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1 Respironics V60 Ventilator Service Manual2 For Technical Support and Customer Service, contact: USA and Canada: (toll free) or Respironics Europe, Africa, Middle East: Respironics Asia Pacific: Facsimile: United States of America Respironics California, Inc Cosmos Court Carlsbad, CA USA and Web Addresses Authorized European Representative Respironics Deutschland GmbH Gewerbestrasse 17 D Herrsching Germany Copyright 2009 Respironics California, Inc. and its affiliates. All rights reserved. This work is protected under Title 17 of the United States copyright code and is the sole property of Respironics California, Inc. No part of this document may be copied or otherwise reproduced, or stored in any electronic information retrieval system, except as specifically permitted under United States copyright law, without the prior written consent of Respironics California, Inc.3 Table of Contents 1 Introduction and Intended Use Intended Use Recommended Test Equipment, Tools, and Supplies Where to Go for Help Warnings and Cautions General Preparing for Ventilation Operation Alarms and Messages Care and Maintenance First-Time Installation Communications Interface Diagnostic Mode Theory of Operation Pneumatics Air Inlet Air Inlet Filter Air Flow Sensor Machine and Proximal Pressure Transducers Barometric Pressure Transducer Oxygen Pressure Transducer Manifold, Oxygen Inlet Filter, Filter Element Oxygen Solenoid Valve Oxygen Flow Sensor Blower Solenoid Valves Electronics Power management (PM) PCBA Power Supply Internal Battery CPU PCBA Motor Controller (MC) PCBA Data Acquisition (DA) PCBA Flow Sensors Rev A V60 Ventilator Service Manual iii4 Table of Contents User Interface LCD Assembly Backlight Inverter PCBA Touch Screen Assembly Nav-Ring Assembly (Rotary Adjustment) Power Switch Overlay Switch PCBA UI PCBA Electronic Signal Paths Periodic Maintenance Annual Preventive Maintenance Instructions Diagnostic Mode and Troubleshooting System Settings Selecting a Language Setting Date and Time Restoring Default Settings Selecting Pressure Units Enabling Software Options Baud Rate Service Viewing Ventilator Information Pneumatic Controls Output Controls Miscellaneous Touch Screen Calibration Diagnostic Codes, Alarms, and Troubleshooting Miscellaneous Troubleshooting Tips Reports and Software Downloads Setting Up the Service PC Setting Up the Serial Interface Using HyperTerminal Setting Up the Serial Interface Using Tera Term Generating a Diagnostic Report (DRPTA) Clearing the Significant Event Log Downloading Ventilator Software Programming the Ventilator Serial Number and Power-On Hours Programming the Ventilator Serial Number Programming Ventilator Power-On Hours iv V60 Ventilator Service Manual Rev A5 Table of Contents 7 Component Removal/Installation Disconnecting Power Air Inlet Filter Internal Battery Top Cover AC Inlet Fan Oxygen Inlet Motor Controller (MC) PCBA Separating the UI from the Base Front Panel Gas Outlet Port UI Retainer Proximal Pressure Port Speakers Power Management (PM) PCBA Power Supply CPU PCBA Real-Time Clock Battery Left Side Wall Gas Delivery Subsystem (GDS) Right Side Wall Oxygen Inlet Filter Data Acquisition (DA) PCBA Air and Oxygen Flow Sensor Assembly Oxygen Solenoid Valve Solenoid Valves Blower Opening the User Interface (UI)/ Rear Bezel Power Switch Overlay Switch PCBA Nav-Ring Assembly Front Bezel, Touch Screen LCD User Interface (UI) PCBA Backlight Inverter PCBA LCD Tray Bottom Feet Labels Rev A V60 Ventilator Service Manual v6 Table of Contents 8 Performance Verification Required Test Equipment Preliminary Cleaning, Inspection and Setup View and Record Ventilator Information Pneumatic Calibration Analyzer Setup Measurement Selection Screen Averaging Setup Menu Trigger Options Configurations Menu Performance Verification Procedures Electrical Safety (Test 1) Leak Tests (Test 2) Controls (Test 3) Pressure Accuracy (Test 4) Air Delivery/Flow Accuracy (Test 5) Oxygen Flow Accuracy (Test 6) Oxygen Accuracy (Test 7) S/T Performance (Test 8) Alarms (Test 9) Power Fail (Test 10) Internal Battery (Test 11) Returning Ventilator to Operation Performance Verification Troubleshooting/Repair Test 1: Electrical Safety Test 2: Leak Tests Test 3: Controls Test 4: Pressure Accuracy Test 5: Air Delivery/Flow Accuracy Test 6: Oxygen Flow Accuracy Test 7: Oxygen Accuracy Test 8: S/T Performance Test 9: Alarms Test 10: Power Fail Test 11: Internal Battery Electrical Safety Data Form Performance Verification Data Form vi V60 Ventilator Service Manual Rev A7 Table of Contents 9 Replacement Parts List Complete Parts List Recommended Inventory Parts List Ventilator Chassis Pneumatics Electronics Specifications Control settings Patient data Alarms Menu window settings Operator-accessible diagnostic mode functions Physical characteristics Environmental specifications Pneumatic specifications Electrical specifications Other specifications Contact Information Appendix A Respi-Link A-1 A.1 Downloading Ventilator Software A-1 A.2 Installing Ventilator Options A-6 A.3 Reinitiate a Software Package A-8 A.4 Remote Troubleshooting A-13 Appendix B Field Communications B-1 Index Index Rev A V60 Ventilator Service Manual vii8 Table of Contents (This page is intentionally blank.) viii V60 Ventilator Service Manual Rev A9 Chapter 1. Introduction and Intended Use The V60 ventilator is a microprocessor-controlled, positive pressure ventilator assist system. The ventilator provides noninvasive and invasive ventilatory support for spontaneously breathing adult and pediatric patients. The ventilator has a variety of modes and monitoring capabilities to assist in assessing performance and patient-to-ventilator synchrony. The safety features include in-depth alarms and a variety of integrated safety and self-diagnostic features. Many system functions are automatically checked at startup and during operation. The ventilator includes a touch screen user interface (UI) and navigation ring (nav-ring) that allows the operator to select ventilator and alarm settings and displays of ventilator and patient data. The ventilator is designed to be upgradeable, and features communications capabilities and an internal battery backup option. Read this manual thoroughly before performing service or maintenance on the V60 ventilator. This manual includes advanced troubleshooting, calibration, and maintenance instructions for the ventilator. All maintenance and repair work should be performed by qualified biomedical technicians who have appropriate training and authorization to provide maintenance, repair, and service for the V60. Review the operating instructions for the V60 ventilator before running tests, checking operational readiness, or initiating patient use. These instructions include important information about ventilator safety and operation. For additional information about accessories or related equipment, such as humidifiers and remote alarm systems, refer to the appropriate instruction manual prior to operating the V60 ventilator. Review the applicable warnings and cautions in the V60 User Manual before operating the ventilator Rev A V60 Ventilator Service Manual 1-110 Chapter 1 Introduction and Intended Use 1.1 Intended Use The Respironics V60 ventilator is an assist ventilator that is intended to augment patient breathing. It is intended for spontaneously breathing individuals who require mechanical ventilation: patients with respiratory failure, chronic respiratory insufficiency, or obstructive sleep apnea in a hospital or other institutional settings under the direction of a physician. The ventilator is intended to support pediatric patients weighing 20 kg (44 lb.) or greater to adult patients. It is also intended for intubated patients meeting the same selection criteria as the noninvasive applications. The ventilator is intended to be used by qualified medical professionals such as physicians, nurses, and respiratory therapists. The ventilator is intended to be used only with various combinations of Respironics recommended patient circuits, interfaces (masks), humidifiers, and other accessories. 1-2 V60 Ventilator Service Manual Rev A11 Chapter 1 Introduction and Intended Use 1.2 Recommended Test Equipment, Tools, and Supplies Table 1-1 lists the recommended tools, test equipment, and materials required to service and maintain the V60 ventilator. Table 1-1: Recommended Test Equipment, Tools, and Materials Description Manufacturer and Model Test Equipment Digital multimeter (DMM) accurate to three decimal places Electrical safety analyzer Pneumatic calibration analyzer capable of measuring low pressure (cmh 2 O), flow rate (LPM), and volume (liters) Temperature/humidity monitor Test lung Local Supplier Dale LT 5440 or equivalent Respironics P/N or equivalent Fisher Scientific or equivalent IngMar QuickLung or equivalent Service Tools and Supplies V60 Service Kit, which includes: Respironics P/N Adapter, 22-mm OD, both ends Respironics P/N Adapter, 25-pin to 9-pin Respironics P/N Adapter, torque, cap/collar Respironics P/N BiPAP test adapter, 0.25-in. Respironics P/N Cable, null modem Respironics P/N Cable, TTL communications Respironics P/N Circuit tube, 18-in. smooth-bore (qty. 2) Respironics P/N Coupling, straight, silicone Respironics P/N Forceps, locking, red plastic Respironics P/N Plug, low-pressure Respironics P/N Plug, tapered 23 / / 64 in., silicone (qty. 2) Respironics P/N Plug, tapered 9 / 16-3 / 4 in., silicone Respironics P/N Pressure pick-off port (oxygen enrichment attachment SNGL) Respironics P/N Proximal pressure line tubing Respironics P/N Remote alarm test cable Respironics P/N Remote alarm test cable adapter Respironics P/N Rev A V60 Ventilator Service Manual 1-312 Chapter 1 Introduction and Intended Use Table 1-1: Recommended Test Equipment, Tools, and Materials Description Manufacturer and Model Syringe, system leak test Respironics P/N Valve, ball Respironics P/N Valve, oxygen/regulator shut-off Respironics P/N Whisper Swivel II Respironics P/N Adapter, USB to serial Cleaning cloth Respironics P/N or equivalent Local supplier Fitting, system leak test syringe (replacement) Respironics P/N Isopropyl alcohol Lubricant, KRYTOX GPL 226 Metric hex key set (rounded ends), 1.5 to 4 mm Mild detergent or antiseptic wipes Needle nose pliers PC or laptop (required for downloading software and capturing diagnostic codes) Pliers Screwdriver, #0 Phillips Screwdriver, #1 Phillips Screwdriver, #2 Phillips Screwdriver, #3 Phillips Screwdriver, pen size, Phillips Screwdriver, pen size, slotted Socket, deep, 5/16-in. Socket, deep, 9/16-in. Torque driver capable of 11.2 to 283 N cm / 1 to 25 in.-lbf Torque driver capable of 226 to 1130 N cm/ 20 to 100 in.-lbf Vacuum, ESD-safe Workstation, antistatic Local supplier Respironics P/N or equivalent Local supplier Local supplier Local supplier Required: Windows XP operating systems, serial port, and USB port Local supplier Local supplier Local supplier Local supplier Local supplier Local supplier Local supplier Local supplier Local supplier 3M Model 497-AJM or equivalent 3M Model 725 or equivalent 1-4 V60 Ventilator Service Manual Rev A13 Chapter 1 Introduction and Intended Use 1.3 Where to Go for Help For Technical Support and Customer Service, contact: USA and Canada: or Respironics Europe, Africa, Middle East: Respironics Asia Pacific: Facsimile: Rev A V60 Ventilator Service Manual 1-514 Chapter 1 Introduction and Intended Use (This page is intentionally blank.) 1-6 V60 Ventilator Service Manual Rev A15 Chapter 2. Warnings and Cautions Before servicing the Respironics V60 ventilator, read and understand this service manual, especially safety considerations. These safety considerations are for reference only, and are not intended to supersede your institution s protocol for service or safe use of noninvasive ventilation. The instructions in this manual are primarily reserved for use by a qualified service technician. WARNING: Alerts the user to the possibility of injury, death, or other serious adverse reactions associated with the use or misuse of the device. CAUTION: Alerts the user to the possibility of a problem with the device associated with its use or misuse, such as device malfunction, device failure, damage to the device, or damage to other property. NOTE: Emphasizes information of particular importance. 2.1 General WARNING: An alternative means of ventilation shall be available whenever the ventilator is in use. If a fault is detected in the ventilator, disconnect the patient from it and immediately start ventilation with such a device. The ventilator must be removed from clinical use and serviced by Respironics-authorized service personnel. WARNING: WARNING: WARNING: Use the Respironics V60 ventilator on spontaneously breathing patients only. It is an assist ventilator and is intended to augment the ventilation of a spontaneously breathing patient. It is not intended to provide the total ventilatory requirements of the patient. We do not recommend you use the Respironics V60 ventilator on patients who require ventilation at predetermined tidal volumes. The ventilator provides continuous positive airway pressure (CPAP) and positive pressure ventilation (S/T, PCV, and AVAPS) and is indicated for assisted ventilation only. These modes do not provide ventilation with guaranteed tidal volume delivery. We do not recommend you use AVAPS on patients who require rapid and frequent IPAP adjustments to maintain a consistent tidal volume. AVAPS, a volume targeted mode, changes the IPAP setting in order to achieve the target tidal volume. During AVAPS setup, there may be a period of time before the target tidal volume is achieved. AVAPS is ideal for more stabilized patients Rev A V60 Ventilator Service Manual 2-116 Chapter 2 Warnings and Cautions WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: To reduce the risk of CO 2 rebreathing, make sure EPAP pressures and exhalation times are sufficient to clear all exhaled gas through the exhalation port. In noninvasive ventilation continuous air flow through the port flushes exhaled gases from the circuit. The ability to completely exhaust exhaled gas from the circuit depends on the EPAP setting and I:E ratio. Higher tidal volumes further increase the volume of CO 2 rebreathed by the patient. To reduce the risk of CO 2 rebreathing, monitor the patient for changes in respiratory status at the start of ventilation and with each change in ventilator settings, circuit configuration, or patient condition. Pay attention to ventilator alarms that warn of increased CO 2 rebreathing risk. Be aware of the possibility of contamination from patient exhalate being exhausted into the room through the exhalation port. To ensure accuracy of oxygen administration and to monitor for the presence of contamination (incorrect gas connected), use an external oxygen monitor to verify the oxygen concentration in the delivered gas. To reduce the risk of fire, use the ventilator in well-ventilated areas away from flammable anesthetics. Do not use in a hyperbaric chamber or other similarly oxygen-enriched environments. Do not use near an open flame. To reduce the risk of electric shock from liquid entering the device, do not put a container filled with a liquid on the ventilator. To reduce patient risk of hypoxemia, keep free-flowing oxygen away from air inlet of ventilator. Connect to the ventilator only items that are specified as part of or compatible with the ventilator system. Additional equipment connected to medical electrical equipment must comply with the respective IEC or ISO standards. Furthermore, all configurations shall comply with the requirements for medical electrical systems (see IEC or clause 16 of edition 3 of IEC , respectively). Anybody connecting additional equipment to medical electrical equipment configures a medical system and is therefore responsible for ensuring that the system complies with the requirements for medical electrical systems. Also be aware that local laws may take priority over the above mentioned requirements. If in doubt, consult Respironics. To reduce the risk of fire, explosion, leakage, or other hazard, take these precautions with respect to the battery: Do not attempt to disassemble, open, drop, crush, bend or deform, insert foreign objects into, puncture, or shred the battery pack; modify or remanufacture it; immerse or expose it to water or other liquids; expose it to fire, excessive heat (including soldering irons); or put it in a microwave oven. Replace the battery only with another battery specified by the manufacturer. Follow all instructions for proper use of the battery. Do not short-circuit the battery or allow metallic or conductive objects to contact the battery connector housing. Use the battery with the Respironics V60 ventilator only. 2-2 V60 Ventilator Service Manual Rev A17 Chapter 2 Warnings and Cautions WARNING: WARNING: CAUTION: CAUTION: NOTE: NOTE: NOTE: NOTE: NOTE: NOTE: NOTE: NOTE: NOTE: NOTE: The nurse call/remote alarm should be considered a backup to the ventilator s primary alarm system. To ensure that the alarm will be heard, make sure the alarm loudness is adequate and avoid blocking the alarm speakers beneath the ventilator. Federal law (USA) restricts this device to sale by or on the order of a physician. The Respironics V60 ventilator is designed to operate in the temperature range of 5 to 40 ºC (41 to 104 ºF). To minimize the risk of overheating the device, do not operate adjacent to heaters or other heat sources. The displays shown in this manual may not exactly match what you see on your own ventilator. Pressures are indicated on the ventilator in cmh 2 O. Millibars and hectopascals (hpa) are used by some institutions instead. Since 1 millibar equals 1 hpa, which equals cmh 2 O, the units may be used interchangeably. The ventilator is not intended for use as an ambulance transport ventilator or as an Automatic Transport Ventilator as described by the American Hospital Association and referenced by the FDA. It is intended to allow the patient to be transported within the hospital setting using a cart to move the ventilator. When attachments or other components or subassemblies are added to the ventilator breathing system, the pressure gradient across the ventilator breathing system, measured with respect to the ventilator outlet, may increase. The Respironics V60 ventilator parts that have patient contact are free of latex. If an alarm persists for no apparent reason, discontinue ventilator use and contact Respironics. If you detect any unexplained changes in the performance or visual displays of the ventilator, discontinue ventilator use and contact Respironics. The Respironics V60 ventilator does not support automatic record keeping Rev A V60 Ventilator Service Manual 2-318 Chapter 2 Warnings and Cautions 2.2 Preparing for Ventilation WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: To ensure the correct performance of the ventilator and the accuracy of patient data, we recommend you use only Respironics-approved accessories with the ventilator. To prevent possible asphyxia and to reduce the risk of CO 2 rebreathing, take these precautions with respect to mask and exhalation port use: Use only a mask with an exhalation port or a nasal mask for noninvasive ventilation. Do not occlude the exhalation port. Turn on the ventilator and verify that the port is operational before application. Pressurized gas from the ventilator should cause a continuous flow of air to exhaust from the leak port, flushing exhaled gas from the circuit. Never leave the mask on the patient while the ventilator is not operating. When the ventilator is not operating, the exhalation port does not allow sufficient exhaust to eliminate CO 2 from the circuit. Substantial CO 2 rebreathing may occur. To ensure normal air circulation and exchange, do not cover or block the ports on the ventilator or ventilator circuit. Do not block the air inlet panel on the right side of the ventilator. To prevent possible patient injury and possible water damage to the ventilator, make sure the humidifier is set to appropriate temperature and humidification settings. To prevent the possibility of inadequate humidification, pay close attention to the humidifier s functioning when operating the ventilator at an ambient temperature > 30 ºC (86 ºF). The ventilator warms the air delivered to the patient above ambient temperature, which may impair the humidifier s performance. To reduce the risk that the patient will aspirate condensed water from the breathing circuit, position any humidifier lower than both the ventilator and the patient. To prevent possible patient injury and equipment damage, do not turn the humidifier on until the gas flow has started and is regulated. Starting the heater or leaving it on without gas flow for prolonged periods may result in heat build-up, causing a bolus of hot air to be delivered to the patient. Circuit tubing may melt under these conditions. Turn the heater power switch off before stopping gas flow. To reduce the risk of fire, use only patient circuits intended for use in oxygenenriched environments. Do not use antistatic or electrically conductive tubing. To prevent patient or ventilator contamination, recommend you use a Respironics-approved main flow bacteria filter on the patient gas outlet port. Filters not approved by Respironics may degrade system performance. 2-4 V60 Ventilator Service Manual Rev A19 Chapter 2 Warnings and Cautions WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: WARNING: CAUTION: CAUTION: To reduce the risk of bacterial contamination or damage, handle bacteria filters with care. To reduce the risk of strangulation from patient tubing, use a tubing support arm and secure the proximal pressure line with clips. To reduce the risk of electric shock, connect the ventilator to an AC supply mains with protective earth only. Do not use extension cords, adapters, or power cords with the ventilator that are not approved by Respironics. To prevent unintentional disconnection of the power cord, always use the correct, Respironics-supplied power cord and lock it into place with the power cord retainer before you switch the ventilator on. The retainer is designed to hold the connector end of the Respironics-supplied cord securely in place. To reduce the risk of electric shock, regularly inspect the AC power cord and verify that it is not frayed or cracked. To reduce the risk of strangulation, route the power cord to avoid entanglement. To reduce the risk of power failure, pay close attention to the battery s charge level. The battery s operation time is approximate and is affected by ventilator settings, discharge and recharge cycles, battery age, and ambient temperature. Battery charge is reduced at low ambient temperatures or in situations where the alarm is continuously sounding. To ensure the ventilator s safe operation, always run the full preoperational check described in the operator s manual before using the ventilator on a patient. If the ventilator fails any tests, remove it from clinical use immediately. Do not use the ventilator until necessary repairs are completed and all tests have passed. To prevent possible patient injury, disconnect the patient from the ventilator before running the preoperational check. Make sure another source of ventilatory support is available. To prevent possible patient injury due to nonannunciating alarms, verify the operation of any remote alarm device before use. To prevent possible damage to the ventilator, ensure that the connection to the oxygen supply is clean and unlubricated, and that there is no water in the oxygen supply gas. For 120 V equipment, grounding reliability can only be achieved when it is connected to an equivalent receptacle marked hospital only or hospital grade Rev A V60 Ventilator Service Manual 2-520 Chapter 2 Warnings and Cautions 2.3 Operation WARNING: To prevent possible patient injury, avoid setting alarm limits to extreme values, which can render the alarm system useless. 2.4 Alarms and Messages WARNING: If AC power fails and the backup battery is not installed or is depleted, an audible and visual alarm annunciates for at least 2 minutes. Immediately discontinue ventilator use and secure an alternative means of ventilation. As in most ventilators with passive exhalation ports, when power is lost, sufficient air is not provided through the circuit and exhaled air may be rebreathed. 2.5 Care and Maintenance WARNING: WARNING: WARNING: CAUTION: CAUTION: CAUTION: CAUTION: CAUTION: CAUTION: WARNING: To reduce the risk of electric shock, power down the ventilator and disconnect it from AC power before cleaning or servicing it. WARNING: To prevent patient or ventilator contamination, inspect and replace the main flow bacteria filter between patients and at regular intervals (or as stated by the manufacturer). WARNING: To prevent possible patient injury, inspect and verify the proper operation of the exhalation port regularly during use. Do not attempt to sterilize or autoclave the ventilator. To prevent possible damage to the ventilator, use only those cleaning agents listed in this manual. To prevent possible damage to the touchscreen, take care when cleaning it. Do not drip water and/or soap solution. After cleaning and rinsing, remove all moisture with a dry, soft cloth. Never clean the touchscreen with an abrasive brush or device, since this will cause irreparable damage. To avoid introducing foreign matter into the ventilator and to ensure proper system performance, change the air inlet filter at regular intervals (or as stipulated by your institution). To ensure proper system performance, use a Respironics-approved air inlet filter. Because some environments cause a quicker collection of lint and dust than others, inspect the filters more often when needed. The air inlet filter should be replaced; the cooling fan filter should be cleaned. To prevent possible damage to the ventilator, always ship it with the original packing material. If the original material is not available, contact Respironics to order replacements. 2-6 V60 Ventilator Service Manual Rev A21 Chapter 2 Warnings and Cautions 2.6 First-Time Installation WARNING: CAUTION: Never attempt to disconnect or reconnect the battery during operation. To prevent possible damage to the ventilator, always secure it to its stand or securely place it on a flat, stable surface that is free of dirt and debris. Do not use the ventilator adjacent to, or stack it with, other equipment. 2.7 Communications Interface WARNING: WARNING: WARNING: WARNING: WARNING: CAUTION: Connect to the ventilator only items that are specified as part of or compatible with the ventilator system. Additional equipment connected to medical electrical equipment must comply with the respective IEC or ISO standards. Furthermore, all configurations shall comply with the requirements for medical electrical systems (see IEC or clause 16 of edition 3 of IEC , respectively). Anybody connecting additional equipment to medical electrical equipment configures a medical system and is therefore responsible for ensuring that the system complies with the requirements for medical electrical systems. Also be aware that local laws may take priority over the above mentioned requirements. If in doubt, consult Respironics. It is the responsibility of the end user to validate the compatibility and use of information transmitted from the ventilator with the device to be connected to the ventilator. The data provided through the communications interface is for reference only. Decisions for patient care should be based on the clinician s observations of the patient. To prevent possible patient injury due to nonannunciating alarms, verify the operation of any remote alarm device before use. To ensure the functionality of the remote alarm, connect only Respironicsapproved cables to the remote alarm port. The remote alarm port is intended to connect only to an SELV (safety extra-low voltage and ungrounded system with basic insulation to ground), in accordance with IEC To prevent damage to the remote alarm, make sure the signal input does not exceed the maximum rating of 24 VAC or 36 VDC at 500 ma with a minimum current of > 1 ma. 2.8 Diagnostic Mode WARNING: To prevent possible patient injury, do not enter the diagnostic mode while a patient is connected to the ventilator. Verify that the patient is disconnected before proceeding Rev A V60 Ventilator Service Manual 2-722 Chapter 2 Warnings and Cautions (This page is intentionally blank.) 2-8 V60 Ventilator Service Manual Rev A23 Chapter 3. Theory of Operation The V60 ventilator is a microprocessor-controlled gas flow control and monitoring system that can deliver air and oxygen to augment or replace the work normally performed by the patient s respiratory system. The ventilator uses electromechanical control circuits, flow and pressure monitors, and software programs to deliver pressure controlled breaths. The ventilator includes a user interface (UI), internal blower, and gas delivery subsystem (GDS) that mixes air and oxygen. The ventilator can operate from a 40 to 87 psig (276 to 600 kpa) medical grade oxygen source for enriched oxygen operation. The internal power supply that can operate from mains (100 to 240 V AC 50/60 Hz) or internal battery (14.4 V DC) power. The ventilator also includes several communications interfaces. Schematic diagrams of the V60 ventilator are available upon request. 3.1 Pneumatics The pneumatic subsystem delivers and monitors pressurized gas to the patient in response to commands from the CPU subsystem. The pneumatic subsystem includes the: Manifold Blower Oxygen solenoid valve Air and oxygen flow sensors Pressure transducers Solenoid valves Motor controller (MC) PCBA Data acquisition (DA) PCBA The ventilator uses ambient air and high-pressure oxygen. Air enters through an inlet filter. Oxygen enters though a high-pressure inlet, and a proportional valve provides the operator-set concentration. The system mixes the air and oxygen, pressurizes it in the blower, and then regulates it to the user-set pressure. To do this, the ventilator compares the proximal (patient) pressure measurement with the ventilator outlet (machine) pressure, and adjusts the machine pressure to compensate for the pressure drop across the inspiratory filter, patient circuit, and humidifier. This helps ensure accurate and responsive pressure delivery and leak compensation. The ventilator delivers gas to the patient through a main flow (inspiratory) bacteria filter, a single-limb patient breathing circuit, a humidification device (optional), and a patient interface such as a mask or ET tube. A pressure tap Rev A V60 Ventilator Service Manual 3-124 Chapter 3: Theory of Operation proximal to the patient is used to monitor patient pressure. The internal exhalation port continually clears gas from the ventilator airway to ensure delivery of an accurate oxygen mixture. Figure 3-1 shows a pneumatic schematic of the V60 ventilator. Proximal pressure sensor Machine pressure sensor Ambient pressure Ambient air inlet Air inlet filter Bypass element Machine pressure line Purge solenoid Ambient pressure Air flow sensor Proximal pressure High pressure oxygen inlet O 2 inlet filter O 2 inlet pressure Proportional solenoid valve O 2 flow sensor Mixing air & O 2 Blower Patient port Barometric pressure sensor Sintered flow normalizers Bypass element Internal exhalation port Ambient pressure Figure 3-1: V60 Ventilator Pneumatic Subsystem Schematic Air Inlet Ambient air is entrained through the air inlet. Air inlet Air Inlet Filter Air inlet filter The air inlet filter is designed to filter 5-micron particles at 70% efficiency at 150 SLPM flow. 3-2 V60 Ventilator Service Manual Rev A25 Chapter 3: Theory of Operation Manifold Air flow sensor Air Flow Sensor The air flow sensor measures a subset (bypass flow) of total flow in the pneumatic air path and interpolates the measurements according to constants that are calculated during gas delivery subsystem (GDS) calibration. The air flow sensor also helps provide closed-loop control of gas flow during oxygen blending Machine and Proximal Pressure Transducers The machine and proximal pressure transducers on the DA PCBA measure the machine and proximal pressure over a range of -20 to +65 cmh 2 O Barometric Pressure Transducer The barometric pressure transducer on the DA PCBA measures barometric pressure over a range of 525 to 850 mmhg Oxygen Pressure Transducer The oxygen pressure transducer on the DA PCBA measures inlet pressure over Oxygen pressure transducer Machine pressure transducer Proximal pressure transducer Barometric pressure transducer DA PCBA a range of 0 to 87 psig. An alarm results if oxygen supply pressure is below 40 psig (276 kpa) or above 92 psig (634 kpa) Rev A V60 Ventilator Service Manual 3-326 Chapter 3: Theory of Operation Oxygen inlet filter Manifold, Oxygen Inlet Filter, Filter Element The manifold includes a connection for the oxygen inlet, allowing countryspecific oxygen connections to be attached to the manifold. The manifold provides the pneumatic interfaces to the air inlet, oxygen inlet, blower inlet, and proximal and machine pressure lines. Oxygen filter element Manifold Oxygen breather vent The oxygen inlet filter removes 5-micron particles from the oxygen gas supply. A 40-micron sintered bronze filter element acts to reduce turbulence in the oxygen flow. The 40-micron oxygen breather vent reduces noise in the oxygen flow Oxygen Solenoid Valve The oxygen solenoid valve and valve driver circuitry control the flow of oxygen according to the set O 2 and flow. The oxygen solenoid valve is closed when there is a loss of power or system reset. Manifold Oxygen solenoid valve Oxygen Flow Sensor Manifold The oxygen flow sensor measures a subset (bypass flow) of the total flow. These measurements are interpolated according to constants that are calculated during GDS calibration. Together, the oxygen solenoid valve and flow sensor provide closed-loop control for delivered oxygen flow. Oxygen flow sensor Blower Blower The blower is controlled by the MC PCBA, and generates flow and pressure for the system. The blower includes an impeller, housing, and a three-phase brushless DC motor. The blower delivers a maximum pressure of less than 125 cmh 2 O in a dead-head condition, can accelerate from 10,000 to 22,500 revolutions per minute (RPM) in 120 msec from a nominal 5- to 25-cmH 2 O pressure rise. Maximum motor speed is approximately 40,000 RPM. The blower motor has internal Hall Effect sensors that are monitored by the MC PCBA and measure impeller speed. 3-4 V60 Ventilator Service Manual Rev A27 Chapter 3: Theory of Operation Manifold Solenoid valves (x4) Solenoid Valves Four solenoid valves are mounted on the manifold and controlled by the DA PCBA. These three-way autozero solenoids include SOL1 (purge solenoid), SOL2 and SOL4 (machine pressure autozero solenoids), and SOL3 and SOL4 (proximal pressure autozero solenoids). Solenoid valves SOL3, SOL4: Proximal pressure autozero solenoids. SOL4: Also connects machine pressure to the proximal pressure transducer during autozero. SOL2, SOL4: Machine pressure autozero solenoids. SOL1: Purge solenoid, uses the machine pressure line to purge the proximal pressure line Rev A V60 Ventilator Service Manual 3-528 Chapter 3: Theory of Operation 3.2 Electronics The electronics system provides software-based control and monitoring, power management, user input, display, subsystem I/O, external communication, and alarms. The electronics system includes a Cirrus EP9307 microcontroller for control and monitor processing. Control tasks include breath delivery, patient data calculation, and alarm detection/response. Monitoring tasks include controlling the LCD, front panel keys and indicators, inputs, and primary alarm output. An independent watchdog control provides safety monitoring. The electronics system includes: Power management (PM) PCBA Power supply Internal battery CPU PCBA Motor controller (MC) PCBA Data acquisition (DA) PCBA Flow sensors User interface Liquid crystal display (LCD) Backlight inverter PCBA Touch screen assembly Nav-ring assembly Power switch overlay Switch PCB User interface (UI) PCBA 3-6 V60 Ventilator Service Manual Rev A29 Chapter 3: Theory of Operation PM PCBA Power management (PM) PCBA Battery charging and management circuitry Internal supply voltages (supply voltages: 3.3 V, 5 V, 12 V, 35 V). Fan power and tach monitoring. Backup alarm control circuitry, including power fail detection. Power switch control circuitry. System alarm and reset management. Electrical interfaces between the CPU PCBA, LCD, and the user interface (UI) PCBA. Includes an EEPROM for calibration data, board identification information, and PM PCBA power-on hours. Power supply Power Supply Provides ventilator and battery recharging power from AC line voltage. Converts AC line voltage (100 to 240 VAC, 50 to 60 Hz) into 24 VDC power. Includes input over-current, output over-voltage, and output currentlimiting protection. Internal battery Internal Battery 14.4-V, 11.5-Ah lithium-ion battery has a run-time of at least six hours under normal conditions. Provides operating power when AC power is not available. Provides charge and temperature status to the PM PCBA. Internal circuitry monitors battery status, provides self-contained fault control features, and communicates this information to the PM PCBA Rev A V60 Ventilator Service Manual 3-730 Chapter 3: Theory of Operation CPU PCBA CPU PCBA Microprocessor: once in a run state, the microprocessor can only be reset by a watchdog timeout or out-of-specification power condition. Monitors operation of the ventilator and controls delivery of air and oxygen to the patient. Verifies safe ventilator operation. Flash memory: 8 MB program storage. RAM: 8 MB for program execution and volatile data storage. EEPROM: 4 KB of storage for board-specific information (including operating hours, time since last service, serial numbers, part numbers, and software and hardware revisions). Watchdog timer: disables the blower and oxygen flow if not strobed by software within a predefined time window that is independent of the CPU master clock. In addition, ensures that software is operating. Real-time clock (RTC): a time of day clock that provides the date and time to the ventilator, and is powered by a dedicated 3-V lithium coin cell battery. LCD interface supports a display of 1024 horizontal x 768 vertical pixels in 256 colors with a refresh rate of at least 50 Hz. The CPU PCBA controls LCD brightness by varying a control voltage over a range of 0 to 3.5 V (minimum to maximum brightness). Touch screen interface supports a five-wire type touch screen. Nav-ring rotary adjustment interface with a minimum resolution of 24 ticks per revolution. User key switches: interfaces to front panel keys. Alarm subsystem: includes a speaker driver circuit for the two main speakers, a backup piezo alarm, and a three-wire relay-controlled remote alarm interface (normal open, NO, or normal closed, NC) on the ventilator back panel. Blower speed monitor measures blower speeds from 3,000 to 50,000 RPM with 2% accuracy. Electrical interfaces to the power management (PM) and motor controller (MC) PCBAs. Two USB ports and an ethernet connection are designed for future enhancements. Table 3-1 summarizes hospital information system (HIS) RS-232 port pinout. 3-8 V60 Ventilator Service Manual Rev A31 Chapter 3: Theory of Operation Table 3-1: V60 HIS Serial Communications Port Pinout Pin Signal I/O Description 1 HIS_RS232_SHLD Power HIS RS232 cable shield 2 HIS_RS232_TxD Output HIS RS232 transmit data output 3 HIS_RS232_RxD Input HIS RS232 receive data input 4 HIS_RS232_RTS Output HIS RS232 ready to send 5 HIS_RS232_CTS Input HIS RS232 clear to send 6 HIS_RS232_DSR Input HIS RS232 data set ready 7 HIS_SIG_RTN Power HIS RS232 signal common 8 PULSE_OX_IN Input Pulse oximeter analog input 9 HIS_DIG_IN0 Input HIS digital input #0, V digital logic level (0-5 V tolerant) 10 HIS_DIG_IN1 Input HIS digital input #1, V digital logic level (0-5 V tolerant) 11 HIS_ANALOG_IN00 Input HIS analog input #0, V analog voltage level 12 HIS_ANALOG_IN01 Input HIS analog input #1, V analog voltage level 13 HIS_SIG_RTN Power HIS RS232 signal common 14 HIS_DIG_IN2 Input HIS digital input #2, V digital logic level (0-5 V tolerant) 15 HIS_DIG_IN3 Input HIS digital input #3, V digital logic level (0-5 V tolerant) 16 HIS_DIG_OUT0 Output HIS digital output #0, V digital logic level 17 HIS_DIG_OUT1 Output HIS digital output #1, V digital logic level 18 HIS_DIG_OUT2 Output HIS digital output #2, V digital logic level 19 HIS_DIG_OUT3 Output HIS digital output #3, V digital logic level 20 HIS_RS232_DTR Output HIS RS232 data terminal ready 21 HIS_SIG_RTN Power HIS RS232 signal common 22 nhis_boot_sel Input Boot select signal: 0 = download, 1 = flash 23 HIS_ANALOG_OUT0 Output HIS analog output #0, V analog voltage level 24 HIS_ANALOG_OUT1 Output HIS analog output #1, V analog voltage level 25 HIS_ANALOG_OUT2 Output HIS analog output #2, V analog voltage level SHLD Chassis Power Cable shield Rev A V60 Ventilator Service Manual 3-932 Chapter 3: Theory of Operation MC PCBA Motor Controller (MC) PCBA Controls the blower motor according to speed or current as commanded by ventilator software. Provides electrical interfaces to the DA PCBA, oxygen and air flow sensors, fan, and primary speaker. Includes monitoring of an embedded temperature sensor in the blower motor. Includes analog to digital converters (ADCs) and digital to analog converters (DACs) for flow control and monitoring. Includes two energy storage capacitors that increase motor power usage efficiency and power a backup audible alarm (a piezo alarm) and Alarm LED for at least two minutes. Includes EEPROM for calibration data, board identification information, and MC PCBA power-on hours. DA PCBA Data Acquisition (DA) PCBA Provides precision measuring and signal conditioning. Includes analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) for flow and pressure monitoring signals. Controls the oxygen solenoid valve with 12-bit accuracy. Includes barometric (measurement range 525 to 850 mmhg) and oxygen pressure (measurement range 0 to 87 psig) transducers. Includes individual patient proximal and machine pressure transducers (measurement range -20 to +65 cmh 2 O). Includes EEPROM for calibration data, board identification information, and DA PCBA power-on hours. Drives the solenoid valves mounted to the manifold. Interfaces to the air and oxygen flow sensors. Oxygen flow sensor Flow Sensors Calibrated to the specific gas (air or oxygen). Provide the signal source for the oxygen and air flow signals. Convert manifold gas flow into an analog signal, which is sent to DA PCBA for filtering and conversion. Air flow sensor measures flows from -240 to 240 SLPM. Oxygen flow sensor measures flows from 0 to 240 SLPM. Includes EEPROM for calibration data, board identification information, and power-on hours for each flow sensor. Air flow sensor 3-10 V60 Ventilator Service Manual Rev A33 Chapter 3: Theory of Operation User Interface Includes indicators and controls for setting and monitoring parameters. Includes LCD, backlight inverter PCBA, touch screen, power switch overlay, rotary adjustment (nav-ring) assembly, UI PCBA, and switch PCBA. Audible alarms: Primary audio alarm includes two alarm speakers in the base unit (adjustable from 60 to 95 dba at 1 m), one connected through the PM PCBA, and one connected through the MC PCBA. Backup audio alarm (piezo alarm) mounted on the CPU PCBA. User interface LCD Assembly 12.1-in. diagonal flat panel, 768 x 1024 pixels with 6-bit color. Connects to backlight inverter PCBA and CPU PCBA through the PM PCBA. Cold cathode fluorescent lamp (CCFL) backlight with 10,000-hour minimum life (half initial brightness). LCD assembly Backlight Inverter PCBA Backlight inverter PCBA provides adjustable backlight drive voltage. Backlight dimming capability using a 0 to 3.5-V control voltage from the CPU PCBA through the PM PCBA Backlight inverter PCBA Rev A V60 Ventilator Service Manual 3-1134 Chapter 3: Theory of Operation Touch Screen Assembly Uses a robust five-wire resistive panel. Resolves touches in a configuration 0.3 x 0.3-in. matrix. Touch screen assembly Nav-ring assembly Nav-Ring Assembly (Rotary Adjustment) Rotary adjustment used to change setting values. Center push-button (on switch PCBA) to accept a value of a selected field Power Switch Overlay Includes power switch, and embedded indicators for power status, battery charge status, and alarms. Power switch overlay Switch PCBA Interconnection between rotary adjustment and UI PCBA and CPU PCBA. Provides a center push button and interface to nav-ring. Connects to UI PCBA. Switch PCBA 3-12 V60 Ventilator Service Manual Rev A35 Chapter 3: Theory of Operation UI PCBA Provides a connection for backlight PCBA, touch panel, switches, and switch PCBA to PM PCBA. Mounts behind LCD, provides connectors to backlight inverter PCBA, power switch overlay, switch PCBA, and touch screen. Connects to PM PCBA. UI PCBA Rev A V60 Ventilator Service Manual 3-1336 Chapter 3: Theory of Operation 3.3 Electronic Signal Paths The following table summarizes the electronic signal paths for V60 ventilator components. Table 3-2: V60 Signal Paths Component Air flow sensor Alarm indicator Backlight inverter PCBA Signal Path Sequence DA PCBA, MC PCBA, CPU PCBA Power switch overlay, UI PCBA, PM PCBA, CPU PCBA Input: UI PCBA, PM PCBA, CPU PCBA Output: LCD CCFL Barometric pressure Battery indicator Blower motor CPU PCBA DAC DA PCBA ADC DA PCBA DAC Ethernet connector Fan LCD Internal battery Speaker #1 Speaker #2 MC PCBA ADC MC PCBA DAC Nav-ring assembly Nurse call connector Oxygen flow sensor Oxygen inlet pressure sensor Oxygen solenoid valve Power indicator Power supply Power switch Proximal pressure sensor Solenoid valves Switch PCBA Touch screen USB device connector USB host connector DA PCBA, MC PCBA, CPU PCBA Power switch overlay, UI PCBA, PM PCBA, CPU PCBA MC PCBA CPU PCBA DA PCBA, MC PCBA, CPU PCBA DA PCBA, MC PCBA, CPU PCBA CPU PCBA MC PCBA, CPU PCBA, PM PCBA Power: PM PCBA Signal: PM PCBA, CPU PCBA CCFL: Backlight inverter PCBA PM PCBA MC PCBA, CPU PCBA PM PCBA, CPU PCBA MC PCBA, CPU PCBA MC PCBA, CPU PCBA Switch PCBA, UI PCBA, PM PCBA, CPU PCBA CPU PCBA DA PCBA, MC PCBA, CPU PCBA DA PCBA, MC PCBA, CPU PCBA DA PCBA Power switch overlay, UI PCBA, PM PCBA, CPU PCBA Input: AC inlet Output: PM PCBA Power switch overlay, UI PCBA, PM PCBA, CPU PCBA DA PCBA, MC PCBA, CPU PCBA DA PCBA UI PCBA, PM PCBA, CPU PCBA UI PCBA, PM PCBA, CPU PCBA CPU PCBA CPU PCBA 3-14 V60 Ventilator Service Manual Rev A37 Chapter 3 Theory of Operation Figure 3-2 shows a wiring diagram for the main assembly. Figure 3-2: V60 Main Assembly Wiring Diagram Rev A V60 Ventilator Service Manual 3-1538 Chapter 3 Theory of Operation (This page is intentionally blank.) 3-16 V60 Ventilator Service Manual Rev A39 Chapter 3 Theory of Operation Figure 3-3 shows a wiring diagram for the UI subsystem. Figure 3-3: V60 UI Assembly Wiring Diagram Rev A V60 Ventilator Service Manual 3-1740 Chapter 3 Theory of Operation (This page is intentionally blank.) 3-18 V60 Ventilator Service Manual Rev A41 Chapter 3 Theory of Operation Figure 3-4 shows a block diagram of the power supply. Figure 3-4: Power Supply Block Diagram Rev A V60 Ventilator Service Manual 3-1942 Chapter 3 Theory of Operation (This page is intentionally blank.) 3-20 V60 Ventilator Service Manual Rev A43 Chapter 3 Theory of Operation Figure 3-5 shows a block diagram of the PM PCBA. Figure 3-5: Power Management (PM) PCBA Block Diagram Rev A V60 Ventilator Service Manual 3-2144 Chapter 3 Theory of Operation (This page is intentionally blank.) 3-22 V60 Ventilator Service Manual Rev A45 Chapter 3 Theory of Operation Figure 3-6 shows a block diagram of the MC PCBA. Figure 3-6: Motor Controller (MC) PCBA Block Diagram Rev A V60 Ventilator Service Manual 3-2346 Chapter 3 Theory of Operation (This page is intentionally blank.) 3-24 V60 Ventilator Service Manual Rev A47 Chapter 4. Periodic Maintenance Perform cleaning, sterilizing, and periodic maintenance procedures (Table 4-1) to ensure consistent ventilator operation. Hospital personnel can perform all maintenance tasks except the annual preventive maintenance procedures (the preventive maintenance procedures must be performed by a qualified service technician). The V60 Ventilator User Manual summarizes periodic care and maintenance procedures. Table 4-1: Periodic Maintenance Procedures Frequency Component Maintenance Daily Patient outlet bacteria filter Check for occlusions, cracks, and tears. Monthly Cooling fan filter Inspect for occlusions, dust lint, etc. If discolored or dirty, replace or remove and wash or rinse thoroughly and let dry completely before reinstalling. 250 hours Air inlet filter Inspect and replace as required (environments with more lint and dust may require more frequent replacement). Annually Reusable bacteria filters Replace and destroy reusable filters. Air inlet filter Cooling fan filter Install annual preventive maintenance kit (P/N). Kit contents are subject to change. Clean ventilator interior and exterior. Inspect the oxygen inlet filter. Complete performance verification procedure. CAUTION: Only qualified service technicians are to install preventive maintenance kits or perform service procedures Rev A V60 Ventilator Service Manual 4-148 Chapter 4 Periodic Maintenance 4.1 Annual Preventive Maintenance Instructions Follow these steps to perform the annual preventive maintenance (PM) procedure on the V60 ventilator. NOTE: The annual PM procedure must be performed by a qualified service technician in an appropriate setting, such as a biomedical repair facility. Use a clean patient circuit and filters when performing any testing or operational checkout. 1. Clean the exterior of the V60 ventilator using universal precautions (including mask, gloves, eye protection). 2. Enter Diagnostic mode by pressing and holding the nav-ring Enter button and turn on the ventilator by pressing the On/Shutdown button on the user interface. Within 5 seconds, press the nav-ring Enter button again to enter Diagnostic mode. The Diagnostics Menu appears (Figure 4-1). Figure 4-1: Diagnostics Menu 4-2 V60 Ventilator Service Manual Rev A49 Chapter 4 Periodic Maintenance 3. Touch Service to display the V60 Ventilator Information screen (Figure 4-2). Figure 4-2: Ventilator Information Screen 4. Record the following information on the Performance Verification Data Form (Chapter 8): Software options Ventilator serial number Software version Total power-on hours Hours since last PM Battery lot number Battery manufacture date 5. Generate a diagnostic report (DRPTA) for the ventilator (Chapter 6). 6. Turn off the V60 by pressing the ON/Shutdown button. 7. Disconnect all power, remove the top cover, and remove the EMI shroud from the power supply (section 7.16). 8. Use an electrostatic discharge (ESD) safe vacuum to remove any accumulated dust and debris from the inside the ventilator enclosure. 9. Inspect all electrical and pneumatic connections Rev A V60 Ventilator Service Manual 4-350 Chapter 4 Periodic Maintenance 10. Replace the air inlet filter (section 7.2). 11. Remove the oxygen filter cap from the GDS (section 7.20). Inspect the oxygen inlet filter for contamination or debris and verify that it is properly installed. 12. From outside the bottom enclosure, remove the filter retainer and replace the cooling fan filter (Figure 4-3). Filter retainer Cooling fan filter Figure 4-3: Cooling Fan Filter Retainer 13. Reassemble the V60 ventilator and complete the Performance Verification (Chapter 8). 14. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button and turn on the ventilator by pressing the On/ Shutdown button on the user interface. Within 5 seconds, release and press the nav-ring Enter button again to enter Diagnostic mode. 15. Turn on the PC and connect a standard 9-pin male/female RS-232 null modem cable and a 9-pin to 25-pin female/male adapter between the PC serial port and the V60 ventilator. 16. Click on the HyperTerminal or Tera Term icon to enable communication with the V60 ventilator. 4-4 V60 Ventilator Service Manual Rev A51 Chapter 4 Periodic Maintenance 17. Type: #RESETPM (all caps) in the dialog box, and press Enter to reset hours since last PM to zero (Figure 4-4). Figure 4-4: Reset Hours since Last PM Command (HyperTerminal) 18. When the hours since last PM have been successfully reset, the dialog box displays:?resetpmok Rev A V60 Ventilator Service Manual 4-552 Chapter 4 Periodic Maintenance 19. Type #CLRLOG (all caps) in the dialog box, and press Enter to clear the diagnostic log (Figure 4-5). Figure 4-5: Clear Diagnostic Codes Command (HyperTerminal) 20. When the diagnostic log has been successfully cleared, the dialog box displays:?clrlogok 21. Touch System Settings, and then touch Restore Default Settings. 22. Touch Date/Time and correct the date and time if necessary. 23. Turn the V60 ventilator off by pressing the ON/Shutdown button. 24. Upon successful completion of the performance verification, hours reset, and restoring the default settings, enter the required information on the PM and electrical safety labels. 4-6 V60 Ventilator Service Manual Rev A53 Chapter 4 Periodic Maintenance Affix the labels to the V60 ventilator (Figure 4-6). Electrical safety label PM label Figure 4-6: Electrical Safety and PM Label Placement 25. Apply the clear chemical-resistant label over the PM label. 26. The annual PM is complete Rev A V60 Ventilator Service Manual 4-754 Chapter 4 Periodic Maintenance (This page is intentionally blank.) 4-8 V60 Ventilator Service Manual Rev A55 Chapter 5. Diagnostic Mode and Troubleshooting Use diagnostic mode to perform these functions: System settings: language, ventilator date and time, pressure units, restore default settings, enable software options, and Baud rate. Service: ventilator information, pneumatics and outputs screens (for troubleshooting), and miscellaneous features (viewing the significant event log, downloading software, touch screen diagnostics, high pressure leak test, and system leak test). Touch screen calibration. This chapter also provides detailed information on diagnostic codes and troubleshooting (section 5.4). WARNING: NOTE: Do not enter diagnostic mode while a patient is connected to the ventilator. This mode is primarily reserved for use by a qualified service technician. To enter diagnostic mode: 1. Press and hold the nav-ring Enter button then press and release the ventilator On/Shutdown button on the user interface. 2. Within five seconds, press the nav-ring Enter button again to enter the Diagnostics Menu (Figure 5-1). Figure 5-1: Diagnostics Menu 3. To exit diagnostic mode at any time, press the ON/Shutdown button Rev A V60 Ventilator Service Manual 5-156 Chapter 5 Diagnostic Mode and Troubleshooting 5.1 System Settings The System Settings button allows access to these functions (Figure 5-2): Language (language button is a different color) Date/Time Pressure Units Restore Default Settings Software Options Baud Rate Figure 5-2: Diagnostic Mode: System Settings 5-2 V60 Ventilator Service Manual Rev A57 Chapter 5 Diagnostic Mode and Troubleshooting Selecting a Language The Set Language screen allows you to select the language displayed during ventilation mode. NOTE: Screens displayed after touching the Service button from the Diagnostics Menu appear in English, regardless of the selected language. 1. From the System Settings screen, touch Language. 2. Touch the language button on the Set Language screen (Figure 5-3). Figure 5-3: Set Language Screen 3. The screen shows the selected language (Figure 5-4). 4. To apply the new language, touch Ventilator Shutdown. To exit without changing the language, touch Cancel Rev A V60 Ventilator Service Manual 5-358 Chapter 5 Diagnostic Mode and Troubleshooting Figure 5-4: Set Language - Apply or Cancel 5-4 V60 Ventilator Service Manual Rev A59 Chapter 5 Diagnostic Mode and Troubleshooting Setting Date and Time The Set Date and Time screen allows you to update the ventilator s date and time. The ventilator uses these settings for the significant event log, and does not adjust settings for daylight savings. 1. From the System Settings screen, touch Date/Time. 2. Enter the date and time, then touch Accept (Figure 5-5). To exit without changing the date and time, touch Cancel. Figure 5-5: Set Date and Time Screen Rev A V60 Ventilator Service Manual 5-560 Chapter 5 Diagnostic Mode and Troubleshooting Restoring Default Settings The Restore Default Settings screen allows you to restore ventilation and alarm settings to their default values. This function does not change other settings such as brightness, loudness, language, Baud rate, or pressure units. 1. From the System Settings screen, touch Restore Default Settings. 2. Touch Restore Defaults on the Restore Default Settings screen (Figure 5-6). To exit without restoring default settings, touch Cancel. Figure 5-6: Restore Default Settings Screen 3. When all ventilator and alarm settings have been restored to factory default values, the screen displays this message: Ventilation and Alarm Settings have been restored to factory defaults. 5-6 V60 Ventilator Service Manual Rev A61 Chapter 5 Diagnostic Mode and Troubleshooting Selecting Pressure Units The Set Pressure Units screen allows you to select what unit of pressure the ventilator displays during ventilation and Diagnostic modes. 1. From the System Settings screen, touch Pressure Units. 2. Touch the selected pressure unit button on the Set Pressure Units screen (Figure 5-7). Figure 5-7: Set Pressure Units Screen 3. The screen displays the selected pressure unit and this message: Pressure units will apply after a ventilator shutdown and restart. 4. To apply the new unit of pressure, touch Ventilator Shutdown. To exit without changing the unit of pressure, touch Cancel Rev A V60 Ventilator Service Manual 5-762 Chapter 5 Diagnostic Mode and Troubleshooting Enabling Software Options Every software option has a unique enable code for each ventilator. A unique option code is required for each software option before it can be enabled. NOTE: Do not install an option until you have verified that the ventilator serial number on the enclosure matches the serial number shown on the Ventilator Information screen (section 5.2.1). If a serial number must be reprogrammed, do so before enabling an option. 1. From the System Settings screen, touch Software Options. 2. Use the onscreen keypad on the Enable Software Options screen (Figure 5-8) to enter the option code, then touch Accept. Figure 5-8: Enable Software Options Screen 3. If the option code is invalid, the screen prompts you to reenter. 4. When the software option has been successfully enabled, the screen displays Enabled: followed by the option name. 5. Repeat as needed to enable additional options. 6. To exit the Enable Software Options screen at any time, touch Back to System Settings. 5-8 V60 Ventilator Service Manual Rev A63 Chapter 5 Diagnostic Mode and Troubleshooting Baud Rate The Set Baud Rate screen allows you to change the ventilator Baud rate for serial communications during ventilation mode. Diagnostic mode always uses 19,200 Baud. 1. From the System Settings screen, touch Baud Rate. 2. Touch the button to select the Baud rate (Figure 5-9). Figure 5-9: Set Baud Rate Screen 3. The screen then displays this message: Baud rate is now set to: followed by the selected Baud rate Rev A V60 Ventilator Service Manual 5-964 Chapter 5 Diagnostic Mode and Troubleshooting 5.2 Service The Service button allows access to these functions: Ventilator information Pneumatic controls Output controls Miscellaneous (significant event log, download mode, and touch screen diagnostics, high pressure leak test, and system leak test). NOTE: Service button functions are intended for use by qualified service technicians V60 Ventilator Service Manual Rev A65 Chapter 5 Diagnostic Mode and Troubleshooting Viewing Ventilator Information Ventilator information is used for periodic maintenance and troubleshooting. 1. From the Service screen, touch the Vent Info tab. 2. The Ventilator Information screen displays software options, serial numbers, software versions, power-on hours, hours since last PM, and information on the internal battery and PCBAs (Figure 5-10). Figure 5-10: Ventilator Information Screen Rev A V60 Ventilator Service Manual 5-1166 Chapter 5 Diagnostic Mode and Troubleshooting Pneumatic Controls This Pneumatic Controls screen allows you to adjust flows, pressures, oxygen concentrations, and the state of each solenoid. 1. From the Service screen, touch the Pneumatics tab. 2. The screen displays real-time diagnostic information and pneumatic controls (Figure 5-11). Figure 5-11: Pneumatic Controls Screen 5-12 V60 Ventilator Service Manual Rev A67 Chapter 5 Diagnostic Mode and Troubleshooting Output Controls This Output Controls screen allows you to set and verify wrap, analog, and digital outputs. NOTE: When entering wrap counts, ensure that the displayed values are within + 23 counts of the set value. 1. From the Service screen, touch the Outputs tab. 2. The screen shows diagnostic information and output controls (Figure 5-12). Figure 5-12: Output Controls Screen Rev A V60 Ventilator Service Manual 5-1368 Chapter 5 Diagnostic Mode and Troubleshooting Miscellaneous The Miscellaneous screen allows you to access the significant event log, touch screen diagnostics, download mode, high pressure leak test, and system leak test. 1. From the Service screen, touch the Misc tab. 2. The screen includes the Significant Event Log, Download Mode, Touch Screen Diagnostics, High Pressure Leak Test, and System Leak Test buttons (Figure 5-13). Figure 5-13: Miscellaneous Screen 3. To exit the Miscellaneous screen at any time, touch Back to Diagnostics Menu V60 Ventilator Service Manual Rev A69 Chapter 5 Diagnostic Mode and Troubleshooting Significant Event Log The significant even log allows you to view a log of setting changes, alarms, and diagnostic codes. 1. From the Miscellaneous screen, touch Significant Event Log. 2. You can use the arrow buttons to page through the significant event log (Figure 5-14) 25 entries at a time. Figure 5-14: Significant Event Log 3. To display the beginning or end of the significant event log, touch the To Newest or To Oldest button. Refer to Chapter 6, Reports and Software Downloads for information on interpreting the significant event log and saving it to a computer Rev A V60 Ventilator Service Manual 5-1570 Chapter 5 Diagnostic Mode and Troubleshooting Download Mode The Download Mode screen allows you to load operational software onto the CPU PCBA. 1. From the Miscellaneous screen, touch Download Mode to prepare the ventilator for a software download. Refer to Chapter 6, Reports and Software Downloads for more information on downloading software. 2. When the software download is complete, the download complete screen appears (Figure 5-15). Figure 5-15: Download Complete Screen 5-16 V60 Ventilator Service Manual Rev A71 Chapter 5 Diagnostic Mode and Troubleshooting Touch Screen Diagnostics The Touch Screen Diagnostics screen allows you to verify touch screen x and y coordinates. 1. From the Miscellaneous screen, touch Touch Screen Diagnostics. 2. At the touch screen diagnostics screen (Figure 5-15), touch the screen in multiple places to verify correct touch screen function. Figure 5-16: Touch Screen Diagnostics Screen Rev A V60 Ventilator Service Manual 5-1772 Chapter 5 Diagnostic Mode and Troubleshooting 5.3 Touch Screen Calibration The Touch Screen Calibration button allows you to calibrate the touch screen x and y coordinates (Figure 5-17): 1. From the Diagnostics Menu, touch Touch Screen Calibration. NOTE: If the Touch Screen Calibration button does not respond, press the navring Enter button to begin. 2. Follow the onscreen instructions to perform the calibration. Touch the middle of each target with a blunt, narrow object. Figure 5-17: Calibrate Touch Screen 5-18 V60 Ventilator Service Manual Rev A73 Chapter 5 Diagnostic Mode and Troubleshooting 5.4 Diagnostic Codes, Alarms, and Troubleshooting This section lists possible ventilator diagnostic codes (codes generated by the ventilator when an event such as a setting change or fault condition is detected, or when an alarm indicates patient or ventilator conditions), and the recommended repair for each. Follow the repair procedures in order until the problem is resolved. NOTE: See Chapter 7 for information on removing and replacing ventilator components. See Chapter 8 for performance verification procedures. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair FF Vent Inop Diagnostic Codes (High-priority error conditions that preclude continued safe operation of the ventilator. A Vent Inop alarm displays on the screen, turns on remote alarm interfaces, and disables oxygen flow and blower operation. Immediately place the patient on another means of ventilatory support.) CBIT = continuous built-in tests. POST = power on self test (CBIT) 1001 (CBIT) 3.3 V supply failed. 1.Replace PM PCBA. 12 V supply failed. 1.Replace PM PCBA (CBIT) 1003 (CBIT) 1004 (CBIT) 1005 (CBIT) 1006 (CBIT) 1007 (POST) 1008 (CBIT) Blower temperature too high. Internal temperature high at CPU PCBA. Internal temperature high at DA PCBA. Internal temperature high at MC PCBA. DA PCBA ADC failed. Machine and proximal pressure sensors failed. 1.Verify that cooling fan is operational 2. Replace blower. 3.Replace MC PCBA. 1.Replace CPU PCBA. 1.Verify that cooling fan is operational. 2.Replace DA PCBA. 1.Verify that cooling fan is operational. 2.Replace MC PCBA. 1.Replace DA PCBA. 1.Replace DA PCBA to MC PCBA cable. 2.Replace DA PCBA Rev A V60 Ventilator Service Manual 5-1974 Chapter 5 Diagnostic Mode and Troubleshooting 1009 Pressure regulation high. 1.Verify pressures and flows. 2.Replace DA PCBA. 3.Replace MC PCBA. 100A (CBIT) 100B (POST) DA PCBA ADC reference failed. Watchdog test failed. 1.Verify 3.3V in diagnostics. 2.Verify 2.5V ref on DA PCBA. 3.Replace DA PCBA to MC PCBA cable. 4.Replace DA PCBA. 5.Replace PM PCBA. Replace CPU FF Check Vent Diagnostic Codes (High-priority error conditions that require immediate attention. Ventilator continues to operate with limited performance. Do not use the ventilator until the problem is corrected.) CBIT = continuous built-in tests. POST = power on self test (CBIT) Program CRC test failed. 1.Re-load software. 2.Replace CPU PCBA Ventilator restarted. 1.Replace CPU PCBA (POST) 1104 (POST) 1105 (POST) 1106 (POST) Primary alarm failed. Backup alarm failed. Alarm LED failed. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair Machine pressure sensor calibration data error. Proximal pressure is not measured. Pressure-related alarms are compromised. 1.Listen for audible sound from speakers. 2.Verify speakers are connected. 3.Replace speaker #1 (MC PCBA). 4.Replace speaker #2 (PM PCBA). 5.Replace CPU PCBA. 1.Replace PM PCBA. 2.Replace CPU PCBA. 1.Replace power switch overlay. 2.Replace UI to PM PCBA cable. 3.Replace PM PCBA (PM PCBA only if LED is functioning). 1.Replace DA PCBA V60 Ventilator Service Manual Rev A75 Chapter 5 Diagnostic Mode and Troubleshooting Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1107 (POST) 1108 (POST) 1109 (CBIT) 110A (POST) 110B (CBIT) 110C (CBIT) 110D (CBIT) 110E (POST) 110F (POST) 1110 (POST) Proximal pressure sensor calibration data error. Proximal pressure is not measured. Pressure-related alarms are compromised. Machine pressure sensor auto-zero failed. Proximal pressure is not measured. Pressure-related alarms are compromised. Proximal pressure sensor auto-zero failed. Proximal pressure is not measured. Pressure-related alarms are compromised. Machine pressure sensor range error. Proximal pressure is not measured. Pressure-related alarms are compromised. Proximal pressure sensor range error. Proximal pressure is not measured. Pressure-related alarms are compromised. Air flow sensor calibration data error. Flow-related patient data is disabled. Oxygen concentration switches to 21% (air only). Default volume used in AVAPS mode. Standby disabled. Volume, leak, disconnect, and occlusion alarms compromised. Oxygen flow sensor calibration data error. Ventilation continues with air only. Oxygen pressure sensor calibration data error. Ventilation continues with air only. 1.Replace DA PCBA. 1.Verify pin alignment between solenoids and DA PCBA. 2.Replace machine auto-zero solenoid (SOL 2). 3.Replace DA PCBA. 1.Verify pin alignment between solenoids and DA PCBA. 2.Replace proximal auto-zero solenoid (SOL 3). 3.Replace DA PCBA. 1.Cycle ventilator power to reset proximal pressure sensor. 2.Replace DA PCBA. 1.Cycle ventilator power to reset proximal pressure sensor. 2.Replace DA PCBA. 1.Replace flow sensor cable. 2.Replace flow sensor assembly. 3.Replace DA PCBA. 1.Replace flow sensor cable. 2.Replace flow sensor assembly. 3.Replace DA PCBA. 1.Replace DA PCBA Rev A V60 Ventilator Service Manual 5-2176 Chapter 5 Diagnostic Mode and Troubleshooting 1111 (CBIT) 1112 (CBIT) 1113 (POST) Oxygen device failed. Ventilation continues with air only. Oxygen pressure sensor range error. Ventilation continues with air only. Barometer calibration data error. Default barometric pressure of mmhg (approximately 900 m/2953 ft above sea level) used in calculations Barometer sensor range error. Default barometric pressure of mmhg (approximately 900 m/2953 ft above sea level) used in calculations Auxiliary alarm supply failed (CBIT) 1117 (CBIT) 1118 (POST) 1119 (CBIT) 111A (POST) 111B (POST) Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair Audible and visual alarm indicators activate and the ventilator continues to ventilate with air only in a reduced capacity. 1.Inspect the oxygen inlet filter for contamination or debris. 2.Perform high pressure leak test (Chapter 8). 3.Verify oxygen flows (Chapter 8). 4.Replace oxygen valve. 5.Replace DA PCBA. 1.Verify correct oxygen pressure sensor function. 2.Replace DA PCBA. 1.Replace DA PCBA. 1.Verify correct barometric pressure sensor function. 2.Replace DA PCBA. 1.Replace MC PCBA. 2.Replace PM PCBA. 1.8 V supply failed. 1.Replace CPU PCBA. 3.3 V supply failed. 1.Replace PM PCBA. 5 V supply failed. 2.Replace PM PCBA. 12 V supply failed. 1.Replace PM PCBA. 24 V supply failed. 1.Replace power supply. 35 V supply failed. 1.Replace PM PCBA. 2.Replace MC PCBA V60 Ventilator Service Manual Rev A77 Chapter 5 Diagnostic Mode and Troubleshooting Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 111C

(CBIT) DA PCBA ADC failed. 1.Replace DA PCBA. 111D (CBIT) 111E (CBIT) 111F (CBIT) 1120 (CBIT) 1121 (CBIT) 1122 (CBIT) 1123 (CBIT) 1124 (CBIT) 1125 (CBIT) MC PCBA ADC failed. CPU PCBA ADC failed. Internal temperature high at CPU PCBA. Internal temperature high at DA PCBA. Internal temperature high at MC PCBA. Blower temperature high. Battery temperature high. Battery failed. Audible and visual alarm indicators activate and the ventilator continues to ventilate. Battery charger turns off. Cooling fan speed error. Ventilator overheating possible. 1.Replace MC PCBA. 1.Replace CPU PCBA. 1.Replace CPU PCBA. 1.Verify that cooling fan is operational. 2.Replace DA PCBA. 1.Verify that cooling fan is operational. 2.Replace MC PCBA. 1.Verify that cooling fan is operational. 2. Replace blower. 3.Replace MC PCBA. 1.Replace internal battery. 2.Replace PM PCBA. 1.Replace internal battery. 2.Replace PM PCBA. 1.Verify that cooling fan RPM is RPM. 2.Replace fan. 3.Replace PM PCBA Flash file system error. 1.Repeat software download. 2.Replace CPU PCBA OVP circuit failed. 1.Replace MC PCBA Rev A V60 Ventilator Service Manual 5-2378 Chapter 5 Diagnostic Mode and Troubleshooting Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair F Alarm Message Diagnostic Codes (Alarm conditions that indicate a patient or ventilator condition that requires immediate attention.) 1200 Alarm message: Patient Disconnect Patient is no longer connected to the ventilator, either through circuit, mask, or ET tube; or the patient circuit is disconnected from the ventilator and the patient is no longer receiving ventilatory support. Ventilation continues Alarm message: Patient Circuit Occluded Patient circuit occluded Alarm message: Proximal Pressure Line Disconnect Proximal pressure line is disconnected. Air flow to patient continues Alarm message: Low Leak-CO 2 Rebreathing Risk Exhalation port may be occluded. Ventilation continues if possible Alarm message: Low Internal Battery Battery can provide operating power for only an additional 15 minutes under nominal conditions. Autoresets when ventilator is connected to AC power Alarm message: Pressure Regulation High Pressures exceed ventilator-defined thresholds. Ventilation continues. Autoresets when alarm condition removed. Transitions to the ventilator inoperative state if pressure continues to rise. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Check patient circuit for bulk liquid, crimps, or blocked filter. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Reconnect proximal pressure line. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient, as possibility of CO 2 rebreathing could pose a potential problem. Check the port for occlusions. Connect the ventilator to AC power. Provide alternate ventilation. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator V60 Ventilator Service Manual Rev A79 Chapter 5 Diagnostic Mode and Troubleshooting Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1206 Alarm message: High Inspiratory Pressure Measured inspiratory pressure is greater than the HIP setting and the ventilator cycles into exhalation. Autoresets after a complete inspiration without the alarm condition Alarm message: Low Inspiratory Pressure Measured inspiratory pressure is less than the LIP setting Alarm message: Oxygen Not Available Oxygen supply pressure out of range, oxygen device failed, air flow sensor and/or oxygen flow sensor calibration failed, or oxygen inlet pressure sensor calibration failed. The ventilator discontinues oxygen support Alarm message: Low O 2 Supply Pressure 120A 120D Oxygen supply pressure is less than 40 psig and delivered oxygen is at least 5% lower than O 2 setting. The ventilator continues to deliver as much oxygen as possible, but ends oxygen support when oxygen inlet pressure drops to less than 18 psig. Autoresets when oxygen supply pressure exceeds 23 psig. Alarm message: High O 2 Supply Pressure O 2 inlet pressure is greater than 92 psig, O 2 enrichment ends. Autoresets when O 2 supply pressure falls below 87 psig. Alarm message: Low Rate A low-priority alarm if the measured respiratory rate is less than the Lo Rate setting, escalating to a high-priority alarm in 60 sec. Begins as a high-priority alarm if: The Lo Rate setting is < 4 BPM and there are no breaths for > 60/Lo Rate setting. The Lo Rate setting is > 4 BPM and there are no breaths for > 15 sec. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Check if high/low O 2 source is the problem and correct. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator Rev A V60 Ventilator Service Manual 5-2580 Chapter 5 Diagnostic Mode and Troubleshooting Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 120E 120F Alarm message: Low Minute Ventilation Estimated minute ventilation is less than the Lo. V E setting. Escalates to a high-priority alarm if the alarm condition persists for more than 60 sec. Alarm message: Low Tidal Volume Estimated tidal volume is less than the Lo V T setting. Escalates to a high-priority alarm if the alarm condition persists for more than 60 sec Alarm message: High Tidal Volume Measured estimated tidal volume is greater than the Hi V T setting. Escalates to a high-priority alarm if the alarm condition persists for more than 60 sec Alarm message: High Rate Measured respiratory rate is greater than the Hi Rate setting. Escalates to a high-priority alarm if the alarm condition persists for more than 60 sec Alarm message: Running on Internal Battery Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Check patient. Confirm that ventilator and alarm settings are appropriate. If problem persists, provide alternative ventilation. Service ventilator. Connect ventilator to AC power. System is powered by internal battery. Autoresets when ventilator is connected to AC power Alarm message: Using Default Settings Displayed after power on if setting values are corrupted or not set, or if default values were restored by the user Alarm message: AVAPS: Target Vt Not Achieved. Insufficient Max Pressure AVAPS target pressure exceeds AVAPS Max P setting. The ventilator limits applied pressure to Max P Alarm message: AVAPS: Target Vt Exceeded. Min Pressure Too High AVAPS target pressure is less than Min P setting. The ventilator limits applied pressure to Min P. Check patient. Check and adjust settings as required. Check patient. Confirm that pressure settings are compatible with target. Evaluate pressure and volume settings. Check patient. Confirm that pressure settings are compatible with target. Evaluate pressure and volume settings V60 Ventilator Service Manual Rev A81 Chapter 5 Diagnostic Mode and Troubleshooting 1216 Alarm message: Mask:x, Exh Port:y Use Menu to change Displays when ventilator is turned on. Displays selected mask type and exhalation port Alarm message: Power Has Been Restored Power is restored following loss of power. The ventilator restarts and continues ventilation in the mode set before power was lost Informational Diagnostic Codes (no user action required) Select mask and port from Menu tab. Message is removed when user confirms selections, or after 5 minutes. Check patient. Confirm that ventilator and alarm settings are appropriate System startup (diagnostic). Occurs when ventilator is power ON in diagnostic mode: no action required System startup (ventilation). Occurs when ventilator is powered ON in normal ventilation: no action required System shutdown. Occurs when ventilator is powered OFF: no action required Restored default settings Occurs when default settings are restored: no action required. 5xxx: Leaks Tests Diagnostic Codes 5000 Passed high pressure leak test. No action required Failed high pressure leak test. Leak detected. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1.Verify that oxygen source is adequate for this test. 2.Check for leaks at the oxygen fitting, oxygen filter element cap, oxygen solenoid valve, and oxygen pressure transducer. 3.Check that the oxygen solenoid valve is fully closed by verifying that there is zero flow across the oxygen flow sensor. If not, replace the oxygen solenoid valve. 4.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA Rev A V60 Ventilator Service Manual 5-2782 Chapter 5 Diagnostic Mode and Troubleshooting 5002 Failed high pressure leak test. Start pressure too low Failed high pressure leak test. Start pressure too high. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1.Verify that oxygen source is adequate for this test. 2.Check for leaks at the oxygen fitting, oxygen filter element cap, oxygen solenoid valve, and oxygen pressure transducer. 3.Check that the oxygen solenoid valve is fully closed by verifying that there is zero flow across the oxygen flow sensor. If not, replace the oxygen solenoid valve. 4.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA. 1.Verify that oxygen source is adequate for this test. 2.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA Failed high pressure leak test. Pressure rise detected. 1.Verify shut off valve is closed on the that oxygen source is adequate for this test. 2.Check for leaks at the oxygen fitting. 3.Check that the oxygen solenoid valve is fully closed by verifying that there is zero flow across the oxygen flow sensor. If not, replace the oxygen solenoid valve. 4.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA Passed system leak test. No action required V60 Ventilator Service Manual Rev A83 Chapter 5 Diagnostic Mode and Troubleshooting 5006 Failed system leak test. Leak detected. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1.Verify that the internal exhalation port, air inlet port, gas outlet port and proximal port are plugged properly. 2.Verify that the system leak test syringe tubing is properly clamped. 3.Check for disconnected or cut tubing from the GDS to the gas outlet port, and from the gas outlet port to the base assembly. 4.Check for misaligned or cut rubber boots from the GDS to the blower, and from the blower to the gas outlet port. 5.Check for leaks at the flow sensor assembly, solenoid valves, and pressure transducers. 6.Verify that the machine and proximal pressure transducers are reading correctly. If not, replace the DA PCBA Rev A V60 Ventilator Service Manual 5-2984 Chapter 5 Diagnostic Mode and Troubleshooting 5007 Failed system leak test. Start pressure too low Failed system leak test. Start pressure too high Failed system leak test. Pressure rise detected. Table 5-1: Diagnostic Codes and Troubleshooting Diagnostic code Description Recommended repair 1.Verify that the internal exhalation port, air inlet port, gas outlet port and proximal port are plugged properly. 2.Verify that the system leak test syringe tubing is properly clamped. 3.Check for disconnected or cut tubing from the GDS to the gas outlet port, and from the gas outlet port to the base assembly. 4.Check for misaligned or cut rubber boots from the GDS to the blower, and from the blower to the gas outlet port. 5.Check for leaks at the flow sensor assembly, solenoid valves, and pressure transducers. 6.Verify that the machine and proximal pressure transducers are reading correctly. If not, replace the DA PCBA. 1.Verify that the system leak test syringe tubing is properly clamped. 2.Verify that the machine and proximal pressure transducers are reading correctly. If not, replace the DA PCBA. 1.Verify that the system leak test syringe tubing is properly clamped. 2.Verify that the machine and proximal pressure transducers are reading correctly. If not, replace the DA PCBA V60 Ventilator Service Manual Rev A85 Chapter 5 Diagnostic Mode and Troubleshooting 5.5 Miscellaneous Troubleshooting Tips Table 5-2 summarizes troubleshooting tips for the V60 ventilator. Follow the repair procedures in order until the problem is resolved. Symptom Cannot turn ventilator off because LCD is blank or touch screen is unresponsive. Table 5-2: Miscellaneous Troubleshooting Tips Recommended repair 1.Press ON/Shutdown and then release and press the nav-ring Enter button. Unexpected touch screen response. 1.Calibrate the touch screen (section 5.3). Low Leak-CO 2 Rebreathing Risk alarm occurs during performance verification oxygen accuracy test. DAC ADC reference voltage failure. Cooling fan does not operate when the ventilator is off and the internal battery is charging. 1.Verify test setup and that Whisper Swivel is correctly installed. 1.Verify that the MC PCBA is fully seated onto the CPU PCBA. 1.Replace fan. 2. Replace PM PCBA. 3.Replace power supply Rev A V60 Ventilator Service Manual 5-3186 Chapter 5 Diagnostic Mode and Troubleshooting (This page is intentionally blank.) 5-32 V60 Ventilator Service Manual Rev A87 Chapter 6. Reports and Software Downloads This chapter describes how to set up and use a service PC to generate diagnostic reports, download software to the ventilator, or program the ventilator serial number. Section describes how enable communication between a service PC and a ventilator. Section 6.2 describes how to generate diagnostic reports. Section 6.4 describes how to downloading software to the ventilator. Section 6.5 describes how to programming the ventilator serial number. 6.1 Setting Up the Service PC This section describes how to set up a service PC to communicate with the ventilator. Once communication is enabled, you can generate diagnostic reports, download software to-the ventilator, or program the ventilator serial number. Use either of these programs to enable PC-to-ventilator communication: HyperTerminal (Section 6.1.1) Tera Term (Section 6.1.2) Rev A V60 Ventilator Service Manual 6-188 Chapter 6 Reports and Software Downloads Setting Up the Serial Interface Using HyperTerminal Follow these steps to set up the HyperTerminal program, which enables the ventilator to communicate to a service PC. 1. Launch the HyperTerminal program on the PC by clicking Start > All Programs > Accessories > Communications > HyperTerminal. 2. If the Default Telnet Program? screen appears, click No (Figure 6-1). Figure 6-1: Default Telnet Program Screen 3. Enter V60 as the name, choose an icon, then click OK (Figure 6-2). Figure 6-2: Selecting the Connection Description 6-2 V60 Ventilator Service Manual Rev A89 Chapter 6 Reports and Software Downloads 4. Select the appropriate COM port, then click OK (Figure 6-3). Figure 6-3: Selecting the COM Port 5. Select the COM port properties, then click OK (Figure 6-4). Figure 6-4: Selecting the COM Port Properties Rev A V60 Ventilator Service Manual 6-390 Chapter 6 Reports and Software Downloads 6. At the HyperTerminal window, click File, then Properties (Figure 6-5). Figure 6-5: Selecting HyperTerminal Properties 7. Select these HyperTerminal settings, then click ASCII Setup (Figure 6-6). Figure 6-6: Entering HyperTerminal Settings 6-4 V60 Ventilator Service Manual Rev A91 Chapter 6 Reports and Software Downloads 8. Select these ASCII settings, then click OK (Figure 6-7). Figure 6-7: Entering ASCII Settings 9. Select File, then Save As and save the V60 icon to the Windows desktop (Figure 6-8). Figure 6-8: Saving the V60 Icon to the Desktop Rev A V60 Ventilator Service Manual 6-592 Chapter 6 Reports and Software Downloads Setting Up the Serial Interface Using Tera Term Follow these steps to set up the Tera Terminal program, which enables the ventilator to communicate to a service PC. 1. From your web browser go to: then click the download page link. 2. Click on teraterm-x.xx.exe. NOTE: If your PC does not allow the download, follow the instructions for click this link. 3. Click Run on the File Download screen (Figure 6-9). Figure 6-9: File Download Screen 4. A progress screen is displayed during the file download (Figure 6-10). Figure 6-10: File Download 6-6 V60 Ventilator Service Manual Rev A93 Chapter 6 Reports and Software Downloads 5. When the file download is complete, click Run (Figure 6-11). Figure 6-11: File Download Complete 6. If the security warning screen appears, click Run (Figure 6-12). Figure 6-12: Internet Explorer Security Warning Rev A V60 Ventilator Service Manual 6-794 Chapter 6 Reports and Software Downloads 7. When the Tera Term setup screen appears, click Next (Figure 6-13). Figure 6-13: Tera Term Setup Screen 8. Click the I accept the agreement radio button, then click Next (Figure 6-14). Figure 6-14: Tera Term License Agreement Screen 6-8 V60 Ventilator Service Manual Rev A95 Chapter 6 Reports and Software Downloads 9. Select a destination, then click Next (Figure 6-15). Figure 6-15: Destination Location Screen 10. Select Standard installation on the Select Components screen, then click Next (Figure 6-16). Figure 6-16: Select Components Screen Rev A V60 Ventilator Service Manual 6-996 Chapter 6 Reports and Software Downloads 11. Select a language, then click Next (Figure 6-17). Figure 6-17: Select Language Screen 12. At the Select Start Menu screen, click Next (Figure 6-18). Figure 6-18: Select Start Menu Screen 6-10 V60 Ventilator Service Manual Rev A97 Chapter 6 Reports and Software Downloads 13. At the Select Additional Tasks screen select Create Tera Term shortcut to Desktop, then click Next (Figure 6-19). Figure 6-19: Select Additional Tasks Screen 14. At the Ready to Install screen, then click Install (Figure 6-20). Figure 6-20: Ready to Install Screen Rev A V60 Ventilator Service Manual 6-1198 Chapter 6 Reports and Software Downloads 15. Tera Term begins installing on your PC (Figure 6-21). Figure 6-21: Tera Term Installing Screen 16. At the Completing the Tera Term Setup screen, click Launch Tera Term, then click Finish (Figure 6-22). Figure 6-22: Completing the Tera Term Setup Screen 6-12 V60 Ventilator Service Manual Rev A99 Chapter 6 Reports and Software Downloads 17. Once the Tera Term Setup is installed, the New Connection screen appears (Figure 6-23). Figure 6-23: Tera Term New Connection Screen 18. Select the Serial radio button, then click OK (Figure 6-24). Figure 6-24: Selecting a Serial Connection Rev A V60 Ventilator Service Manual 6-13100 Chapter 6 Reports and Software Downloads 19. Select Setup, then click Serial port (Figure 6-25). Figure 6-25: Selecting the Serial Port Setup 20. Select these serial port properties, then click OK (Figure 6-26). Figure 6-26: Serial Port Setup Screen 6-14 V60 Ventilator Service Manual Rev A101 Chapter 6 Reports and Software Downloads 21. Select Setup, then click Terminal (Figure 6-27). Figure 6-27: Selecting the Terminal Setup 22. Select these terminal properties, then click OK (Figure 6-28). Figure 6-28: Terminal Setup Screen Rev A V60 Ventilator Service Manual 6-15102 Chapter 6 Reports and Software Downloads 23. Select Setup, then click Save setup (Figure 6-29). Figure 6-29: Saving the Tera Term Setup 24. At the Save setup screen, click Save (Figure 6-30). Figure 6-30: Tera Term Save Setup Screen 6-16 V60 Ventilator Service Manual Rev A103 Chapter 6 Reports and Software Downloads 6.2 Generating a Diagnostic Report (DRPTA) The DRPTA command allows you to save ventilator diagnostic codes to your PC. NOTE: Do not connect the null modem cable until instructed to do so. 1. Place the ventilator in diagnostic mode. 2. Connect the 25-pin to 9-pin adapter and a null modem cable between the ventilator COM port and the service PC. 3. Click on the HyperTerminal or Tera Term icon to launch the program that communicates with the V60 ventilator. 4. Type DRPTA (all caps) in the dialog box (Figure 6-31), and press Enter. HyperTerminal dialog box Tera Term dialog box Figure 6-31: Entering the DRPTA Command Rev A V60 Ventilator Service Manual 6-17104 Chapter 6 Reports and Software Downloads 5. If the command is successful, a DRPTA appears (Figure 6-32). HyperTerminal DRPTA Tera Term DRPTA Figure 6-32: Example Diagnostic Report (DRPTA) 6-18 V60 Ventilator Service Manual Rev A105 Chapter 6 Reports and Software Downloads 6. Figure 6-33 shows example lines of a DRPTA report and how to interpret them. Diagnostic code Time of event Date of event Description Diagnostic code Time of event Date of event Setting description Previous (from) setting New (to) setting Figure 6-33: Interpreting the DRPTA Report Rev A V60 Ventilator Service Manual 6-19106 Chapter 6 Reports and Software Downloads 6.3 Clearing the Significant Event Log The #CLRLOG command allows you to use your PC to clear the significant event log. CAUTION: Only qualified service technicians are to clear the significant event log. NOTE: Do not clear the significant log until you have used the DRPTA command to save the information to your PC using HyperTerminal or Tera Term. 1. Enter Diagnostic mode by pressing and holding the nav-ring Enter button and turn on the ventilator by pressing the On/Shutdown button. Within 5 seconds, press the nav-ring Enter button again to enter Diagnostic mode. 2. Connect the 25-pin to 9-pin adapter and null modem cable between the ventilator COM port and the service PC. 3. Click on the HyperTerminal or Tera Term icon to launch the program that communicates with the V60 ventilator. 4. Type: #CLRLOG (all caps) in the dialog box, and press Enter to clear the diagnostic log (Figure 6-34). Figure 6-34: Clear Diagnostic Codes Command 5. When the diagnostic log has been successfully cleared, the dialog box displays this response:?clrlogok 6. Clearing the diagnostic log is complete V60 Ventilator Service Manual Rev A107 Chapter 6 Reports and Software Downloads 6.4 Downloading Ventilator Software Use the Respi-Link Remote Diagnostic System to download V60 ventilator software. If your institution is not Respi-Link capable, contact Respironics to request Respi-Link information from your local Field Service Specialist or Regional Service Provider. If your institution is Respi-Link capable, contact Respironics to have a software package deployed. See Appendix A for installation instructions using Respi-Link. NOTE: Note: If you have replaced the CPU PCBA, please contact Respironics to have your local Field Service Specialist or Regional Service Provider install the software for you. For technical support and customer service, contact: USA and Canada: or Respironics Europe, Africa, Middle East: Respironics Asia Pacific: Programming the Ventilator Serial Number and Power- On Hours The ventilator serial number and power-on hours must be re-programmed to the CPU PCBA whenever you replace the CPU PCBA. CAUTION: NOTE: Only qualified service technicians are to program the ventilator serial number and power-on hours. V60 ventilator software must be installed before programming the ventilator serial number or power-on hours Programming the Ventilator Serial Number NOTE: Do not connect the null modem cable until instructed to do so. Follow these steps to re-program the ventilator serial number to a new CPU PCBA: 1. Enter Diagnostic mode by pressing and holding the nav-ring Enter button and turn on the ventilator by pressing On/Shutdown. Within 5 seconds, press the nav-ring Enter button again to enter Diagnostic mode. 2. Turn on the PC and connect a standard 9-pin male/female RS 232 null modem cable and a 9-pin to 25-pin female/male adapter between the PC serial port and the V60 ventilator. 3. Click on the HyperTerminal or Tera Term icon to launch the program that enables communication with the V60 ventilator Rev A V60 Ventilator Service Manual 6-21108 Chapter 6 Reports and Software Downloads 4. Type: #PCNFGxxxxxxxxx (all caps) in the dialog box (xxxxxxxxx is the ventilator serial number), and press Enter (Figure 6-35). (HyperTerminal dialog box) (Tera Terminal dialog box) Figure 6-35: Ventilator Serial Number Programming Command 6-22 V60 Ventilator Service Manual Rev A109 Chapter 6 Reports and Software Downloads 5. The V60 ventilator stores the serial number and the dialog box displays this response:?cfgok 6. Touch Misc then Vent Info, and verify that the serial number displayed on the Vent Info screen matches the ventilator serial number. 7. Programming the serial number is complete Programming Ventilator Power-On Hours NOTE: Do not connect the null modem cable until instructed to do so. Follow these steps to re-program the ventilator power-on hours to a new CPU PCBA: 1. If the ventilator is not already in Diagnostic mode, press and hold the nav-ring Enter button and turn on the ventilator by pressing the On/Shutdown button. Within 5 seconds, release and press the nav-ring Enter button again to enter Diagnostic mode. 2. Turn on the PC and then connect a standard 9-pin male-female RS-232 null modem cable and 9-pin to 25-pin female-male adapter between the PC serial port and the V60 ventilator. 3. Click on the HyperTerminal or Tera Term icon to enable communication with the V60 ventilator. 4. Type: #SETOPTIME (all caps) with the additional information listed in the table below separated by a comma (Table 6-1). Table 6-1: Power-On Hours Command Format Field Operating time ID Hours Description 0 = Total power-on hours 1 = CPU PCBA 2 = PM PCBA 3 = MC PCBA 4 = DA PCBA 5 = Oxygen flow sensor PCBA 6 = Air flow sensor PCBA Must be 6 digits, zero padded (for example:), up to a maximum of Rev A V60 Ventilator Service Manual 6-23110 Chapter 6 Reports and Software Downloads 5. For example, this command sets the total power-on hours to 1234 hours: #SETOPTIME0, #SETOPTIME0, Total power-on hours = 1234 (6 digits, zero padded) Set power-on hours command, total power-on hours Figure 6-36: Power-On Hours Command Format 6. Programming the power-on hours is complete V60 Ventilator Service Manual Rev A111 Chapter 7. Component Removal/Installation This chapter describes how to remove and install the replaceable components in the V60 ventilator. WARNING: CAUTION: CAUTION: CAUTION: CAUTION: To avoid personal injury, disconnect all power from the ventilator before servicing or cleaning. Component removal and installation is to be performed only by a qualified service technician. To avoid equipment damage due to static electricity, perform all repairs in an antistatic, electrostatic discharge (ESD)-protected environment. Replacing the CPU PCBA deletes the serial number, significant event log entries, and ventilator preferences. Review the significant event log before removing the CPU PCBA. The gas delivery subsystem (GDS) must be leak tested if you replace any of these components: Data acquisition (DA) PCBA Oxygen inlet filter Oxygen solenoid valve Oxygen filter cap Rev A V60 Ventilator Service Manual 7-1112 Chapter 7 Component Removal/Installation 7.1 Disconnecting Power Follow these steps to disconnect AC and battery power. 1. Shut down and then unplug the ventilator. 2. Disconnect the internal battery from the power harness connector (Figure 7-1). Bracket Internal battery Power harness connector Figure 7-1: Disconnecting the Internal Battery 7-2 V60 Ventilator Service Manual Rev A113 Chapter 7 Component Removal/Installation 7.2 Air Inlet Filter Follow these steps to remove the air inlet filter (Figure 7-2). Reverse to install. 1. Turn the unit OFF and disconnect the power cord from the outlet. 2. Twist the locking pin 1/4 turn with a slotted screwdriver or by hand, and pull down on locking pin to remove right side panel (locking pin is captive). 3. Remove air inlet filter. Right side panel Air inlet filter Figure 7-2: Removing the Air Inlet Filter 7.3 Internal Battery Follow these steps to remove and install the internal battery (Figure 7-3). 1. Disconnect power (section 7.1). 2. Disconnect the internal battery from the power harness connector. 3. Remove the side panel by turning the captive Phillips head fastener a 1/4 turn and releasing. 4. Using a 3-mm hex wrench, remove the battery bracket by removing two screws Rev A V60 Ventilator Service Manual 7-3114 Chapter 7 Component Removal/Installation 5. Holding the battery so that the vent hole faces up and the Philips logo faces out, thread the battery cable through the battery bracket. Position and place the battery inside the battery compartment. Pinching the end of the battery connector, plug it in so that it locks in place. 6. Reinstall the battery bracket by replacing the two screws. Reinstall the side panel and secure the fastener with a 1/4 turn clockwise. 7. Make sure the battery is properly installed by plugging the ventilator into an AC power receptacle and verifying that the yellow Battery (charged) LED on the front panel flashes. The flashing LED indicates the battery is being charged. 8. If necessary, attach the option label. NOTE: When installing a new battery: The battery must be charged for at least 5 hours before being placed into service. Dispose of the old battery according to your institution s protocol. Follow all local, state, and federal regulations with respect to environmental protection. M4 x 8 screw (x2) (N cm/ in.-lbf) Install battery with vent hole on top and Philips logo facing out Battery bracket Internal battery Left side wall Figure 7-3: Removing the Internal Battery 7-4 V60 Ventilator Service Manual Rev A115 Chapter 7 Component Removal/Installation 7.4 Top Cover Follow these steps to remove the top cover (Figure 7-4). Reverse to install. 1. Disconnect all power (section 7.1). 2. Turn and pull down on the locking pin to remove right side panel (locking pin is captive). 3. Remove the screws that attach the top cover, the remove the top cover. M4 x 8 screw (x4) (N cm in.-lbf) Top cover Figure 7-4: Removing the Top Cover Rev A V60 Ventilator Service Manual 7-5116 Chapter 7 Component Removal/Installation 7.5 AC Inlet Follow these steps to remove the AC inlet (Figure 7-5). Reverse to install. 1. Remove top cover (section 7.4). 2. Remove EMI shroud from power supply (section 7.16). 3. Remove the screws that attach the power cord retainer, then remove retainer and power cord. 4. Remove screws that attach the AC inlet to the back panel. 5. Disconnect AC inlet cables from power supply and ground terminal. 6. Feed cable through back panel cutout, and pull AC inlet from back panel. CAUTION: NOTE: Install ground wires and nuts in this order to ensure proper grounding: 1. Kep nut 2. AC inlet wire 3. Kep nut 4. Power supply connector wire 5. GDS ground wire 6. Kep nut When reinstalling, orient the AC inlet with ground terminal as shown. Ground terminal Power cord M2.5 x 8 screw (x2) Power (N cm/ M4 x 8 screw (x2) retainer AC inlet wire to cord in.-lbf) (N cm/ ground terminal AC inlet in.-lbf) M4 kep nut (x3) AC inlet wires to power supply (N cm/ in.-lbf) Figure 7-5: Removing AC Inlet 7-6 V60 Ventilator Service Manual Rev A117 Chapter 7 Component Removal/Installation 7.6 Fan Follow these steps to remove the fan (Figure 7-6). Reverse to install. NOTE: See Chapter 4 for fan filter replacement instructions. 1. Remove top cover (section 7.4). 2. Remove fan mount push pins that attach the fan to the back panel (pliers may be required). 3. Disconnect fan cable from the motor controller (MC) PCBA. 4. Remove the fan from inside the back panel. 5. Remove fan filter assembly (fan filter and housing) from outside the back panel. NOTE: When installing, orient the fan as shown (cable at the top inside of the fan). Orient the fan filter and housing as shown. Fan cable (to MC PCBA) Fan Fan isolation mount (x4) Fan filter Fan filter housing Fan mount push pin (x4) Install fan as shown: ^ AIR FLOW (into ventilator) < ROTATION Back panel Figure 7-6: Removing the Fan Rev A V60 Ventilator Service Manual 7-7118 Chapter 7 Component Removal/Installation 7.7 Oxygen Inlet Follow these steps to remove the oxygen inlet (Figure 7-7). Reverse to install. 1. Disconnect all power (section 7.1). 2. Loosen the screws that attach the retaining bracket to the GDS, then remove the bracket. 3. Pull to remove the oxygen inlet. M3 screw (x2) (N cm/ in.-lbf) Washer (x2) Oxygen inlet Retaining bracket Figure 7-7: Removing the Oxygen Inlet 7-8 V60 Ventilator Service Manual Rev A119 Chapter 7 Component Removal/Installation 7.8 Motor Controller (MC) PCBA Follow these steps to remove the MC PCBA (Figure 7-8). Reverse to install. 1. Remove top cover (section 7.4). 2. Remove the screws and wing nuts that attach the MC PCBA to the PCBA brackets. 3. Loosen the captive screws that attach the capacitor bracket to the base. 4. Disconnect cables: Blower cable Fan cable DA-MC ribbon cable 5. Gently pull MC PCBA up from its connection on the CPU PCBA, then disconnect speaker #1 cable. 6. Remove PCBA brackets. NOTE: To avoid bending connector pins, reinstall the MC PCBA, and then the PCBA brackets. Verify that the MC PCBA does not protrude above the brackets. PCBA bracket (x2) M3 x 12 screw (x2) (N cm/ in.-lbf) Wing nut (x2) DA-MC ribbon cable Blower cable MC PCBA Fan cable #6 washer (x2) (under bracket, not shown) M4 x 8screw (x4) (N cm/ in.-lbf) Capacitor bracket Speaker #1 cable Figure 7-8: Removing the MC PCBA Rev A V60 Ventilator Service Manual 7-9120 Chapter 7 Component Removal/Installation 7.9 Separating the UI from the Base Follow these steps to separate the UI from the base (Figure 7-9). Reverse to install. NOTE: When connecting the LCD cable to the PM PCBA, ensure that the connector tab faces the front panel. NOTE: After installing a new UI assembly, perform the touch screen calibration (section 5.3). 1. Remove top cover (section 7.4). 2. Remove MC PCBA (section 7.8). 3. Disconnect cables: LCD cable from PM PCBA. LCD cable ground wires from the ground terminal. LCD tray ground wires from the ground terminal. UI cable (ribbon cable) from the PM PCBA. 4. Loosen the captive screw that attaches the UI retainer to the UI. 5. Slide retainer up, then remove UI from base. LCD cable UI cable PM PCBA UI retainer M4 x 8 screw (x1) (N cm/ in.-lbf) Ground wires (from LCD cable and LCD tray) Figure 7-9: Separating the UI from the Base 7-10 V60 Ventilator Service Manual Rev A121 Chapter 7 Component Removal/Installation 7.10 Front Panel Follow these steps to remove the front panel (Figure 7-10). Reverse to install. 1. Separate UI from base (section 7.9). 2. Remove hose clamp and boot that attach blower to the gas outlet. 3. Remove the tubing from the barbed fittings inside the front panel. 4. Disconnect gas outlet and proximal port ground wires from the base. 5. Remove the screws that attach the front panel to the base and side walls. NOTE: When reinstalling tubing, ensure that: Longer (9-in.) tube is connected between manifold barb M (machine) to barbed gas outlet fitting. Shorter (8-in.) tube is connected between manifold barb P (proximal) and barbed proximal pressure port. Proximal pressure port (8-in. tube from manifold P) Hose clamp (to gas outlet) Internal exhalation port fitting (7.5-in. tube from base) Boot (opposite end connects to blower) Gas outlet Machine pressure fitting (9-in. tube from manifold M) Gas outlet ground wire M4 x 8 screw (x7) (N cm/ in.-lbf) Figure 7-10: Removing the Front Panel Rev A V60 Ventilator Service Manual 7-11122 Chapter 7 Component Removal/Installation 7.11 Gas Outlet Port Follow these steps to remove the gas outlet port (Figure 7-11). Reverse to install. 1. Remove front panel (section 7.10). 2. Remove screws that attach Gas outlet bracket to inside front panel. Gas outlet M4 x 8 screw (x2) (N cm/ in.-lbf) Inside front panel Bracket Figure 7-11: Removing the Gas Outlet 7-12 V60 Ventilator Service Manual Rev A123 Chapter 7 Component Removal/Installation 7.12 UI Retainer Follow these steps to remove the UI retainer (Figure 7-12). Reverse to install. 1. Remove front panel (section 7.10). 2. Remove screws and washers that attach UI retainer to inside front panel. UI retainer Inside front panel Figure 7-12: Removing the UI Retainer M3 x 6 screw (x4) (N cm/ in.-lbf) Washer (x4) Rev A V60 Ventilator Service Manual 7-13124 Chapter 7 Component Removal/Installation 7.13 Proximal Pressure Port Follow these steps to remove the proximal pressure port (Figure 7-13). Reverse to install. 1. Remove front panel (section 7.10). 2. Remove the nut and lock washer that attach the proximal pressure port to the inside of the front panel. (Proximal pressure port includes the nut and lock washer.) NOTE: When reinstalling the proximal pressure port, install the ground wire first, then the lock washer and nut. Proximal pressure port Nut (x1) (N cm/ in.-lbf) Lock washer (x1) Ground wire (Inside front panel) Figure 7-13: Removing the Proximal Pressure Port 7-14 V60 Ventilator Service Manual Rev A125 Chapter 7 Component Removal/Installation 7.14 Speakers Follow these steps to remove the alarm speakers (Figure 7-14). Reverse to install. 1. Remove front panel (section 7.10). 2. Disconnect speaker #2 from the power management (PM) PCBA. (Speaker #1 is disconnected when the MC PCBA is disconnected.) 3. Remove the screw and washer that attaches each speaker to the base. M3 x 6 screw (x2) (N cm/ in.-lbf) M3 washer (x2) Speaker #2 (to PM PCBA) Speaker #1 (to MC PCBA) Figure 7-14: Removing the Alarm Speakers Rev A V60 Ventilator Service Manual 7-15126 Chapter 7 Component Removal/Installation 7.15 Power Management (PM) PCBA Follow these steps to remove the PM PCBA (Figure 7-15). Reverse to install. 1. Remove top cover (section 7.4). 2. Disconnect cables: Speaker #2 cable Power harness assembly UI cable LCD cable 3. Remove the screws that attach the PM PCBA to the left side wall. 4. Gently pull PM PCBA up from its connection on the CPU PCBA. Speaker cable LCD cable UI cable Power harness assembly Left side wall PM PCBA M3 x 6 screw (x2) (N cm/ in.-lbf) Figure 7-15: Removing the PM PCBA 7-16 V60 Ventilator Service Manual Rev A127 Chapter 7 Component Removal/Installation 7.16 Power Supply Follow these steps to remove the power supply (Figure 7-16). Reverse to install. NOTE: Do not remove any connections from the power supply terminal strip. 1. Remove MC PCBA (section 7.8) and PM PCBA (section 7.15). 2. Remove EMI shroud from power supply by slightly lifting the shroud away from the power supply with a small screwdriver. 3. Remove the screws that attach the mounting plate to the base. (Power supply includes attached mounting plate.) 4. Disconnect AC inlet cable and power harness. NOTE: Squeeze EMI shroud before reinstalling to ensure that it fits snugly over the power supply. Power supply EMI shroud Mounting plate M3 x 6 screw (x4) (N cm/ in.-lbf) Holes in EMI shroud fit over screw heads on the side of the power supply From under mounting plate (not shown): M3 x 6 screw (x4) (N cm/ in.-lbf) Figure 7-16: Removing the Power Supply Rev A V60 Ventilator Service Manual 7-17128 Chapter 7 Component Removal/Installation 7.17 CPU PCBA Follow these steps to remove the CPU PCBA (Figure 7-17). Reverse to install. NOTE: Replacing the CPU PCBA deletes the serial number, installed options, significant event log entries, and ventilator preferences. Review the significant event log before removing the CPU PCBA. To reinstall options on a newly-installed CPU PCBA, please contact Customer Service at or for the appropriate option codes. You must provide this information to customer service: the V60 ventilator serial number and the CPU PCBA serial number. Option-only (no labeling or literature) part numbers: Ramp: P/N AVAPS: P/N C-FLEX: P/N Remove MC PCBA (section 7.8) and PM PCBA (section 7.15). 2. Remove the screws that attach the CPU cover to the underside of the base. 3. Remove the screws that attach the CPU PCBA to the CPU tray. NOTE: After installing a new CPU PCBA, reprogram the ventilator serial number and power-on hours as described in Chapter 6. M12 x 1 nut (x1) (N cm/ in.-lbf) M3 x 6 screw (x12) (N cm/ in.-lbf) CPU cover CPU bracket CPU PCBA M3 x 6 screw (x6) (N cm/ in.-lbf) CPU tray Figure 7-17: Removing the CPU PCBA 7-18 V60 Ventilator Service Manual Rev A129 Chapter 7 Component Removal/Installation 7.18 Real-Time Clock Battery Follow these steps to remove the real-time clock battery (Figure 7-18). Reverse to install. 1. Disconnect all power (section 7.1). 2. Remove the screws that attach the CPU cover to the underside of the base. 3. Remove the real-time clock battery from the CPU PCBA. NOTE: When installing the real-time clock battery, ensure that the positive side of the battery faces up. M3 x 6 screw (x12) (N cm/ in.-lbf) CPU cover Real-time clock battery (install with positive side facing up) CPU PCBA Figure 7-18: Removing the Real-Time Clock Battery Rev A V60 Ventilator Service Manual 7-19130 Chapter 7 Component Removal/Installation 7.19 Left Side Wall Follow these steps to remove the left side wall (Figure 7-19). Reverse to install. 1. Remove front panel (section 7.10). 2. Remove the battery (section 7.3). 3. Remove the PM PCBA (section 7.15). 4. Detach power harness assembly connector from left side wall. 5. Remove screws that attach the left side wall to the base. NOTE: At reinstallation, install the power harness connector with its red wires toward the top of the side wall. Power harness assembly M4 x 8 screw (x4) (N cm/ in.-lbf) Left side wall Figure 7-19: Removing the Left Side Wall 7-20 V60 Ventilator Service Manual Rev A131 Chapter 7 Component Removal/Installation 7.20 Gas Delivery Subsystem (GDS) Follow these steps to remove the GDS (Figure 7-20, Figure 7-21). Reverse to install. NOTE: The oxygen filter cap and air inlet collar attach the GDS to the ventilator, and when removed the GDS is not attached to the ventilator. 1. Remove top cover (section 7.4). 2. Remove the oxygen inlet (section 7.7). 3. Remove the screws that attach the filter retainer, then remove the filter retainer and air inlet filter. Filter retainer M3 x 6 screw (x4) (N cm/ in.-lbf) Filter frame M4 x 8 screw (x6) (N cm/ in.-lbf) Right side wall Oxygen filter cap (N cm/ in.-lbf) Figure 7-20: Removing the Air Inlet Filter and Retainer Air inlet collar (N cm/ in.-lbf) 4. Remove the screws that attach the filter frame, then remove filter frame. 5. Remove the tubing from the barbed fittings inside the front panel. 6. Loosen the hose clamp that attaches the boot to the manifold cap. NOTE: When reinstalling, verify that the boot is attached to the blower before reinstalling the GDS Rev A V60 Ventilator Service Manual 7-21132 Chapter 7 Component Removal/Installation 7. Remove screw that attaches the ground cable to the manifold. 8. Remove the oxygen filter cap and air inlet collar from the right side wall. NOTE: When reinstalling, apply a thin coat of Krytox to the inlet collar flange on the side wall. Tighten the air inlet collar first, and then the oxygen filter cap. 9. Disconnect the DA-MC cable from the DA PCBA. 10. Remove GDS from base. NOTE: When reinstalling, connect tubing so that: Longer (9-in.) tube connects between manifold M (machine) barb and barbed gas outlet fitting. Shorter (8-in.) tube connects between manifold P (proximal) barb and barbed proximal pressure port. DA PCBA: remove DA-MC cable (not shown) Manifold cap GDS manifold: remove ground cable (not shown) Figure 7-21: Removing the GDS 7-22 V60 Ventilator Service Manual Rev A133 Chapter 7 Component Removal/Installation 7.21 Right Side Wall Follow these steps to remove the right side wall (Figure 7-22). Reverse to install. 1. Remove the front panel (section 7.10). 2. Remove the GDS (section 7.20). 3. Remove screws that attach the right side wall to the base. Right side wall M4 x 8 screw (x4) (N cm/ in.-lbf) Figure 7-22: Removing the Right Side Wall Rev A V60 Ventilator Service Manual 7-23134 Chapter 7 Component Removal/Installation 7.22 Oxygen Inlet Filter Follow these steps to remove the oxygen inlet filter (Figure 7-23). Reverse to install. NOTE: When installing the oxygen inlet filter, ensure that the smaller end of the filter is opposite the threads in the GDS. 1. Remove GDS (section 7.20). 2. Use a wrench to loosen the oxygen inlet filter and remove from GDS. Oxygen inlet filter (N cm/ in.-lbf) Gas delivery subsystem (GDS) Figure 7-23: Removing the Oxygen Inlet Filter 7-24 V60 Ventilator Service Manual Rev A135 Chapter 7 Component Removal/Installation 7.23 Data Acquisition (DA) PCBA Follow these steps to remove the DA PCBA (Figure 7-24). Reverse to install. 1. Remove GDS (section 7.20). 2. Remove the screws and washers that attach the DA PCBA to the manifold. 3. Disconnect these cables from the DA PCBA: Oxygen solenoid cable Flow sensor ribbon cable assembly 4. Remove the DA PCBA. CAUTION: To avoid damage to the DA PCBA or solenoid pins, use care to avoid flexing the PCBA or bending the pins. When installing the DA PCBA, ensure that transducer grommets and o-rings are installed to the manifold as shown Rev A V60 Ventilator Service Manual 7-25136 Chapter 7 Component Removal/Installation DA PCBA installed on GDS M3 x 8 screw (x7) (N cm/ in.-lbf) M3 washer (x7) Oxygen solenoid cable DA to MC ribbon cable connector Flow sensor ribbon cable assembly Underside of installed DA PCBA: solenoid pins (do not bend) O-ring (x2) Transducer grommet (x2) This grommet is correctly installed Underside of DA PCBA: ensure that transducer grommets and o-rings are installed at reassembly This grommet is NOT correctly installed Figure 7-24: Removing the DA PCBA 7-26 V60 Ventilator Service Manual Rev A137 Chapter 7 Component Removal/Installation 7.24 Air and Oxygen Flow Sensor Assembly Follow these steps to remove the air and oxygen flow sensor assembly (Figure 7-25). Reverse to install. 1. Remove GDS (section 7.20). 2. Disconnect the flow sensor cable from the DA PCBA and flow sensor assembly. 3. Remove the screws that attach the DA PCBA to the flow sensor assembly. 4. Remove screws that attach the flow sensor assembly to the manifold block. NOTE: When installing a new flow sensor assembly, install the new o-rings. DA PCBA DA to MC ribbon cable connector DA PCBA M3 x 8 screw (x2) (N cm/ in.-lbf) M3 washer (x2) M3 x 14 screw (x4) (N cm/ in.-lbf) GDS Flow sensor assembly Flow sensor ribbon cable Figure 7-25: Removing the Flow Sensor Assembly Rev A V60 Ventilator Service Manual 7-27138 Chapter 7 Component Removal/Installation 7.25 Oxygen Solenoid Valve Follow these steps to remove the oxygen solenoid valve (Figure 7-26). Reverse to install. 1. Remove the GDS (section 7.20). 2. Disconnect the oxygen solenoid cable from the DA PCBA. 3. Remove the screws that attach the solenoid orientation clip to the solenoid mount. NOTE: When installing the oxygen solenoid, apply a thin coat of Krytox on the o-rings. Oxygen solenoid cable DA PCBA O-rings M3 x 8 screw (x3) (N cm/ in.-lbf) Solenoid mount Solenoid orientation clip Oxygen solenoid valve M2.5 x 6 screw (x2) (N cm/ in.-lbf) Oxygen solenoid valve Figure 7-26: Removing the Oxygen Solenoid Valve 7-28 V60 Ventilator Service Manual Rev A139 Chapter 7 Component Removal/Installation 7.26 Solenoid Valves Follow these steps to remove the solenoid valves (Figure 7-27). Reverse to install. 1. Remove the DA PCBA (section 7.23). 2. Remove the screws that attach the retention plate to the manifold. 3. When replacing the solenoid valves, ensure that the solenoid valve seals are properly installed to the manifold. NOTE: When installing a new solenoid valve: Do not bend solenoid pins. Install a new solenoid valve seal. Manifold Solenoid valves (x4) Solenoid valve seals (x4) M3 x 8 screw (x2) (N cm/ in.-lbf) Retention plate SOL1: Purge solenoid SOL2: Machine pressure solenoid SOL4: Crossover solenoid SOL3: Proximal pressure solenoid Figure 7-27: Removing the Solenoid Valves Rev A V60 Ventilator Service Manual 7-29140 Chapter 7 Component Removal/Installation 7.27 Blower Follow these steps to remove the blower (Figure 7-28). Reverse to install. 1. Remove the top cover (section 7.4). 2. Disconnect the blower cable from the MC PCBA. 3. Remove the boot and hose clamps that attach the blower to the gas outlet. 4. Remove the shoulder screws that attach the blower to the base. 5. Loosen the clamps on the boot that attaches the blower to the GDS, then remove the blower, boot, and clamps. NOTE: When installing the blower: Ensure that the boot is fully and clamped to the blower before installing the blower. Install new motor mount grommets when installing a new blower. Hose clamps (x2) Blower Gas outlet Hose clamps (x2) To gas outlet Blower cable to MC PCBA To GDS Blower Manifold to blower boot Shoulder screw (x4) (N cm/ in.-lbf) Manifold to blower boot Figure 7-28: Removing the Blower 7-30 V60 Ventilator Service Manual Rev A141 Chapter 7 Component Removal/Installation 7.28 Opening the User Interface (UI)/ Rear Bezel Follow these steps to open the UI and remove the rear bezel (Figure 7-29). Reverse to install. 1. Separate UI from base (section 7.9). 2. Remove the screws from the end cap and remove the end cap. 3. Remove the screws from the rear bezel. 4. Separate the front and rear bezel. NOTE: When reinstalling rear bezel: Ensure that gasket is properly installed around the inside of the bezel. Verify that all cables extend through the same slot as shown. All cables extend from same slot End cap Bezel cord gasket M3 x 14 screw (x13) Rear bezel ((N cm/ in.-lbf) Rear bezel gasket Rear bezel (interior) Ensure that bezel cord gasket is properly installed Figure 7-29: Opening the UI Rev A V60 Ventilator Service Manual 7-31142 Chapter 7 Component Removal/Installation 7.29 Power Switch Overlay Follow these steps to remove the power switch overlay (Figure 7-30). Reverse to install. 1. Open the UI (section 7.28). 2. From inside the front bezel, disconnect the power switch overlay cable from the UI PCBA. 3. Carefully peel the power switch overlay from the front bezel. 4. Once the power switch overlay is removed, use isopropyl alcohol to remove any remaining adhesive. Ensure that the bezel surface is clean and dry. CAUTION: NOTE: Do not flex the overlay. When installing a new power switch overlay, peel the backing from the overlay, feed the cable through the bezel cutout, align the overlay to the front bezel, and press to adhere. LCD tray Power switch overlay position on front bezel Power switch overlay cable Figure 7-30: Removing the Power Switch Overlay 7-32 V60 Ventilator Service Manual Rev A143 Chapter 7 Component Removal/Installation 7.30 Switch PCBA Follow these steps to remove the switch PCBA (Figure 7-31). Reverse to install. 1. Open the UI (section 7.28). 2. Remove the screws that attach the switch PCBA to the inside of the front bezel. 3. Disconnect the nav-ring and UI PCBA cables from the switch PCBA. NOTE: During installation, verify that the nav-ring cable is fully seated into its connector on the switch PCBA. Front bezel Switch PCBA to UI PCBA cable M3 x 6 screw (x4) (N cm/ in.-lbf) Switch PCBA Nav-ring cable Figure 7-31: Removing the Switch PCBA Rev A V60 Ventilator Service Manual 7-33144 Chapter 7 Component Removal/Installation 7.31 Nav-Ring Assembly Follow these steps to remove the nav-ring assembly (Figure 7-32). Reverse to install. 1. Remove the switch PCBA (section 7.30). 2. Remove the nav-ring button from the front of the bezel. 3. Carefully remove the nav-ring assembly from the front of the bezel. Use isopropyl alcohol to remove any remaining adhesive. Ensure that the surface is clean and dry. NOTE: After installing the nav-ring assembly, install the button so that its check mark is upright as shown. Install switch button with check mark in upright position Figure 7-32: Nav-Ring Assembly Button 7-34 V60 Ventilator Service Manual Rev A145 Chapter 7 Component Removal/Installation 7.32 Front Bezel, Touch Screen Follow these steps to remove the front bezel and touch screen (Figure 7-33). Reverse to install. NOTE: When installing a new touch screen, remove the protective film and avoid touching the screen surface. NOTE: After installing a new UI assembly, perform the touch screen calibration (section 5.3). 1. Open the UI (section 7.28). 2. Disconnect these cables from the UI PCBA: Switch PCBA cable Nav-ring cable Power switch overlay cable Touch screen cable 3. Remove the switch PCBA. 4. Remove the screw that attaches the cable clamp to the LCD tray. 5. Remove the screws and washers that attach the LCD tray to the front bezel, then remove the LCD tray. 6. Remove the touch screen from the front bezel. Nav-ring cable Switch PCBA to UI PCBA cable Touch screen LCD tray Front bezel Cable clamp M3 x 6 screw (x8) (N cm/ in.-lbf) Power switch overlay cable Touch screen cable M3 x 6 screw (x1) (N cm/ in.-lbf) Figure 7-33: Removing the Touch Screen Rev A V60 Ventilator Service Manual 7-35146 Chapter 7 Component Removal/Installation 7.33 LCD Follow these steps to remove the LCD (Figure 7-34). Reverse to install. NOTE: When installing a new LCD, remove the protective film before reinstalling the LCD tray to the front bezel, and avoid touching the LCD screen. 1. Open and separate the UI bezel (section 7.28). 2. Remove the front bezel (section 7.32). 3. Remove the screws that attach the LCD to the LCD tray. 4. With the LCD face up, carefully lift the LCD slightly to disconnect the backlight inverter and LCD cable. 5. Remove the LCD. NOTE: When installing the LCD cable to the LCD, use a new piece of Kapton tape V60 Ventilator Service Manual Rev A147 Chapter 7 Component Removal/Installation M1.6 x 4screw (x4) (N cm/ in.-lbf) LCD LCD tray Underside of LCD Kapton tape LCD cable Underside of LCD Backlight inverter cable UI PCBA Figure 7-34: Removing the LCD Rev A V60 Ventilator Service Manual 7-37148 Chapter 7 Component Removal/Installation 7.34 User Interface (UI) PCBA Follow these steps to remove the UI PCBA (Figure 7-35). Reverse to install. 1. Remove the LCD (section 7.33). 2. Remove the screws that attach the UI PCBA to the LCD tray. 3. Disconnect these cables from the UI PCBA: Backlight inverter cable UI ribbon cable LCD tray M3 x 6 screw (x5) (N cm/ in.-lbf) UI PCBA Figure 7-35: Removing the UI PCBA 7-38 V60 Ventilator Service Manual Rev A149 Chapter 7 Component Removal/Installation 7.35 Backlight Inverter PCBA Follow these steps to remove the backlight inverter PCBA (Figure 7-36). Reverse to install. 1. Remove the LCD (section 7.33). 2. Remove the screws that attach the backlight inverter PCBA to the LCD tray. 3. Disconnect the backlight inverter cable from the backlight inverter PCBA. LCD tray Backlight inverter PCBA M2.5 x 8 screw (x2) (N cm/ in.-lbf) Figure 7-36: Removing the Backlight Inverter PCBA Rev A V60 Ventilator Service Manual 7-39150 Chapter 7 Component Removal/Installation 7.36 LCD Tray Follow these steps to remove the LCD tray (Figure 7-37). Reverse to install. 1. Remove the UI PCBA (section 7.34). 2. Remove the backlight inverter PCBA (section 7.35). Backlight inverter PCBA LCD tray UI PCBA Figure 7-37: Removing the LCD Tray 7-40 V60 Ventilator Service Manual Rev A151 Chapter 7 Component Removal/Installation 7.37 Bottom Feet Follow these steps to remove the bottom feet (section Figure 7-38:). Reverse to install. CAUTION: Follow these instructions to remove the right rear bottom foot: it is attached with a hex nut inside the base assembly. 1. Remove the 3 screws that attach the front and left rear bottom feet to the base assembly. 2. Disconnect all power (section 7.1). 3. Remove the GDS (section 7.20). 4. From inside the base assembly, remove the hex nut that attaches the screw and bottom foot. M4 hex kep nut (x1) (N cm/ in.-lbf) M4 x 14 screw (x4) (N cm/ in.-lbf) Figure 7-38: Removing the Bottom Feet Rev A V60 Ventilator Service Manual 7-41152 Chapter 7 Component Removal/Installation 7.38 Labels Follow these steps to remove and replace labels (Figure 7-39, Figure Figure 7-41, Figure 7-42): 1. Use isopropyl alcohol to remove any remaining adhesive from the original part. Ensure that surface is clean and dry. 2. Peel backing from new part and press to adhere. Logo label Auto-Trak option label Product label Figure 7-39: Labels: Front of UI Option labels Electrical safety label PM label Figure 7-40: Labels: Back of UI 7-42 V60 Ventilator Service Manual Rev A153 Chapter 7 Component Removal/Installation Classification label Rating label Oxygen label Patent label Serial number label CSA label Figure 7-41: Labels: Back Panel of Base Protective earth ground label Figure 7-42: Protective Earth Ground Label (inside base assembly) Rev A V60 Ventilator Service Manual 7-43154 Chapter 7 Component Removal/Installation (This page is intentionally blank.) 7-44 V60 Ventilator Service Manual Rev A155 Chapter 8. Performance Verification Performance verification verifies the integrity of the sensors and other critical components in the ventilator using external measurement devices. The performance verification consists of several tests (Table 8-1). The type of service performed determines which tests are required (Table 8-2). Run all tests in order. CAUTION: Performance verification is to be performed only by a qualified service technician. Table 8-1: Performance Verification Tests Test number Description 1 Electrical safety 2 Leak tests 3 Ventilator controls 4 Pressure accuracy 5 Air delivery/flow accuracy* 6 Oxygen flow accuracy* 7 Oxygen accuracy 8 S/T performance 9 Alarms 10 Power fail 11 Internal battery * Flow testing above 1951 m (6400 ft.) cannot attain 130 SLPM Rev A V60 Ventilator Service Manual 8-1156 Chapter 8 Performance Verification Table 8-2: Performance Verification Test Requirements Service performed Annual preventive maintenance AC inlet: removal/replacement Air and oxygen flow sensor assembly: removal/ replacement Backlight inverter cable: removal/replacement Backlight inverter PCBA: removal/replacement Blower: removal/replacement CPU PCBA: removal/replacement Data acquisition (DA) PCBA: removal/ replacement Data acquisition (DA) PCBA to flow sensors cable: removal/replacement Data acquisition (DA) PCBA to motor controller (MC) PCBA cable: removal/replacement Fan: removal/replacement Required tests All Electrical safety Electrical safety High pressure leak test System leak test Pressure accuracy Air delivery/flow accuracy Oxygen flow accuracy Oxygen accuracy Breath rate Electrical safety Ventilator controls Electrical safety Ventilator controls Electrical safety System leak test Pressure accuracy Air delivery/flow accuracy Electrical safety Alarms Electrical safety High pressure leak test System leak test Pressure accuracy Air delivery/flow accuracy Oxygen flow accuracy Oxygen accuracy Breath rate Electrical safety Electrical safety Electrical safety 8-2 V60 Ventilator Service Manual Rev A157 Chapter 8 Performance Verification Table 8-2: Performance Verification Test Requirements Service performed Gas delivery subsystem (GDS): removal/ replacement Gas outlet port: removal/replacement Internal battery: removal/replacement LCD: removal/replacement LCD cable: removal/replacement Motor controller (MC) PCBA: removal/ replacement Nav-ring: removal/replacement Oxygen inlet filter: removal/replacement Oxygen valve: removal/replacement Power harness cable: removal/replacement Power management (PM) PCBA: removal/ replacement Power supply: removal/replacement Required tests Electrical safety High pressure leak test System leak test Pressure accuracy Air delivery/flow accuracy Oxygen flow accuracy Oxygen accuracy Breath rate Electrical safety System leak test Pressure accuracy Electrical safety Internal battery Electrical safety Ventilator controls Electrical safety Ventilator controls Electrical safety Air delivery/flow accuracy Internal battery Power fail Electrical safety Ventilator controls Electrical safety High pressure leak test System leak test Pressure accuracy Oxygen flow accuracy Oxygen accuracy Electrical safety High pressure leak test System leak test Pressure accuracy Oxygen flow accuracy Oxygen accuracy Breath rate Electrical safety Internal battery Electrical safety Internal battery Electrical safety Rev A V60 Ventilator Service Manual 8-3158 Chapter 8 Performance Verification Table 8-2: Performance Verification Test Requirements Service performed Power switch overlay: removal/replacement Electrical safety Rubber boots: removal/replacement/adjustment Electrical safety System leak test Pressure accuracy Solenoid valve: removal/replacement Electrical safety High pressure leak test System leak test Pressure accuracy Air delivery/flow accuracy Oxygen flow accuracy Oxygen accuracy Breath rate Speaker: removal/replacement Electrical safety Alarms Switch PCBA: removal/replacement Electrical safety Ventilator controls Touch screen: removal/replacement Electrical safety Touch screen calibration Ventilator controls User interface (UI) PCBA: removal/replacement Electrical safety Ventilator controls User interface: removal/replacement Electrical safety Ventilator controls UI PCBA to power management (PM) PCBA cable: removal/replacement Required tests Electrical safety Ventilator controls 8-4 V60 Ventilator Service Manual Rev A159 Chapter 8 Performance Verification 8.1 Required Test Equipment Table 8-3 summarizes the test equipment required, and Table 8-4 summarizes the service accessories required for performance verification. Check the calibration status of all test equipment before use. Table 8-3: Required Test Equipment for Performance Verification Description Electrical safety analyzer Pneumatic calibration analyzer(s) capable of measuring low pressure (cmh 2 O), flow rate (LPM), volume (liters), and respiratory rate Oxygen analyzer Pressure analyzer capable of measuring high pressure (PSI) Digital multimeter (DMM) and frequency counter Test lung Temperature/humidity monitor Recommended Manufacturer/Model Dale LT 5440 or equivalent TSI Certifier FA Plus (P/N), or equivalent TSI Certifier FA Plus or equivalent TSI Certifier FA Plus or equivalent Local supplier IngMar QuickLung or equivalent Fisher Scientific or equivalent NOTE: An oxygen source capable of delivering 140 LPM (40-87 PSI) is required for oxygen system tests Rev A V60 Ventilator Service Manual 8-5160 Chapter 8 Performance Verification Table 8-4: Required Service Accessories for Performance Verification Description Part Number V60 Service Kit, which includes: Adapter, 22-mm OD, both ends Adapter, 25-pin to 9-pin Adapter, torque, cap/collar BiPAP test adapter, 0.25-in Cable, null modem Cable, TTL communications Circuit tube, 18-in. smooth-bore (qty. 2) Coupling, straight, silicone Forceps, locking, red plastic Plug, low-pressure Plug, tapered 23 / / 64 in., silicone (qty. 2) Plug, tapered 9 / 16-3 / 4 in., silicone Pressure pick-off port (oxygen enrichment attachment SNGL) Proximal pressure line tubing Remote alarm test cable Remote alarm test cable adapter Syringe, system leak test Valve, ball Valve, oxygen/regulator shut-off Whisper Swivel II V60 Ventilator Service Manual Rev A161 Chapter 8 Performance Verification 8.2 Preliminary Cleaning, Inspection and Setup WARNING: To prevent disease transmission, use protective equipment when handling contaminated bacteria filters or other patient accessories. Before servicing the ventilator, clean and inspect as follows: Clean the ventilator exterior as described in the User Manual. Remove the humidifier from the ventilator, if applicable. Visually inspect the exterior of the ventilator for damage. Replace damaged parts as needed. Remove and inspect the cooling fan filter and air inlet filter. Clean or replace filter as described in the User Manual Rev A V60 Ventilator Service Manual 8-7162 Chapter 8 Performance Verification 8.3 View and Record Ventilator Information 1. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button, and press the On/Shutdown button on the user interface. Within 5 seconds of power up, release and press the navring Enter button again to enter the Diagnostics menu. 2. Touch Service to display the Ventilator Information screen (Figure 8-1), and record the following information on the Electrical Safety (section 8.8, Electrical Safety Data Form) or Performance Verification Data Form (section 8.9, Performance Verification Data Form): Software options Ventilator serial number Software version Total power-on hours Hours since last PM Battery lot number Battery manufacture date Figure 8-1: Ventilator Information Screen 3. Touch Pneumatics and record the displayed barometric pressure. 4. Measure and record the ambient temperature and relative humidity. 5. Complete a diagnostic report (DRPTA) download (Chapter 6). 6. Turn the ventilator OFF. 8-8 V60 Ventilator Service Manual Rev A163 Chapter 8 Performance Verification 8.4 Pneumatic Calibration Analyzer Setup Follow these steps to set up the Certifier FA Plus pneumatic calibration analyzer, including: Measurement Selection Screen Averaging Setup Menu Trigger Options menu Configurations menu NOTE: When using a pneumatic calibration analyzer, remember the analyzer should be in STP when measuring flow Measurement Selection Screen Use the Measurement Selection Screen to add or remove parameters from the Certifier FA Plus screen. 1. Touch any parameter on the analyzer touch screen to display the Measurement Selection Screen (Figure 8-2). Figure 8-2: Measurement Selection Screen (Certifier FA Plus) 2. To add a parameter, touch the parameter name in the left window then touch the right arrow. To remove a parameter, touch the parameter name in the right window then touch the left arrow. Use the up and down arrows to determine the order of the selected parameters. Recommended parameters: High Pressure (psig) Rev A V60 Ventilator Service Manual 8-9164 Chapter 8 Performance Verification Low Pressure (cmh 2 O) Absolute Pressure (mmhg) Flow Rate (SLPM) Oxygen Concentration (%) Peak Pressure (cmh 2 O) PEEP Pressure (cmh 2 O) 3. To select or change the measured gas, touch the gas dropdown list and select the gas. 4. Touch OK when parameters selection and order is complete Averaging Setup Menu Use the Averaging Setup Menu to select averages for breath parameters (how many breaths are averaged) and real-time transducer values (the time interval used for averaging). 1. Touch the Breath Average button to display the Averaging Setup Menu (Figure 8-3). Breath Average button Number of Breaths Averaged = 5 Second Average for Real-Time Values = 2.0 Figure 8-3: Averaging Setup Menu (Certifier FA Plus) 8-10 V60 Ventilator Service Manual Rev A165 Chapter 8 Performance Verification 2. Use the up and down arrows to set these values: Number of Breaths Averaged: 5. Second Average for Real-Time Values: Touch OK when complete Trigger Options Use Trigger Options to define how the analyzer detects the start of the inspiratory and expiratory breath cycles. 1. Touch the Trigger options button to display the Trigger Options menu (Figure 8-4). Trigger options button Figure 8-4: Trigger Options Menu (Certifier FA Plus) 2. Select TTL. 3. Use the arrow buttons to select Start Trigger. 4. Touch OK when complete Rev A V60 Ventilator Service Manual 8-11166 Chapter 8 Performance Verification Configurations Menu Use the Configurations menu to save test configurations and switch between saved configurations. 1. Touch the Configuration button to display the Configurations menu (Figure 8-5). Configuration button Figure 8-5: Configurations Menu (Certifier FA Plus) 8-12 V60 Ventilator Service Manual Rev A167 Chapter 8 Performance Verification 2. To create a Respironics folder, touch Save As, then touch New Folder (Figure 8-6). If a Respironics folder already exists go to step 4. Figure 8-6: Save As Configuration - New Folder Button (Certifier FA Plus) 3. Use the touch screen keyboard to enter RESPIRONICS, then touch OK (Figure 8-7). Figure 8-7: Entering a New Folder Name (Certifier FA Plus) Rev A V60 Ventilator Service Manual 8-13168 Chapter 8 Performance Verification 4. Highlight RESPIRONICS and touch Save (Figure 8-8). Figure 8-8: Saving a New Configuration to the RESPIRONICS Folder (Certifier FA Plus) 5. Use the touch screen keyboard to enter the new configuration name (V60), then touch OK (Figure 8-9). Figure 8-9: Entering a New Configuration Name (Certifier FA Plus) 8-14 V60 Ventilator Service Manual Rev A169 Chapter 8 Performance Verification 8.5 Performance Verification Procedures When running a complete performance verification, perform the tests in order to ensure logical fault diagnosis. If the ventilator fails any performance verification test, see section 8.7, Performance Verification Troubleshooting/ Repair for troubleshooting instructions. Fill in the applicable parts of the Performance Verification Data Form as each test is completed Electrical Safety (Test 1) The electrical safety test verifies that the ground resistance and forward and reverse leakage current are within specified limits (Figure 8-10). Required equipment: 0.25-in. test adapter Needle nose vise grips Electrical safety analyzer 1. Check that the ground resistance < 0.2 ohm (Ω) at these test points: Gas outlet port Proximal pressure port Oxygen fitting retention plate 2. Attach the 0.25-in. test adapter to the gas outlet port. 3. Turn the ventilator on and check that the cooling fan is operating correctly. 4. Check that the forward and reverse leakage current is: < 300 microamperes (μa) for ventilators connected to VAC/60 Hz. < 500 μa for ventilators connected to VAC/50 Hz. 5. The electrical safety test is complete Rev A V60 Ventilator Service Manual 8-15170 Chapter 8 Performance Verification Proximal pressure port Electrical safety analyzer set to measure ground resistance Gas outlet port Electrical safety analyzer set to measure ground resistance Oxygen fitting retention plate screw NOTE: Oxygen fitting is not grounded Electrical safety analyzer set to measure ground resistance Oxygen fitting retention plate screw NOTE: Oxygen fitting is not grounded Electrical safety analyzer set to measure leakage current Figure 8-10: Electrical Safety Testing 8-16 V60 Ventilator Service Manual Rev A171 Chapter 8 Performance Verification Leak Tests (Test 2) Leak tests include: High pressure leak test: verifies that there are no leaks on the highpressure (oxygen) side of the GDS. System leak test: verifies that there are no leaks on the low pressure side of the GDS, or connections between the rubber boots, blower patient outlet, and internal tubing. Figure 8-11 shows the test configuration for the leak tests.. High pressure leak test setup System leak test setup Figure 8-11: Leak Tests Configuration Rev A V60 Ventilator Service Manual 8-17172 Chapter 8 Performance Verification High Pressure Leak Test Required equipment: Certifier FA Plus analyzer Oxygen shut-off valve 1. If the ventilator is not already in Diagnostic mode, press and hold the Enter button on the nav-ring and turn the ventilator on by pressing the On/Shutdown button. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics menu. 2. Connect the oxygen regulator/shut-off valve to the ventilator and to the Certifier FA Plus, and connect oxygen. (Touch Service, then Pneumatics, and verify that the O 2 inlet display and the analyzer display read 45 to 50 psig.) 3. Touch Misc, then touch High Pressure Leak Test and follow the onscreen prompts (Figure 8-12). 4. Touch Close and then remove the oxygen regulator/shut-off valve. 5. The high pressure leak test is complete. Figure 8-12: High Pressure Leak Test Screen 8-18 V60 Ventilator Service Manual Rev A173 Chapter 8 Performance Verification System Leak Test Required equipment: 9 / 16-3 / 4 in. tapered plug (2) Clamp (hemostat) Pressure pick-off port System leak test syringe 1. Remove the right side cover, air inlet filter retainer, and air inlet housing to access the GDS (section 7.20). 2. Plug the air inlet, gas outlet, and patient pressure ports. Verify that the system leak test syringe is pulled back, then connect it to the internal exhalation port. 3. If the ventilator is not already in Diagnostic mode, press and hold the Enter button on the nav-ring and turn the ventilator on by pressing the On/Shutdown button on the UI. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics menu. 4. Touch Service, Misc, then touch System Leak Test and follow the onscreen prompts (Figure 8-13). 5. Touch Close, then remove the plugs and system leak test syringe. 6. Reinstall the inlet filter housing,

inlet filter retainer, and the right side cover (Chapter 7). 7. The system leak test is complete. Figure 8-13: System Leak Test Screen Rev A V60 Ventilator Service Manual 8-19174 Chapter 8 Performance Verification Controls (Test 3) The controls test verifies that the touch screen, nav-ring, and nav-ring Enter button work correctly. Required equipment: 0.25-in. test adapter. 1. If the ventilator is not already in normal ventilation mode, cycle power to the ventilator to enter normal ventilation, attach a 0.25-in. test adapter, and verify that the AC power icon is displayed on the UI. 2. Verify that the ON/Shutdown LED is green. 3. Select these ventilator settings and alarm limits: Ventilator settings Alarm limits Mode: S/T High Rate: 30 BPM IPAP: 20 cmh 2 O Low Rate: 4 BPM EPAP: 4 cmh 2 O Hi Vt: 2500 ml Rate: 12 BPM Lo Vt: OFF ml I-Time: 1.00 sec HIP: 50 cmh 2 O Rise: 1 LIP: OFF cmh 2 O Ramp: OFF Low VE: OFF L/min O2: 21% LIP T: 20 sec 4. Touch IPAP to display the IPAP adjustment screen, then use the navring to change the value to Press the nav-ring Enter button to accept the new setting. 6. Touch IPAP to display the IPAP adjustment screen, then use the touch screen arrows to return the IPAP setting to Touch Menu, then Brightness and verify that the display information is visible when brightness is set to its minimum value. 8. Adjust brightness to 5, then touch Close. 9. Touch Screen Lock, then attempt to change a setting. Verify that the user interface displays Screen Locked at the top of the screen. 10. Press the nav-ring Enter button to unlock the screen. 11. Press the On/Shutdown button, then touch Ventilator Shutdown. 12. Verify that the ON/Shutdown LED is amber. 13. The controls test is complete V60 Ventilator Service Manual Rev A175 Chapter 8 Performance Verification Pressure Accuracy (Test 4) The pressure accuracy test verifies the accuracy of the inhalation and exhalation pressure transducers. Required equipment: Low-pressure plug 9 / 16-3 / 4 in. tapered plug 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Certifier FA Plus analyzer 1. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button and turn the ventilator on by pressing the On/ Shutdown button on the user interface. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics Menu. 2. Touch Service, then Pneumatics. 3. Plug the internal exhalation port orifice (Figure 8-14). Use low-pressure plug to plug internal exhalation port orifice (underside of ventilator) Figure 8-14: Plug Internal Exhalation Port Orifice 4. Verify that the barometric pressure reading displayed on the ventilator is within + 3.5% of the analyzer reading Rev A V60 Ventilator Service Manual 8-21176 Chapter 8 Performance Verification 5. Set the analyzer's pressure range to measure at least 60 cmh 2 O, and connect the pneumatic calibration analyzer to the ventilator as shown (Figure 8-15). NOTE: Zero the analyzer transducers, if required. Figure 8-15: Pressure Accuracy Test Configuration 6. Configure the diagnostic screen (Figure 8-16) as follows: Pressure: 0 cmh2o Flow: 0 SLPM O2: 21% Solenoid 1: None Solenoid 2: Machine Pressure Line Solenoid 3: Machine Pressure Line Solenoid 4: Prox Pressure 8-22 V60 Ventilator Service Manual Rev A177 Chapter 8 Performance Verification Figure 8-16: Diagnostics Menu - Pneumatics Tab Selected 7. Set ventilator pressure values and verify that they correspond to pressure measurements: NOTE: Add the machine pressure offset reading (pneumatics screen) at 0 to the analyzer readings for 1, 35, and 60 cmh 2 O. Set Pressure to: Verify that analyzer, average Machine, and Proximal displays read: 0 cmh 2 O -1.5 to 1.5 cmh 2 O 1 cmh 2 O 0.5 to 1.5 cmh 2 O 35 cmh 2 O 32.5 to 38.5 cmh 2 O 60 cmh 2 O 54 to 66 cmh 2 O 8. To reset the pressure setting to 0, touch Flow then Accept. 9. The pressure accuracy test is complete. Remove low-pressure plug if additional testing is not required Rev A V60 Ventilator Service Manual 8-23178 Chapter 8 Performance Verification Air Delivery/Flow Accuracy (Test 5) The air delivery flow accuracy test verifies the accuracy of the air flow sensor and function of the blower. Required equipment (air delivery): Coupling, straight, silicone Ball valve 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Certifier FA Plus analyzer 1. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button and turn the ventilator on by pressing the On/ Shutdown button on the user interface. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics Menu. 2. Touch Service, then Pneumatics. 3. Disconnect the oxygen source to the ventilator. 4. Plug the internal exhalation port orifice (Figure 8-14). 5. Connect a ball valve and pneumatic calibration analyzer to the ventilator, set analyzer gas source to Air and select STP mode (Figure 8-17). Figure 8-17: Air Delivery Test Configuration 6. Set the analyzer's flow range to measure at least 100 cmh 2 O and 230 SLPM V60 Ventilator Service Manual Rev A179 Chapter 8 Performance Verification 7. Configure the diagnostic screen as follows: Pressure: 0 cmh 2 O Flow: 0 SLPM O2: 21% Solenoid 1: None Solenoid 2: Machine Pressure Line Solenoid 3: Machine Pressure Line Solenoid 4: Prox Pressure 8. Ensure that the ball valve is fully open, then touch Flow and set to 200 SLPM. 9. Begin closing the ball valve until the low pressure display on the analyzer is greater than cmh 2 O. Verify that the flow displayed on the analyzer is greater than SLPM. 10. Touch Pressure, then Accept to zero the flow setting. 11. Disconnect and remove the ball valve and pressure pick-off port from the ventilator. Required equipment (flow accuracy): Low-pressure plug 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Certifier FA Plus analyzer 12. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button and turn the ventilator on by pressing the On/ Shutdown button on the user interface. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics menu. 13. Connect the pneumatic calibration analyzer to the ventilator, set analyzer gas source to Air, and select STP mode (Figure 8-18). Figure 8-18: Air Flow Accuracy Test Configuration Rev A V60 Ventilator Service Manual 8-25180 Chapter 8 Performance Verification 14. Verify that the set air flow values correspond to the flow measurements: NOTE: When using the Certifier FA Plus the air delivery/flow accuracy test requires that the temperatures of the delivered gas and ambient air must be within 10 o C of each other, and that the relative humidity of the gas must be less than 30% at 21.1 o C. Most air flow analyzer flow sensors are sensitive to relative humidity, and typically indicate higher-than-actual air flow readings when the relative humidity is above 10%. Consult the manufacturer s instructions for correcting any air flow inaccuracies due to high relative humidity. Verify that analyzer and Set Flow to: average Air Flow displays read: 10 SLPM 9 to 11 SLPM 120 SLPM 108 to 132 SLPM 230 SLPM 207 to 253 SLPM (N/A if above 6400 feet) 15. Remove the low-pressure plug and verify that the flow reading on the analyzer drops by more than 15 SLPM. 16. Touch Pressure then Accept to zero the flow setting. 17. The air delivery/flow accuracy test is complete V60 Ventilator Service Manual Rev A181 Chapter 8 Performance Verification Oxygen Flow Accuracy (Test 6) The oxygen flow accuracy test verifies the accuracy of the oxygen flow sensor and function of the oxygen valve. Required equipment: Low-pressure plug 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Certifier FA Plus analyzer 1. If the ventilator is not already in diagnostic mode, press and hold the nav-ring Enter button and turn the ventilator on by pressing the On/ Shutdown button on the user interface. Within 5 seconds release and press the nav-ring Enter button again to enter the Diagnostics menu. 2. Touch Service, then Pneumatics. 3. Connect the oxygen source to the ventilator. 4. Plug the internal exhalation port orifice (Figure 8-14). 5. Connect the pneumatic calibration analyzer to the ventilator, set analyzer gas source to O2 and select STP mode (Figure 8-19). Figure 8-19: Oxygen Flow Accuracy Test Configuration 6. Set the analyzer flow range to measure at least 130 LPM Rev A V60 Ventilator Service Manual 8-27182 Chapter 8 Performance Verification 7. Configure the diagnostic screen as follows: Pressure: 0 cmh 2 O Flow: 0 SLPM O2: 100% Solenoid 1: None Solenoid 2: Machine Pressure Line Solenoid 3: Machine Pressure Line Solenoid 4: Prox Pressure 8. Verify that the set oxygen flow values correspond to the flow measurements: Verify that analyzer and Set Flow to: average O 2 Flow displays read: 10 SLPM 9 to 11 SLPM 140 SLPM 126 to 154 SLPM 9. Touch Pressure then Accept to zero the flow setting. 10. Touch O2 and set to 21%. 11. The oxygen flow accuracy test is complete. Remove low-pressure plug V60 Ventilator Service Manual Rev A183 Chapter 8 Performance Verification Oxygen Accuracy (Test 7) The oxygen accuracy test verifies the accuracy of the oxygen percentage delivered to the patient. Required equipment: 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Whisper Swivel Ingmar test lung Certifier FA Plus analyzer with oxygen sensor 1. Connect a patient circuit, including test lung, Whisper Swivel, and analyzer to the ventilator (Figure 8-20). Set the analyzer to measure oxygen. Set up the test lung with an Rp20 and a compliance of 20. Figure 8-20: Oxygen Accuracy Test Configuration 2. If the ventilator is not already in normal ventilation mode, cycle power to the ventilator to enter normal ventilation mode Rev A V60 Ventilator Service Manual 8-29184 Chapter 8 Performance Verification NOTE: 3. Select these ventilator settings and alarm limits: Ventilator settings Alarm limits Mode: S/T High Rate: 30 BPM IPAP: 20 cmh 2 O Low Rate: 4 BPM EPAP: 4 cmh 2 O Hi Vt: 2500 ml Rate: 12 BPM Lo Vt: OFF ml I-Time: 1.00 sec HIP: 50 cmh 2 O Rise: 1 LIP: OFF cmh 2 O Ramp: OFF Low VE: OFF L/min O2: 21% LIP T: 20 sec 4. With the oxygen source disconnected, touch O2 and set to 22%. 5. Verify that the ventilator alarms and displays Oxygen Not Available. 6. Touch O2 and set to 21%, reset alarms. 7. Connect an oxygen source to the ventilator. Calibrate the oxygen analyzers sensor prior to proceeding. 8. Verify that the set O 2 % values corresponds to the measured values: Touch O2 and set to: Verify that analyzer measures: 21% 18 to 24% (after 12 breaths) 30% 27 to 33% (after 12 breaths) 60% 57 to 63% (after 12 breaths) 100% 97 to 103% (after 12 breaths) 9. Touch O2 and set to 21%. 10. The oxygen accuracy test is complete V60 Ventilator Service Manual Rev A185 Chapter 8 Performance Verification S/T Performance (Test 8) The S/T performance test verifies the accuracy of the IPAP and EPAP settings. Required equipment: 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Whisper Swivel Ingmar test lung TTL communications cable Certifier FA Plus analyzer 1. Connect a patient circuit, including test lung, Whisper Swivel, TTL cable, and analyzer to the ventilator (Figure 8-21). Figure 8-21: S/T Performance Test Configuration 2. Set up the test lung with an Rp20 and a compliance of If the ventilator is not already in normal ventilation mode, cycle power to the ventilator to enter normal ventilation mode. 4. Set the analyzer to display peak inspiratory pressure (PIP) and positive end expiratory pressure (PEEP) Rev A V60 Ventilator Service Manual 8-31186 Chapter 8 Performance Verification 5. Select these ventilator settings and alarm limits, and reset any alarms if necessary: Ventilator settings Alarm limits Mode: S/T High Rate: 30 BPM IPAP: 15 cmh 2 O Low Rate: 4 BPM EPAP: 4 cmh 2 O Hi Vt: 2500 ml Rate: 12 BPM Lo Vt: OFF ml I-Time: 1.00 sec HIP: 50 cmh 2 O Rise: 2 LIP: OFF cmh 2 O Ramp: OFF Low VE: OFF L/min O2: 21% LIP T: 20 sec 6. Allow the ventilator to operate for at least one minute. 7. Watch the waveforms on the V60 display to verify that the unit cycles between IPAP and EPAP. 8. Verify that the set IPAP and EPAP values correspond to these measurements: Select this setting: IPAP = 40 cmh 2 O EPAP = 25 cmh 2 O Verify that analyzer measures: 36.4 to 43.6 cmh 2 O (PIP) 22 to 28 cmh 2 O (PEEP) 9. The S/T performance test is complete V60 Ventilator Service Manual Rev A187 Chapter 8 Performance Verification Alarms (Test 9) This test verifies the performance of the alarm outputs. Required equipment: 22-mm connector Pressure pick-off port 18-in. smooth-bore tubing Proximal pressure line assembly Whisper Swivel Ingmar test lung Certifier FA Plus analyzer DMM Remote alarm test cable Remote alarm test cable adapter 1. Connect a patient circuit, including test lung, Whisper Swivel, and analyzer to the ventilator (Figure 8-22). Figure 8-22: Alarms Test Configuration 2. Set up the test lung with an Rp20 and a compliance of If the ventilator is not already in normal ventilation mode, cycle power to the ventilator to enter normal ventilation mode Rev A V60 Ventilator Service Manual 8-33188 Chapter 8 Performance Verification 4. Select these ventilator settings and alarm limits: Ventilator settings Alarm limits Mode: S/T High Rate: 30 BPM IPAP: 10 cmh 2 O Low Rate: 4 BPM EPAP: 4 cmh 2 O Hi Vt: 2500 ml Rate: 12 BPM Lo Vt: OFF ml I-Time: 1.00 sec HIP: 50 cmh 2 O Rise: 1 LIP: OFF cmh 2 O Ramp: OFF Low VE: OFF L/min O2: 21% LIP T: 20 sec 5. Connect the adapter's double banana plugs to the DMM with the GND tab to the common jack and set the DMM to measure resistance. 6. Connect the grey RCA plug (labeled TIP) of the remote alarm test cable to the adapter. 7. Plug the ¼ - in. phono connector into the remote alarm phono jack at the back of the ventilator. 8. Reset any alarms if necessary and verify that the DMM reads infinite resistance (open circuit). 9. Remove the grey RCA plug from the adapter and connect the orange RCA plug (labeled RING) in its place. 10. Reset any alarms if necessary, and verify that the DMM reads ohms. 11. Disconnect the proximal line from the ventilator to create a Proximal Pressure Line Disconnect alarm. 12. Touch Menu, then Loudness, and verify that the audible alarm is still audible when set to 1 and steadily becomes louder as the value increases to Verify that the DMM reads infinite resistance (open circuit). 14. Remove the orange RCA plug from the adapter and connect the grey RCA plug (labeled TIP) in its place. 15. Verify that the DMM reads ohms. 16. Reconnect the proximal line to the ventilator and verify that the audible alarm is automatically silenced. 17. Remove the adapter from the DMM and the remote alarm test cable from the remote alarm phono jack. 18. The alarms test is complete V60 Ventilator Service Manual Rev A189 Chapter 8 Performance Verification Power Fail (Test 10) This test verifies the integrity of the power fail alarm. Required equipment: 0.25-in. test adapter. If the internal battery is installed: 1. Turn ventilator power off and disconnect power cord from AC outlet. 2. Disconnect the internal battery from the ventilator. 3. Reconnect the power cord to the AC outlet. 4. Connect a 0.25-in. test adapter to the gas outlet port. 5. Turn the ventilator on in normal ventilation mode. 6. With the ventilator operating on AC power, unplug the power cord from the AC outlet. 7. Verify that the audible alarm sounds and start a stopwatch. After 2 minutes, verify that the audible alarm is still sounding. 8. Press and hold the On/Shutdown button for about 5 seconds to turn ventilator power off, then verify that the audible alarm is silenced. 9. Reconnect the internal battery to the ventilator. 10. Plug the ventilator into an AC outlet and verify that the battery icon changes to the AC icon. 11. The power fail alarm test is complete. If the internal battery is not installed: 1. Connect a test adapter to the gas outlet port. 2. Turn the ventilator on in normal ventilation mode, then unplug the power cord from the AC outlet. 3. Verify that the audible alarm sounds and start a stopwatch. After 2 minutes, verify that the audible alarm is still sounding. 4. Press and hold the On/Shutdown button for about 5 seconds to turn ventilator power off, then verify that the audible alarm is silenced. 5. The power fail alarm test is complete Rev A V60 Ventilator Service Manual 8-35190 Chapter 8 Performance Verification Internal Battery (Test 11) This test verifies that the ventilator can transition to and from optional battery power. Do not perform this test if the internal battery is not installed. Required equipment: 0.25-in. test adapter. NOTE: The internal battery (if installed) should be fully charged before performing this test. If the internal battery is not fully charged, this test may fail. Record the result of this test as Limited use on the Performance Verification Data Form until the internal battery is charged and internal battery test passes. 1. If the ventilator is not already in Diagnostic mode, press and hold the nav-ring Enter button and turn on the ventilator by pressing the On/Shutdown button on the user interface. Within 5 seconds, release and press the nav-ring Enter button again to enter the Diagnostic menu. 2. Connect a 0.25-in. test adapter to the gas outlet port. 3. Touch Service, Pneumatics, and then Pressure and set the pressure to 65 cmh 2 O. 4. Unplug the AC power cord and verify that ventilator operation continues uninterrupted and that Battery % on the diagnostic screen is above 70%. 5. Allow ventilator to a minimum of 20 minutes on battery power, then verify that the Battery % displayed on the diagnostic screen is at least 70%. 6. With AC still disconnected, cycle power to the ventilator and allow it to come up in normal ventilation. 7. Verify that the ventilator operates in normal ventilation, the message Running on Internal Battery is displayed in the Alert window, the Battery In Use icon is displayed, and the Battery Low alarm is off. 8. Reconnect the AC power cord. Verify that ventilator operation is uninterrupted, the AC icon is displayed, and the Battery icon turns off. 9. Verify that the Battery Charging LED begins flashing within 30 seconds. 10. The internal battery test is complete V60 Ventilator Service Manual Rev A191 Chapter 8 Performance Verification 8.6 Returning Ventilator to Operation Follow these steps to return the ventilator to operation after a successful performance verification: 1. Remove all test equipment, tools, and materials from ventilator. 2. Verify that the internal exhalation port orifice is not plugged. 3. If the ventilator is not already in diagnostic mode: power up the ventilator: press and hold the nav-ring Enter button and the On/ Shutdown button on the user interface. Within 5 seconds of power up, release and press the nav-ring Enter button to enter the Diagnostics menu. 4. Touch System Settings, and then Restore Default Settings. 5. Touch Date/Time and verify that the date and time are correct. 6. Turn ventilator OFF. 8.7 Performance Verification Troubleshooting/ Repair Use the following troubleshooting procedures if the ventilator fails a performance verification test. Make sure that the external measurement devices such as the pneumatic calibration analyzer are calibrated and functioning properly. Perform the repair procedures in the order listed until the problem is resolved. (See Chapter 5 for diagnostic mode procedures, and Chapter 7 for component replacement procedures.) CAUTION: Troubleshooting and repair should be performed only by a qualified service technician Rev A V60 Ventilator Service Manual 8-37192 Chapter 8 Performance Verification Test 1: Electrical Safety Symptom Ground resistance out of range Cooling fan not operating Forward/reverse leakage current out of range Recommended Repair 1.Verify that the AC outlet is properly grounded. Try another AC outlet. 2.Verify that the AC power cord is completely inserted into the AC inlet. 3.Check for secure connections of AC mains ground wires, power supply, gas outlet, proximal pressure port, and GDS. 4.Check for visible damage to the power cord. 5.Replace power cord. 1.Check that the fan wires are properly seated in the connector on the MC PCBA. 2.Slave in a replacement fan and replace if it is operational. 3.Replace the MC PCBA. 1.Check for secure connections of ground wires from the AC inlet, power supply, and GDS. 2.Replace power cord and rerun test. 3.Check for pinched cables and harnesses or damaged wire insulation throughout the ventilator. 4.Replace power supply and rerun test Test 2: Leak Tests Symptom Oxygen inlet reading out of range (45-50 psig) Recommended Repair 1.Verify that oxygen source is adequate for this test. 2.Check for leaks at the oxygen fitting. 3.Check that the oxygen solenoid valve is fully closed by verifying that there is zero flow across the oxygen flow sensor. If not, replace the oxygen solenoid valve. 4.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA V60 Ventilator Service Manual Rev A193 Chapter 8 Performance Verification Symptom High pressure leak test fails System pressure leak test fails Recommended Repair 1.Verify that oxygen source is adequate for this test. 2.Check for leaks at the oxygen fitting, oxygen filter element cap, oxygen solenoid valve, and oxygen pressure transducer. 3.Check that the oxygen solenoid valve is fully closed by verifying that there is zero flow across the oxygen flow sensor. If not, replace the oxygen solenoid valve. 4.Verify that the oxygen pressure transducer is reading correctly. If not, replace the DA PCBA. 1.Verify that the internal exhalation port, air inlet port, gas outlet port, and proximal port are plugged properly. 2.Verify that system leak test syringe tubing is properly clamped. 3.Check for disconnected or cut tubing from the GDS to the gas outlet port, and from the gas outlet port to the base. 4.Check for misaligned or cut rubber boots from the GDS to the blower, and from the blower to the gas outlet port. 5.Check for leaks at the flow sensor assembly, solenoid valves, and pressure transducers. 6.Verify that the machine and proximal pressure transducers are reading correctly. If not, replace the DA PCBA Test 3: Controls Symptom Touch screen not responding properly Nav-ring not responding properly On/Shutdown switch not responding properly Recommended Repair 1.Calibrate the touch screen. 2.Slave in a different user interface-to-pm PCBA cable, and replace original cable if the problem is resolved. 3.Replace PM PCBA. 4.Replace the CPU PCBA. 1.Verify connections between the nav-ring and the switch PCBA. 2.Slave in a different switch PCBA cable, and replace the original cable if the problem is resolved. 3.Replace the nav-ring assembly. 1.Verify connections between power switch overlay and UI PCBA. 2.Slave in a different power switch overlay and replace original overlay if this resolves the problem Rev A V60 Ventilator Service Manual 8-39194 Chapter 8 Performance Verification Test 4: Pressure Accuracy Symptom Average machine or proximal pressure readings out of range Recommended Repair 1.Verify that the internal exhalation port orifice is plugged. 2.Check for leaks at circuit connections, calibration analyzer, filters, etc. 3.Check for kinked or cut tubing from GDS to gas outlet port, and from the gas outlet port to the base. 4.Check for kinked or cut rubber boots from the GDS to the blower, and from the blower to the gas outlet port. 5.Check for leaks at the solenoid valves and pressure transducers. 6.Replace the DA PCBA Test 5: Air Delivery/Flow Accuracy Symptom Measured air flow values out of range Recommended Repair 1.Verify that the internal exhalation port orifice is plugged. 2.Verify that the calibration analyzer is set to measure air in STP mode. 3.Check that nothing is obstructing the ventilator gas outlet port. 4.If air flow sensor reading is not within limits as compared to the calibration analyzer, replace the flow sensor assembly. 5.Slave in a different air flow sensor to data acquisition cable. 6.Replace the DA PCBA V60 Ventilator Service Manual Rev A195 Chapter 8 Performance Verification Test 6: Oxygen Flow Accuracy Symptom Measured oxygen flow values out of range Recommended Repair 1.Verify that the internal exhalation port orifice is plugged. 2.Verify that the calibration analyzer is set to measure oxygen in STP mode. 3.Check that nothing is obstructing the ventilator gas outlet port. 4.If oxygen flow sensor reading is not within limits as compared to the calibration analyzer, replace the flow sensor assembly. 5.Slave in a different oxygen flow sensor to DA PCBA cable. 6.Replace the DA PCBA Test 7: Oxygen Accuracy Symptom The measured oxygen percentage is out of range Recommended Repair 1.Check that test oxygen monitor is calibrated. 2.Verify that the external oxygen sensor is oriented with cable connector on top. 3.Replace the external oxygen sensor and retest. 4.Replace the oxygen solenoid valve Test 8: S/T Performance Symptom IPAP and EPAP outside acceptable value Recommended Repair 1. Verify correct test setup. 2.Check for leaks at circuit connections, test lung, analyzer, etc. 3.Replace DA PCBA. 4.Replace MC PCBA. 5.Replace CPU PCBA Rev A V60 Ventilator Service Manual 8-41196 Chapter 8 Performance Verification Test 9: Alarms Symptom Normally open or normally closed relay test failure (continuity check) Primary alarm volume not adjustable Recommended Repair 1.Verify continuity of remote alarm test cable. 2.Replace CPU PCBA. Slave in PCBAs in this order until the problem is resolved: MC PCBA, PM PCBA, CPU PCBA Test 10: Power Fail Symptom Backup audible alarm fails to sound Backup audible alarm fails to sound for at least two minutes Power switch turned off but backup alarm remains on 1.Replace MC PCBA. 2.Replace PM PCBA. 1.Replace MC PCBA. 2.Replace CPU PCBA. Recommended Repair 1.Replace power switch overlay. 2.Replace MC PCBA V60 Ventilator Service Manual Rev A197 Chapter 8 Performance Verification Test 11: Internal Battery Symptom Ventilator cannot transition from AC to battery power Internal battery becomes depleted prematurely Connecting AC power resets ventilator When AC power is connected after 10 minutes of battery operation, Battery Charging indicator does not light Following ventilator power cycle, diagnostic code or continuous backup alarm condition occurs Recommended Repair 1.Verify that battery harness connections are secure. 2.Verify that Battery % is above Replace PM PCBA. 1. Verify that battery is fully charged before test. 2.Replace internal battery. 3.Replace PM PCBA. 4.Replace power supply. Replace PM PCBA. Replace PM PCBA. 1.Verify that battery is fully charged before test (recharge for up to 8 to12 hours if fully depleted). 2.Replace an internal battery. 3.Replace PM PCBA Rev A V60 Ventilator Service Manual 8-43198 Chapter 8 Performance Verification 8.8 Electrical Safety Data Form Complete this form at every performance verification. Make copies of this form for data collection. Date: Notification number(s): Customer Information Name: Address: City/State: Account no.: Preliminary ventilator cleaning and inspection Circle one If yes, provide a brief description of damage and repair: Was the ventilator damaged? YES NO Cleaned ventilator exterior? YES NO Inspected cooling fan filter? YES NO Inspected inlet filter? YES NO Serial number: Installed options (circle all that apply): Total power-on hours: Battery lot number: Software version: PAV>>>>>>AVAPS>>>>>>C-Flex>>>>>>Ramp Other: Hours since last PM: Battery manufacture date: Test 1: Electrical safety Circle one Passed value Proper cooling fan operation? YES NO Failed value Value after repair Proximal pressure port GND resistance (>>>>>C-Flex>>>>>>Ramp Other: Hours since last PM: Battery manufacture date: Environmental readings: Barometric pressure: mmhg Relative humidity: % Temperature: o C Test 1: Electrical Safety Circle one Proper cooling fan operation? YES NO Pass value Fail value Value after repair Proximal pressure port GND resistance (

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