $FiO_2$ interface cable's square connector to the mating connector on the monitor's back panel.
2. Attach the interface cable's stereo phone jack to the $FiO_2$ cell.
3. If available on the $FiO_2$ cell, turn the locking ring onto the phone jack connector.
4. Make sure the message "SENSOR O2!" is erased after the $FiO_2$ cell and interface cable are connected.

**NOTE! If "SENSOR O2" is displayed after attaching the interface cable and $FiO_2$ cell, try replacing the cable or cell. If the message persists, contact your authorized repair center.**

## Calibrating the $FiO_2$ Cell

The $FiO_2$ cell must be calibrated for any of these reasons:

- If a new $FiO_2$ cell is connected to the monitor.
- If the $FiO_2$ cell is disconnected then reconnected to the monitor (even if it is the same $FiO_2$ cell).
- After twenty-four (24) hours have passed since the last $FiO_2$ cell calibration.
- If there is a significant change in the ambient or operating pressure.
- If the monitor is turned off then on.

Calibrate the $FiO_2$ cell as follows:

1. Make sure the message "SENSOR O2!" is not displayed.

**NOTE! If "SENSOR O2!" is displayed, see Connecting the $FiO_2$ Cell to the Monitor earlier in this chapter.**

2. Place the $FiO_2$ cell in the calibration gas standard, either 21% (room air) or 100% $O_2$.
3. Show the Main menu.
4. Select the $FiO_2$ Cell item.
5. Select the Calibrate item. Either 21% Cal or 100% Cal.
6. Select either the 21% Cal or 100% Cal from the Calibrate field (depending on which calibration gas standard is being used), then press the MENU/ENTER ( ) key.
7. The message "O2 CAL IN PROGRESS" is shown.
8. When "O2 CAL COMPLETE" is shown, select [EXIT].

**NOTE! If any message other than "O2 CAL COMPLETE" is shown, see $FiO_2$ Messages later in this chapter.**

9. Select [EXIT].

## $FiO_2$ Display

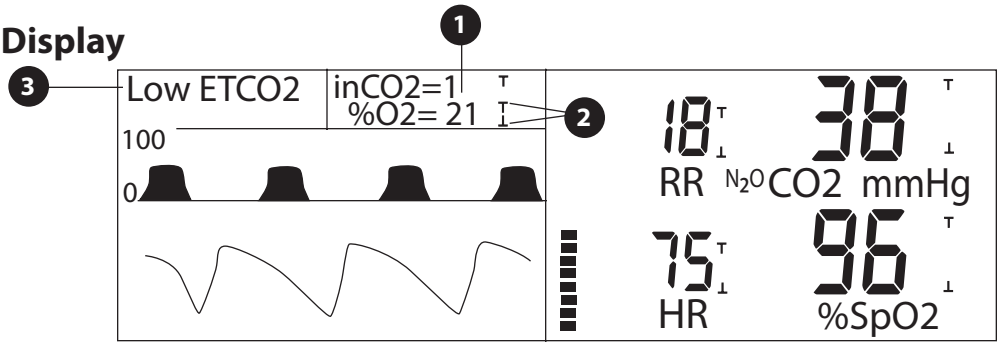



Figure 9.2: $FiO_2$ Display

A few seconds after the $FiO_2$ cell is attached, the $FiO_2$ measurement should be shown.

**NOTE! If the $FiO_2$ measurement is not shown, check the interface cable and $FiO_2$ cell to make sure they are properly connected. Also check for $FiO_2$ messages and see $FiO_2$ Messages later in this chapter for help.**

### 1 $FiO_2$ Measurement ($\%O_2$)

The $FiO_2$ measurement is shown. Dashes (--) indicate the measurement is invalid or unavailable.

### 2 Alarm Limit Indicators

The $FiO_2$ digits have a corresponding set of alarm limit indicators. The uppermost indicator represents the high alarm limit; the lowermost indicator represents the low alarm limit.
For instructions on adjusting or viewing alarm limits, see *Chapter 4: Alarms*.

### 3 Messages

High priority alarm and low priority alarm/alert messages are shown here. The list is prioritized to show the most important messages at the top. See *$FiO_2$ Messages* later in this chapter.

## $FiO_2$ Menu

The $FiO_2$ Cell menu allows the user to view and/or adjust $FiO_2$ monitoring settings.

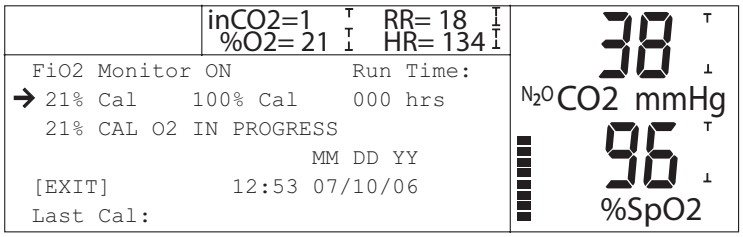



Figure 9.3: $FiO_2$ Cell Menu

### $FiO_2$ Monitor

Indicates whether the $FiO_2$ parameter is on or off. Allows the $FiO_2$ parameter to be turned on or off.

### 21% Cal

Performs a 21% $O_2$ calibration of the $FiO_2$ cell.

### 100% Cal

Performs a 100% $O_2$ calibration of the $FiO_2$ cell.

### Last Cal

Indicates the time and date of the last successful $FiO_2$ cell calibration.

### Run Time

Indicates the amount of time the monitor has been on since the last successful $FiO_2$ cell calibration.

## $FiO_2$ Messages

### High Priority Alarm Messages

| MESSAGE | DESCRIPTION |
|---|---|
| FiO2 > (x) | Indicates the $FiO_2$ measurement is equal to or higher than the high $FiO_2$ alarm limit. (x) is the high alarm limit setting. |
| FiO2 < (x) | Indicates the $FiO_2$ measurement is equal to or lower than the low $FiO_2$ alarm limit. (x) is the low alarm limit setting. |

### Low Priority Alarm/Alert Messages

| MESSAGE | DESCRIPTION |
|---|---|
| SENSOR O2! | The $FiO_2$ "SENSOR O2!" low priority alarm/alert appears when the $FiO_2$ cell is disconnected or when its output is unstable. To correct the low priority alarm/alert: make sure the interface cable and the $FiO_2$ cell are properly connected; try replacing the $FiO_2$ cell; try replacing the interface cable; retry the calibration. If the low priority alarm/alert persists, contact your authorized repair center. |
| FiO2 REF ERR | The "$FiO_2$ REF ERR" low priority alarm/alert appears if the $FiO_2$ factory calibration has been corrupted. If this message appears, contact your authorized repair center.<br><br>**WARNING! The low priority alarm/alert "$FiO_2$ REF ERR" indicates a factory calibration setting is incorrect. Do not use the $FiO_2$ parameter. Contact your authorized repair center.** |

### Indicators

| MESSAGE | DESCRIPTION |
|---|---|
| O2 Limit <21% | The "$FiO_2$ Limit <21%" indicator appears when the low $FiO_2$ alarm limit is set below 21%. To eliminate the indicator, set the $FiO_2$ alarm limit above 21%. If the indicator persists, contact your authorized repair center. |

# Chapter 10: Trends

## Trend Display

Press the WAVE/TREND ( ) key to cycle through displays until Trends is shown. Trends can be displayed for ETCO2, Resp. Rate, %O2, inCO2, SpO2, Pulse Rate, or Signal Pulse Strength. The following diagram and descriptions outline the trend display's features.

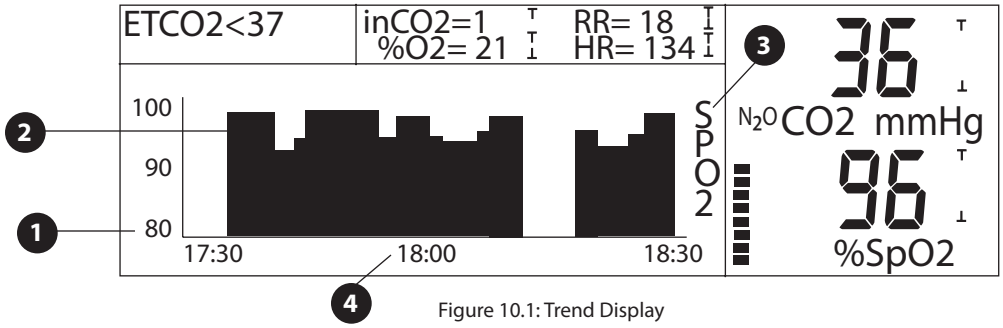



Figure 10.1: Trend Display

**1 Scale**
The trend's scale is shown on the left side of the trend display.

**2 Trend Graph**
The trend graph is displayed here. Displayed trends show elapsed time, that is, what happened over the selected minutes or hours. Gaps will appear in the trend graph for the length of time the monitor has been off or the parameter data has been invalid.

**3 Trended Parameter**
The name of the trended parameter is displayed here.

**4 Trend Time**
The time scale of the trend is displayed here. Trend data and time are continuously updated. When WAVE/TREND ( ) is pressed, the previously viewed trend can be displayed. To view a different trend, press an ARROW ( ∧ or ∨) key until the desired trend is displayed. Press WAVE/TREND ( ) to view one or two waveforms again. Trend times and scales are selected with the Trends menu item (see *Trends Menu*).

## Trends Menu

The **Trends** menu allows the user to view and/or adjust the trend settings.

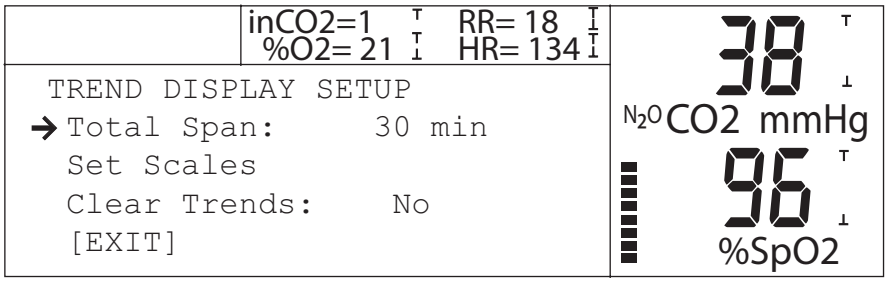



Figure 10.2: Trends Menu

### Total Time
Adjusts the time span of the trend display.

### Set Scales
Displays a menu which allows a separate trend scale to be selected for each parameter. The scale for oximeter signal strength is not selectable.

### Clear Trends?
Select Yes to erase trend memory.

**NOTE! "Yes" means all trended data will be erased when the trend menu is exited.**

Trend data will not be lost if this selection is set back to **No** before **[EXIT]** is selected.

# Chapter 11: Serial Output

## Serial Out Menu

The **Serial Out** menu allows the user to select a data format for output to the serial port, as well as select the output interval or the amount of data to send. This data can be output to a computer or to a compatible printer.

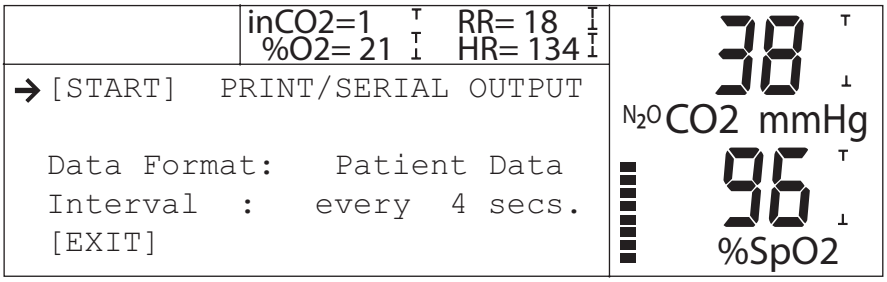



Figure 11.1: Serial Out Menu, Patient Data

### START/STOP

Select this to enable/disable serial output. If no output is currently in progress, this shows **START**. If output is in progress, this shows **STOP**.

### Data Format

Shows data output format. [See *Data Format* later.]

### Interval

If Patient Data format has been selected, this shows the amount of time between data log outputs.

**WARNING! When connecting this monitor to any instrument, verify proper operation before clinical use. Refer to the instrument's user manual for full instructions. Accessory equipment connected to the monitor's data interface must be certified according to the respective IEC standards, i.e., IEC 60950 for data-processing equipment or IEC 601-1 for electromedical equipment. All combinations of equipment must be in compliance with IEC 601-1-1 systems requirements. Anyone connecting additional equipment to the signal input port or signal output port configures a medical system, and, therefore, is responsible that the system complies with the requirements of the system standard IEC 601-1-1.**

**WARNING! IEC 60950 approved equipment must be placed outside of the "patient environment." The patient environment is defined as an area 1.5m (4.92 feet) from the patient.**

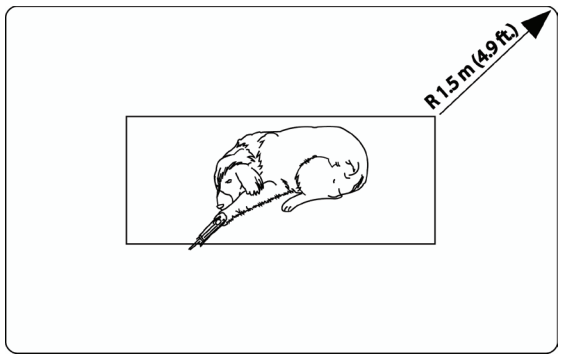



Figure 11.2: Patient Environment

## Serial Output Setup

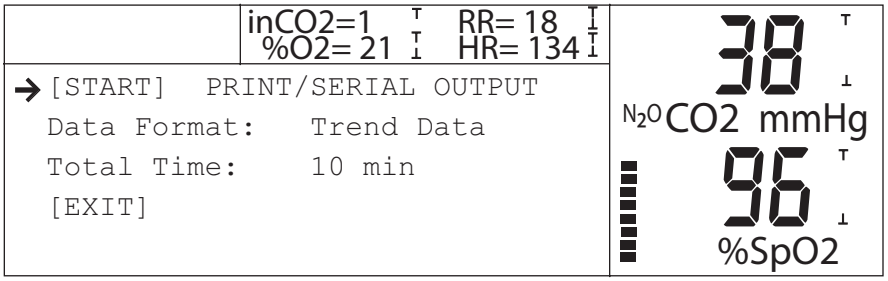



Figure 11.3: Serial Out Menu, Trend Tables

**NOTE! To output data to a PC, "Analog Output Type" must be set to "Internal." See *Chapter 12: Analog Output*.**

The serial output data format and output interval or amount can be changed only if no serial output is in progress. To change the data format selection:

1. Select **Serial Out** from the Main Menu. If "Please change the analog channel to Internal before printing" is displayed, select the **Analog Out** menu and change the **Output Type** to Internal . If **[START]** is displayed, then no serial output is currently in progress, so proceed with step 2. Otherwise, **[STOP]** is shown and you must select STOP to halt the current output before the serial output data settings can be changed to Internal.

To change the data format (Patient Data or Trend Tables):

2. Use the ARROW ( ∧ or ∨) keys to point to the **Data Format** item, then press MENU/ENTER ( ).

3. Use the ARROW ( ∧ or ∨) keys to switch between formats. When the format changes, the menu item below it changes.

If **Patient Data** is selected, the menu item displayed below it is: **Interval**.

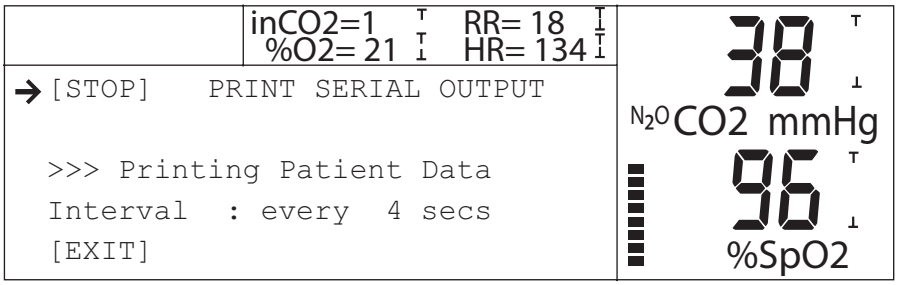



Figure 11.4: Interval Menu

If **Trend Tables** is selected, the menu item below it is: **Time Span**.

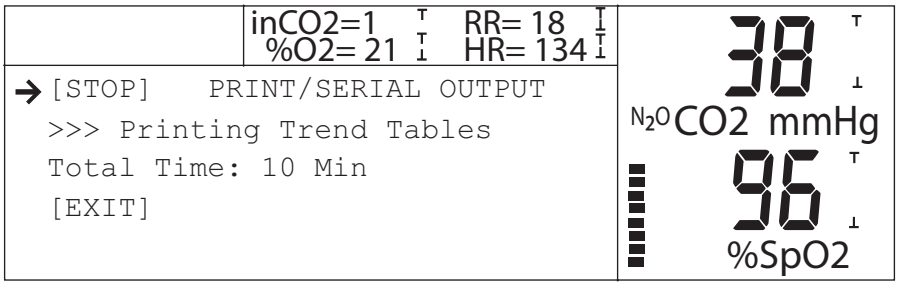



Figure 11.5: Time Span Menu

4. Press MENU/ENTER ( ) to accept the selection.

To change the output interval or trend time span:

5. Use the ARROW ( ^ or v) keys to point to **Interval** (for Patient Data Format) or **Time Span** (for Trend Tables format), then press MENU/ENTER ( ).
6. Use the ARROW ( ^ or v) keys to change the value.
7. Press MENU/ENTER ( ) to accept the selection.
8. When the output format has been set, select **[START]** to enable the serial output. At this point, the **[START]** field will change to **[STOP]**, and the message "**Printing...**" will be displayed in the menu area.
9. Select **[EXIT]** or press WAVE/TREND ( ) to exit menus. If serial output is in progress, exiting menus will not stop it.

To STOP serial output:

1. Select **Serial Out** from the main menu.
2. Select **[STOP]** (if it is shown.)

**NOTE! Serial output is always disabled when the monitor is powered up, but the format and times are remembered.**

## Output Examples

### Patient Data

A real-time Patient Data sample is output in tabular ASCII text format, one table per output interval. The time interval between tables is selected in the **Serial Out** menu. Each line of text in the patient data table ends with a carriage return, line feed.

### Sample Output:

```
15:15:52    09/19/06
Patient_________________
ETCO2         30 mmHg
inCO2          1 mmHg
Resp Rate     12 bpm
SpO2          96 %SpO2
Pulse         73 bpm
Signal Str.    6
FiO2          21 %O2
40% N2O Comp:     No
```

## Trend Table Data

Trend data is output in tabular ASCII text format, one table per trend data record, starting at the oldest record. The number of records printed depends on the time span selected in the **Serial Out** menu. For example, if Time Span = 8 hours, then eight hours of accumulated trend data records will be printed. (Not the last 8 hours of elapsed time.) Every time the monitor is turned off, then on again, a new block of trend data is started in trend memory. Thus, data from days ago might be printed, because trend data is remembered when the monitor is turned off. For this reason, time stamps are stored and output along with trended parameter data.

Each line of text in the trend tables ends with a carriage return, line feed.

Each new block of many trend data records has the following title information:

```
 Trend Data (10 mins)          (Total Accumulated Time)
14:33:07    09/19/06          (Output time/date)
Patient_________________
Sample Interval: 4 secs       (Base Trend Sample Rate)
```

Trend data records will be output as follows:

```
14:23:04    09/19/06          (When the data was stored.)
ETCO2        30 mmHg
inCO2         1 mmHg
Resp Rate    12 bpm
SpO2         96 %SpO2
Pulse        73 bpm
Signal Str.   6
```

**NOTE! The units (mmHg, kPa, %) shown for each $ETCO_2$ and $inCO_2$ entry are the units selected when that trend data was stored.**

# Chapter 12: Analog Output

## Analog Out Menu

The **Analog Out** menu allows the user to select parameter, waveform, or calibration data to output on each of three analog output channels. All output data is scaled to the range [0-1Volt].

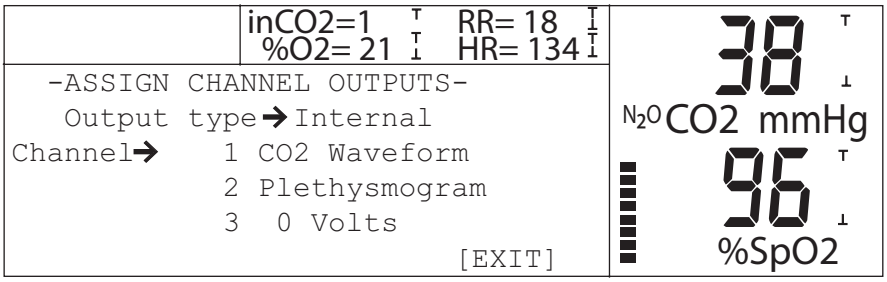



Figure 12.1: Analog Out Menu

To select the data to be output to any analog channel:

1. Select **Analog Out** from the Main Menu. If "Please stop printing before changing the analog channel to external" is displayed, select the **Serial Out** menu and stop printing.

2. Use the arrow keys to select the Output Type. Press MENU/ENTER ( ).

3. Use the arrow keys to select either "Internal or External." External should be selected if catalog #9015 (Analog Output Cable) is being used. Then press MENU/ENTER ( ).

4. Use the arrow keys to select the channel number **1**, **2**, or **3**. Then press MENU/ENTER ( ).

5. Use the ARROW keys to select the desired parameter ($EtCO_2$, Resp Rate, in $CO_2$, Pulse (HR), $SpO_2$, $FiO_2$), waveform ($CO_2$ waveform, Plethysmogram) or calibration signal (0 Volt or 1 Volt). Available options will depend on configuration of monitor ordered.

6. Press MENU/ENTER ( ) to accept the value.

7. Select **[EXIT]** or press ( ) to exit the menu.

This page is intentionally left blank.

# Chapter 13: Routine Maintenance

## Charging the Battery

Charge the battery after the monitor is used under battery operation, when the "**L0W BATTERY**" message is displayed, or after long term storage. Connect the external charger to the back of the monitor. Verify the green LED next to the (%) key is lit.

After connecting the external charger, the unit automatically goes into "fast charge" which is indicated by a flashing green LED. After 3 to 4 hours, the battery is fully charged, indicated by a continuously lit LED.

## Cleaning and Disinfecting

**CAUTION! Do not immerse the monitor or any of its accessories in liquid. Do not autoclave or ethylene oxide sterilize the monitor or any of its accessories. Unplug the external charger before cleaning or disinfecting the monitor or its accessories.**

**CAUTION! Should the device become wet, wipe off all moisture and allow sufficient time for drying before operating.**

Clean the surfaces of the monitor and the accessories with a soft cloth moistened in a mild soap solution. If disinfection is required, wipe the surfaces with isopropyl alcohol, then wipe with a water moistened soft cloth.

## Maintenance Chart

| ITEM | ACTION | INTERVAL | PAGE |
|---|---|---|---|
| Battery | Charge | When LOW BATT message is displayed<br><br>After continuous use under battery power. | 12-1 |
| The monitor's surfaces. | Clean or disinfect. | As required. | 12-1 |
| $SpO_2$ sensors. | Inspect and change patient site.<br><br>Clean or disinfect. | Every 4 hours<br><br>When attaching a new patient. | 12-1 |
| Capnograph patient attachment. | Discard the capnograph patient attachment. | When finished monitoring the patient. The capnograph patient attachments are disposable, single-use items.<br><br>When the patient attachment becomes occluded or has an air leak. | 6-4 |
| Moisture trap. | Discard and replace the moisture trap. | The moisture trap occludes when it is full. | |
| Capnograph calibration. | Perform a Low/High calibration. | Once every month. | 6-3 |

| ITEM | ACTION | INTERVAL | |
|---|---|---|---|
| Pneumatic system. | Check pneumatic system for leaks. | After replacing the moisture trap.<br><br>At least once every two weeks. | 6-1 |
| Calibration gas canister. | Discard and replace the calibration gas canister. | When the gas pressure reading is 20 psi or less as shown on the flow control valve's pressure gauge. | |
| $CO_2$ Absorber | Discard and replace the $CO_2$ Absorber. | When the majority of pellets turn blue. | |
| Filter | Discard and replace the filter | When the filter occludes, or becomes contaminated with nebulized medication. | |

**CAUTION! Follow local governing ordinances and recycling instructions regarding disposal and recycling of device components.**

## Long Term Storage

- Storage Facility: Indoor
- Temperature: -40 to +70°C (-40 to +158°F)
- Relative Humidity: 10 to 95%, non-condensing
- Periodic Inspection: None required.
- Special Procedures: Store the monitor and accessories in the original packing materials and shipping carton.

# Chapter 14: Troubleshooting

| PROBLEM | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| **SpO2 Sensor!** is displayed. | Probe not connected to monitor or patient. | Connect the sensor to the patient cable and connect the patient cable to the monitor. |
| | Probe improperly positioned on patient. | Reposition the sensor on the patient. |
| | Incorrect sensor for application. | Choose the correct sensor for the application. |
| | Defective sensor or patient cable. | Change the sensor or contact Smiths Medical PM, Inc. Veterinary Customer Service. |
| Unit operates when connected to external charger, but not on battery power. | Battery shelf life exceeded. | Contact Smiths Medical PM, Inc. Veterinary Veterinary Customer Service. |
| Display does not light. | If operating on battery, battery may need charging. | Recharge battery. |
| Green (charge) LED not lit. | External charger disconnected. | Connect charger. |
| No pulse registering on bargraph. | Sensor or patient cable disconnected from monitor. | Check connections to patient cable and sensor. |
| | Sensor incorrectly positioned. | Reposition sensor on patient. |
| | Poor patient perfusion. | Reposition sensor on patient. |
| | Defective sensor or patient cable. | Try a new sensor or contact Smiths Medical PM, Inc. Veterinary Customer Service. |
| Pulse rate erratic, intermittent, or incorrect. | Sensor incorrectly positioned. | Reposition sensor on patient. |
| | Poor patient perfusion. | Reposition sensor on patient. |
| | Patient motion. | Patient must be still for monitor to function properly. Place extremity on a pillow which acts as a "buffer" to motion. |
| | Ambient light | Shield with towel. |
| No serial output or incorrect format of serial output. | Analog output type set to external. | Set analog output type to **Internal**. |

**CAUTION! The monitor should be operated from its internal power source (if fited) if the integrity of the protective earth conductor is in doubt.**

## Troubleshooting the Occlusion Low Priority Alarm/Alert

Most occlusions are automatically cleared within a minute. If occlusion cycles occur frequently or the occlusion alert persists, use the following chart to find and repair the problem.

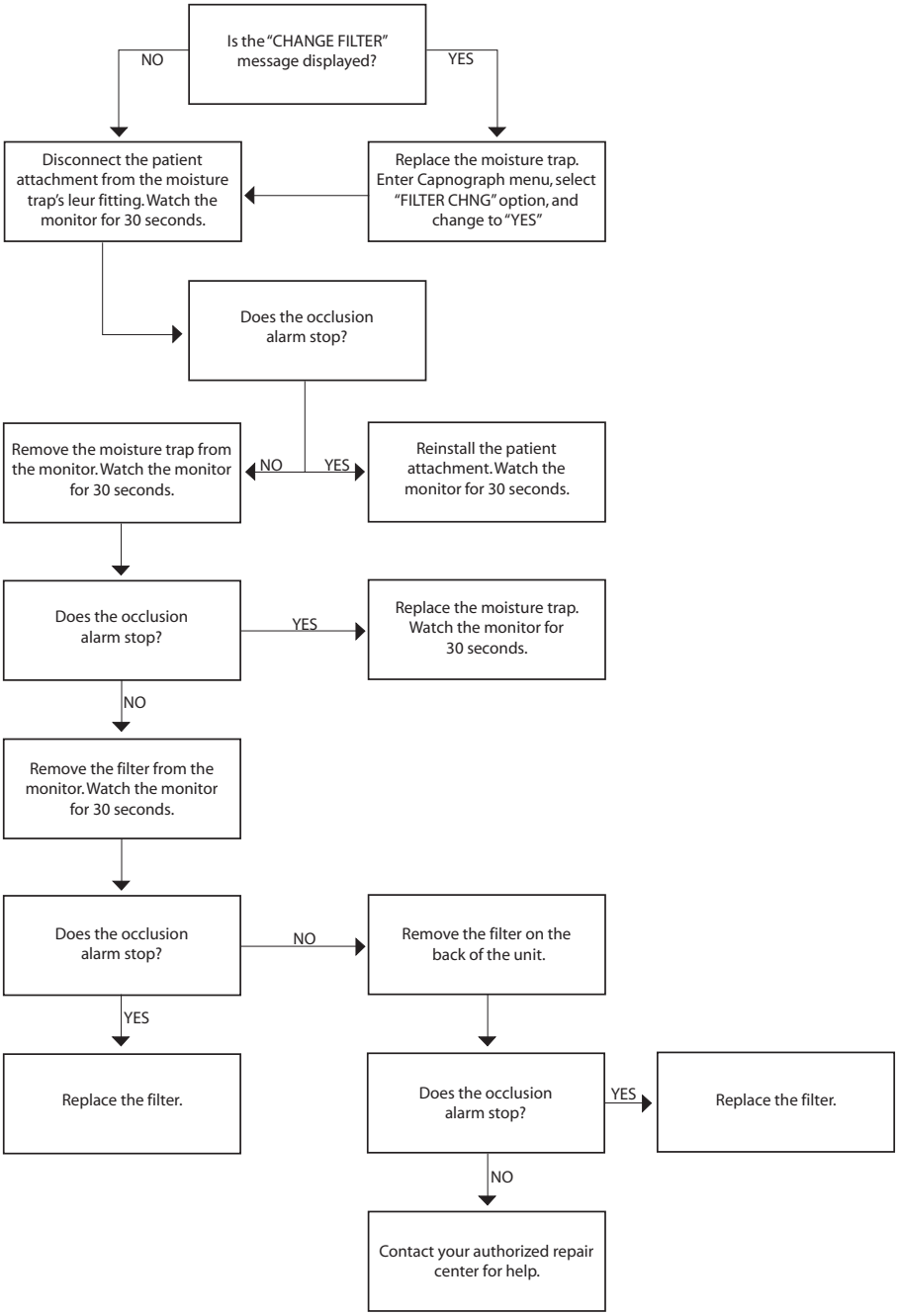



Figure 14.1: Occlusion Low Priority Alarm/Alert Troubleshooting Chart

Repairs of SurgiVet® devices under warranty must be made at authorized repair centers. If the device needs repair, contact your local distributor or Smiths Medical PM, Inc. service department. When calling, have the device's model and serial number ready.

Smiths Medical PM, Inc.
N7W22025 Johnson Drive
Waukesha, WI 53186-1856

Phone: +1 262 513 8500
Toll Free: 1 888 745 6562 (USA only)
Fax: +1 262 513 9069

# Chapter 15: Optional Supplies and Accessories

| CAT NO. | DESCRIPTION | QTY. |
|---|---|---|
| V1100 | Adapter, Airway, Straight, 12.7 ID x 15 OD (mm) | 10/pkg |
| V1114 | Adapter, Airway, Dual Port, Straight | 10/pkg |
| V1129 | Sample Line, Nasal $CO_2$, Adult | 10/pkg |
| V1138 | Airway Adapter, elbow, dual LL port | 10/pkg |
| 1140 | Sample Line, Extension, 4.6 m (15 feet) | 10/pkg |
| V1175 | $CO_2$ Exhaust Kit | each |
| 1178 | Trap, Moisture | 10/pkg |
| 1179 | Absorber, $CO_2$, External | 2/pkg |
| V1186 | Nasal Sample LIne, $CO_2$ | 6/pkg |
| 1606 | Simulator, Oximeter/ECG | Each |
| 1614 | Charger, AC 105-125VAC, 60 Hz | Each |
| 1615 | Charger, 208-252VAC, 50/60 Hz | Each |
| 1616 | Charger, AC 90-110VAC, 50 Hz | Each |
| V1700 | Sensor, Oximetry, Reflectance R/E, small | Each |
| V1703 | Sensor, Oximetry, Lingual, Universal "Y" with Clip | Each |
| V1707 | Sensor, Oximetry, Universal "C" w/ Clip, small | Each |
| V1720 | Clip, replacement for use with Universal "Y" sensor | Each |
| V1872 | Manual, Operation, (V9004) | Each |
| 3311 | Cable, Oximetry, 1.5 m (5 feet) | Each |
| 3356 | IV Pole Bracket | Each |
| 3365 | Printer Interface Cable, 9004 | Each |
| 3366 | PC Interface Cable, 9004 | Each |
| 3374 | V9004 Series Stack Bracket | Each |
| 5093 | Gas, $ETCO_2$ Cal, (10% $CO_2$, bal $N_2$) | Each |
| 8030 | Adapter, Airway, Elbow, 15ID/22OD x 15OD (mm) | 10/pkg |
| 8044 | Sample Line, 2.4 m (8 feet) | 10/pkg |
| 8061 | Regulator, Cal. Gas Flow, w/ gauge | Each |
| 8211 | Sample line, $CO_2$, 1.22 m (4 feet) | 10/pkg |
| 8217 | Kit: Calibration (5093, 8061, 8223, 8211) | Each |
| 8223 | Calibration Adapter | Each |
| V9008 | Kit: Digital Oximetry Smiths Medical PM, Inc. Veterinary Division | Each |
| 9014 | Cable Analog Out, 3 Channel (polysomnography) | Each |
| 9015 | Cable Analog Out 4 Channel (polysomnography) | Each |
| 9048 | Filters, Capnography, 13 mm | 2/pkg |
| 9189 | Adapter, Tee, $FiO_2$ | 10/pkg |
| 9190 | Sensor, $FiO_2$ | Each |
| 9191 | Cable, $FiO_2$ | Each |

## Ordering Information

For ordering information, contact the Smiths Medical PM, Inc. Veterinary Customer Service department at the address or phone number below:

Smiths Medical PM, Inc.
Veterinary Customer Service
N7W22025 Johnson Drive
Waukesha, WI 53186-1856

Phone: +1 262 513 8500
Toll-Free: 1 888 745 6562 (USA only)
Fax: +1 262 513 9069

# Chapter 16: Specifications

## Capnograph

| | |
|---|---|
| Display: | Vacuum Fluorescent 256 x 64 pixels; viewing area: 140.6 x 35.0 mm |
| Measurement: | Non-Dispersive IR absorption |
| Calibration: | Manual 2 point. |
| Measurement Range: | 0-10% $CO_2$ STPD (standard temperature pressure dry) |
| Display Range: | 0-100 mmHg; 0-13.3 kPa; 0-10% $CO_2$ |
| Display Update Rate: | 1Hz for $CO_2$ values, 30Hz for waveform |
| Accuracy: | ± 2mmHg or 4% of reading, whichever is greater (0-10% $CO_2$) |
| Stability: | ≤0.3% (vol) $CO_2$ /24hrs |
| Rise Time: | 360ms (average) |
| Delay Time: | 1.8s (average) |
| Response Time: | 375 msec to 90% of value (Flow= 150 mL/min.)<br>590 msec to 90% of value (Flow= 80 mL/min.) |
| Time from power on to accurate readings: | <35 sec |
| N2O Compensation: | selectable 40% (default = OFF) |
| Averaging: | 4 breath average |
| Flow Rate: | 150 ml/min ± 20 ml |
| LF Monitors: | 80 ml/min. ± 5 mL |

## Respiration Rate

| | |
|---|---|
| Range: | 0-120 breaths/min |
| Accuracy: | ± 1 bpm<br>(from 0-120 breaths/min with flow= 150 mL/min.)<br>(from 0-72 breaths/min. with flow= 80 mL/min.) |
| Averaging: | 4 breath average |
| Display Update Rate: | 1Hz |

## $SpO_2$

| | |
|---|---|
| Range: | 0-100% $SpO_2$ (functional) |
| Accuracy[1]: | ± 2 at 70-100% $SpO_2$<br>± 3 at 50-69% $SpO_2$ |
| Averaging: | User selectable 4,8, or 16 beats (default: 8) |
| Pulse Tone: | Pitch corresponds to $SpO_2$ value. Value adjustable or OFF. |
| Display Update Rate: | 1Hz for $SpO_2$ value, 60Hz for waveform |
| Sensor: | Red 660nm, 2mW (typical)<br>InfraRed 905nm, 2-2.4mW (typical) |
| Calibration: | Factory calibrated over 50% to 100% using human blood samples to functional saturation. Test methods available upon request. No in-service calibration required. |

[1] Because pulse oximeter measurements are statistically distributed, only about two-thirds of pulse oximeter equipment measurements can be expected to fall within the $A_{RMS}$ of the value measured by the CO-oximeter. The 9004 capnograph has been validated in human desaturation studies on 10 adult volunteers that did not have health problems (i.e. diabetes, asthma) and were non-smokers. The study was conducted at oxygen concentrations evenly distributed over an $SaO_2$ range of 50 to 100%.

## Pulse Rate

| | |
|---|---|
| Range: | 20-350 bpm |
| Accuracy: | ± 2% at 20 to 350 bpm |
| Averaging: | User selectable 8 or 16 seconds (default: 8) |
| Display Update Rate: | 1Hz |

## Pulse Strength

**NOTE! Pulse strength is not proportional to pulse volume!**

| | |
|---|---|
| Range: | 20-350 bpm, indicates logarithmic strength of patient's pulse |
| Display: | 8 segment bargraph |
| Display Update Rate: | 60Hz |

## $FiO_2$

| | |
|---|---|
| Sensor: | Galvanic Fuel Cell |
| Range: | 0-100% $O_2$ |
| Accuracy: | ± 2% $O_2$ |
| Drift: | < 2% full scale per month |
| Response Time: | < 10 sec to 90% $O_2$ |
| Display Update Rate: | 1Hz |

## Alarm Limits Ranges

### $ETCO_2$

| | |
|---|---|
| High: | 0-100 mmHg (1 mmHg steps), and OFF<br>0-13.3 kPa (0.1 kPa steps)<br>0-10.0% $CO_2$ (0.1% steps) |
| Low: | 0-100 mmHg (1 mmHg steps), and OFF |
| Defaults: | High = 60<br>Low = 20 mmHg |

### Resp Rate

| | |
|---|---|
| High: | 5-150 bpm (1 bpm steps), and OFF |
| Low: | 5-150 bpm (1 bpm steps), and OFF |
| Defaults: | High = 35 bpm<br>Low = 5 bpm |

### Inspired $CO_2$

| | |
|---|---|
| High: | 0-100 mmHg (1 mmHg steps), and OFF<br>0-13.3 kPa, 0.1 kPa steps<br>0-10.0% $CO_2$, 0.1% steps |
| Default: | High = 8 mmHg |

### Pulse Rate

| | |
|---|---|
| High: | 20-350 bpm (1 bpm steps), and OFF |
| Low: | 20-350 bpm (1 bpm steps), and OFF |
| Defaults: | High = 150 bpm<br>Low = 45 bpm |

### $SpO_2$

| | |
|---|---|
| High: | 50-100% (1% steps), and OFF |
| Low: | 50-100% (1% steps), and OFF |
| Defaults: | High = OFF<br>Low = 85% |

### $FiO_2$

| | |
|---|---|
| High: | 19-100% (1% steps), and OFF |
| Low: | 18-100% (1% steps) |
| Defaults: | High = OFF<br>Low = 18 |

## Audible Alarm Indicators

| | |
|---|---|
| Alarm Volume: | 45dBA to 85 dBA at 1 meter distance (adjustable) |

## Serial Output

| | |
|---|---|
| RS232C | |
| Data Format: | 9600 baud, 1 start bit, 8 data bits, 1 stop bit, no parity |
| Options: | Text only, no graphics. Patient data log or trend tables |

## Analog Output

User selectable, 3 channels, 0-1V scale, any parameter value, waveforms, or cal signals.

## Power

| | |
|---|---|
| AC Charger: | Input of 105-125VAC, 60 Hz<br>Input of 90-110VAC, 50 Hz (optional)<br>Input of 208-252VAC, 50/60 Hz (optional)<br>Output of 24VDC @1.3A with 4kV isolation. |
| Battery: | NiCad, 6VDC<br>Fully charged continuous use life of approximately 2 hours.<br>Maximum full-time charging time is 4 hours. |

## Physical Dimensions

| | |
|---|---|
| Width: | 25.4 cm (10.0 inches) |
| Height: | 8.89 cm (3.5 inches) |
| Depth: | 13.97 cm (5.5 inches) |
| Weight: | 2.2 kg (4.8 pounds) |

## Environment

### Temperature

| | |
|---|---|
| Operation: | 0 to 50° C (32 to 122° F) |
| Storage: | -40 to +70° C (-40 to +158° F) |

### Relative Humidity

| | |
|---|---|
| Operation: | 15 to 95% (non-condensing) |
| Storage: | 10 to 95% (non-condensing) |
| Atmospheric Pressure: | 525 mmHg (altitude: 10,000 feet) to 760 mmHg (altitude: sea level) |

# Appendix A: Digital/Analog Output Protocol and Pinout

## General Description

The Digital/Analog Output connector (rear of Capnograph) allows connection to a variety of external devices for collecting data from the monitor.

## Connector Pinout

The Digital/Analog Output connector is configured as follows:

| PIN NO. | DESCRIPTION |
|---|---|
| 2 | Serial Data In (received data to V9004 Capnograph) |
| 3 | Serial Data Out (transmitted data from V9004 Capnograph) |
| 4 | Busy from pc/printer to V9004 Capnograph |
| 7 | GROUND |
| 21 | Analog 1 |
| 23 | Analog 2 |
| 24 | Analog 3 |

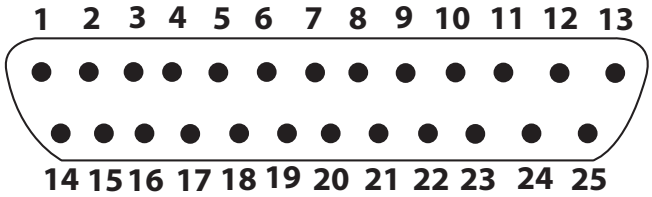



Figure App-1: 25 Pin Male "D" Connector Pinout

This page is intentionally left blank

# Appendix B: Guidance and Manufacturer's Declaration

## Guidance and Manufacturer's Declaration

The V9004 capnograph is intended for use in the electromagnetic environment specified in the tables within this appendix.

**NOTE! The customer or user of the V9004 capnograph should ensure that it is used in such an environment.**

### Electromagnetic Emissions - Emissions Test

| EMISSIONS TEST | COMPLIANCE | ELECTROMAGNETIC ENVIRONMENT GUIDANCE |
|---|---|---|
| RF emissions<br>CISPR 11 | Group 1 | The V9004 capnograph uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment. |
| RF emissions<br>CISPR 11 | Class B | The V9004 capnograph is suitable for use in all establishments, including:<br>• Domestic establishments.<br>• Establishments directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes. |
| Harmonic emissions<br>IEC 61000-3-2 | NA | |
| Voltage fluctuations/ flicker emissions<br>IEC 61000-3-3 | NA | |

### Electromagnetic Emissions – Immunity

| IMMUNITY | | ELECTROMAGNETIC ENVIRONMENT GUIDANCE |
|---|---|---|
| Electrostatic discharge (ESD)<br>IEC 61000-4-2 | **IEC 60601 TEST LEVEL**<br>• ± 6 kV contact<br>• ± 8 kV air<br>**COMPLIANCE LEVEL**<br>• ± 4 kV contact [a]<br>• ± 8 kV air | Floors should be made of:<br>• Wood<br>• Concrete<br>• Ceramic tile<br>If floors are covered with synthetic material, the relative humidity should be at least 30%. |
| [a] During testing, the device experienced intermittent display loss with a recovery time ranging from 1-4 seconds (without operator intervention). The monitor meets the failure criterion specified by the standards it was designed to. A complaint review was conducted and no complaints were reported in which ESD was likely to have caused the monitor to fail. | | |

| IMMUNITY | | ELECTROMAGNETIC ENVIRONMENT GUIDANCE |
|---|---|---|
| Electrical fast transient/ burst IEC 61000-4-4 | **IEC 60601 TEST LEVEL**<br>• ±2 kV for power supply lines.<br>• ±1 kV for input/ output lines<br>**COMPLIANCE LEVEL**<br>• ±0.5 kV to ±2 kV for power supply lines.<br>• ±0.25 kV to ±1 kV for input/output lines | A.C. Mains power voltage should be the typical quality of a:<br>• Commercial environment.<br>• Hospital environment. |
| Surge<br>IEC 61000-4-5 | **IEC 60601 TEST LEVEL**<br>• ±1 kV differential mode<br>• ±2 kV common mode<br>**COMPLIANCE LEVEL**<br>• ±1 kV differential mode<br>• ±2 kV common mode | |
| Voltage dips, short interruptions, and voltage variations on power supply input lines<br>IEC 61000-4-11 | **IEC 60601 TEST LEVEL**<br>• <5% $U_T$ (>95% dip in $U_T$) for 0.5 cycle.<br>• <40% $U_T$ (>60% dip in $U_T$) for 5 cycles.<br>• <70% $U_T$ (>30% dip in $U_T$) for 25 cycles.<br>• <5% $U_T$ (>95% dip in $U_T$) for 5 seconds.<br>**COMPLIANCE LEVEL**<br>• The monitor has an internal battery which powers the device when AC mains power is not available. | |
| *Note: $U_T$ is the A.C. mains voltage prior to application of the test level.* | | |

| IMMUNITY | | ELECTROMAGNETIC ENVIRONMENT GUIDANCE |
|---|---|---|
| Power frequency (50/60 Hz) IEC 61000-4-8 | **IEC 60601 TEST LEVEL**<br>3 A/m<br>**COMPLIANCE LEVEL**<br>10 A/m | Power frequency magnetic fields should be the typical levels of a:<br>• Commercial environment<br>• Hospital environment |
| Conducted RF IEC 61000-4-6 | **IEC 60601 TEST LEVEL**<br>• 3 Vrms<br>• 150 kHz to 80MHz<br>**COMPLIANCE LEVEL**<br>• 3 Vrms<br>• 150 kHz to 80 MHz. | **Recommended separation distance:**<br>$d = 1.2$ |
| Radiated RF IEC 61000-4-3 | **IEC 60601 TEST LEVEL**<br>• 3 V/m<br>• 80 MHz to 2.5 GHz<br>**COMPLIANCE LEVEL**<br>• 3 V/m 80% AM<br>• 80 MHz to 1 GHz [c] | **Recommended separation distance:**<br>$d = 1.2\sqrt{P}$ 80 MHz to 800 Mhz<br>$d = 2.3\sqrt{P}$ 800 MHz to 2.5 GHz |

- $P$ = Manufacturer's output power in watts (W).
- $d$ = Recommended distance in meters (m).

Field strengths from fixed RF transmitter, as determined by an electromagnetic site survey,[a] should be less than the compliance level in each frequency range.[b]

**CAUTION! Interference may occur in the vicinity of equipment marked with the following symbol:** 

*Note: At 80 MHz and 800 MHz, the higher frequency range applies.*

*Note: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.*

[a] Field strengths from fixed RF transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the V9004 capnograph is used exceeds the applicable RF transmitter compliance level above, the V9004 capnograph should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the V9004 capnograph.

[b] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 3 V/m.

[c] Some unknown effects could result from the device not being tested in the 1 GHz-2.5 GHz range, however the risk of failure is low. Designs with good fault monitoring and reporting and user documentation mitigate the risk of failure. No Smiths Medical PM legacy devices that have been tested have ever failed in this range. This statement was confirmed by a complaints review.

## Recommended Separation Distances

The V9004 capnograph is intended for use in an electromagnetic environment where radiated RF disturbances are controlled. The customer or the user of the V9004 capnograph can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the V9004 capnograph as recommended below, according to the maximum output power of the communications equipment.

The recommended separation distances between portable and mobile RF communication equipment and the V9004 capnograph is:

| RATED MAXIMUM OUTPUT POWER OF RF TRANSMITTER (WATTS) | SEPARATION DISTANCE ACCORDING TO THE FREQUENCY OF RF TRANSMITTER (METERS) | | |
|---|---|---|---|
| | 150 kHz to 80MHz<br>$d = 1.2\sqrt{P}$ | 80 MHz to 800 MHz<br>$d = 1.2\sqrt{P}$ | 800 MHz to 2.5 GHz<br>$d = 2.3\sqrt{P}$ |
| 0.01 | 0.12 | 0.12 | 0.23 |
| 0.1 | 0.38 | 0.38 | 0.73 |
| 1 | 1.2 | 1.2 | 2.3 |
| 10 | 3.8 | 3.8 | 7.3 |
| 100 | 12 | 12 | 23 |

For transmitters rated at a maximum output power not listed above, the recommended separation distance *d* in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

*NOTE: At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.*

*NOTE: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.*

**WARNING! The monitor should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the monitor should be observed to verify normal operation in the configuration in which it will be used.**

# Appendix C: Revision History

| REVISION | DATE | COMMENT |
|---|---|---|
| Rev. 10 | 2008-07 | • Added this Revision History<br>• Updated format<br>• Updated company name<br>• Added registered trademark information to Table of Contents.<br>• Added Patent information to Table of Contents<br>• Updated Warranty section<br>• Updated Proprietary Notice<br>• Added "About this Manual" to Chapter 1<br>• Added IFU note to Chapter 1<br>• Added WEEE Recycling Instructions/<br>• Updated symbol chart in Chapter 1.<br>• Updated warnings, cautions and notes.<br>• Updated sensor information<br>• Changed Appendix A and B to Chapter 15 and 16.<br>• Updated parts list in Chapter 15.<br>• Updated Line Art.<br>• Added design frame, SurgiVet and Smiths Medical logos to front cover. |

This page is intentionally left blank.

CE

Authorized Representative (as defined by the Medical Device Directive):

Smiths Medical International Ltd.
Colonial Way, Watford, Herts,
WD24 4LG, UK

Tel: (44) 1923 246434
Fax: (44) 1923 240273

Manufactured By
Smiths Medical PM, Inc.
N7W22025 Johnson Drive
Waukesha, WI 53186-1856 USA